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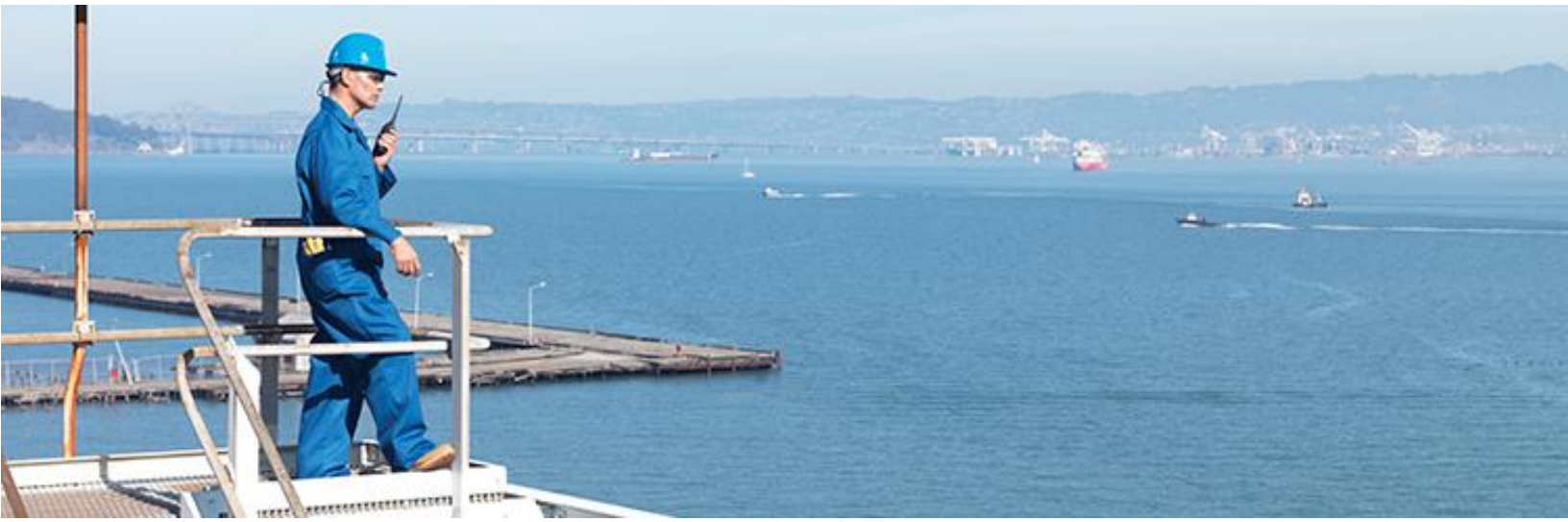

MOTOTRBO™
Connect Plus

MULTI-SITE DIGITAL TRUNKING

System Planner

August 2011

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References:

[1] MOTOTRBO System Planner

[2] MOTOTRBO Connect Plus Portable User Guide

[3] MOTOTRBO Connect Plus Mobile User Guide

[4] MOTOTRBO Connect Plus User Guide for XRC 9000

[5] Motorola Quality Standards Fixed Network Equipment Installation Manual R56

Table of Figures and Tables

1 Introduction

The Connect Plus is an integrated digital trunking solution for voice and data, built on the MOTOTRBO system components.

This system planner will enable the reader to understand the features and capabilities of the Connect Plus system, and will provide guidance on how to deploy and configure the system to utilize all its capabilities.
This document should be used in conjunction with the following documentation:

- MOTOTRBO™ System Planner
- MOTOTRBO™ Customer Programming Software (CPS) and related training
- MOTOTRBO™ Connect Plus Option Board CPS[1] and related training
- System workshop/system service training
- Product specification sheets

This system planner has been developed under the assumption that the reader is familiar with the MOTOTRBO technology as well as the different system configurations offered by MOTOTRBO in *digital* mode such as:

- Single Site Repeater
- Talkaround
- IP Site Connect
- Capacity Plus

For a broader discussion and explanation of the underlying TDMA radio technology, system equipment, configurations and features the reader can refer to [1]. This document is structured in such a way that it compares Connect Plus to the other (non-Connect Plus) modes of operation to highlight the advantages as well as identify features that are not offered or required with Connect Plus.

2 Connect Plus System Feature Overview

2.1 Introduction to Connect Plus

Connect Plus is a single-site or multi-site trunking solution that utilizes MOTOTRBO repeaters and subscribers for its RF components. Because the radios operate in digital mode, a Connect Plus system combines the advantages of MOTOTRBO digital signaling (two voice conversations per repeater, integrated digital features, etc.) with the efficiency of trunking.

A Connect Plus system provides the following capabilities:

- Up to 15 repeaters (30 timeslots) per Connect Plus site.
- Up to 20 networked sites[2] (Release 1.1). For multisite network configuration the controllers need to be purchased with such options.

[1] For brevity, the **MOTOTRBO™ Connect Plus Option Board CPS** will be referred to simply as **Connect Plus CPS** from here on.
[2] When the Multisite Feature is enabled in the XRC 9000, the Connect Plus network supports up to 20 RF sites (Site Numbers 1-20), and up to 5 XRT 9000 Gateways (Site Numbers 251-255). When the Multisite

- Dedicated Control Channel timeslot supporting prioritized Busy Queue.
- Most of the same voice & data features available in digital conventional operation.
- Additional features not found in other MOTOTRBO digital modes, including (but not limited to) the following:
    - Dedicated Control Channel Timeslot
    - Validation of Radio IDs and Group ID
    - Validation of Connect Plus ESN
    - Remote access for user, site, and network management.
    - Prioritized Busy Queue
    - Text Message Mailboxing, with Store and Forward Capability
    - Multigroup ID for Voice and Data Calls
    - Ability to update frequency information and Option Board firmware Over-the-air (OTA)
    - In Multi-site network operation, the XRC 9000 controllers track each Subscriber Unit (SU) through Connect Plus registration and de-registration messages. This process allows the system to use RF resources efficiently. Calls are only carried at sites where radios are presently registered to the target ID.

2.2 Basic Connect Plus System Components

In addition to the MOTOTRBO repeater and subscriber radios, Connect Plus trunking requires the following basic system components: (For a more detailed discussion of System Components, including optional components, see the "Connect Plus System Components and Topologies" section).

- One XRC 9000 Controller per site. Each controller requires a static IP address.
- Each SU in the Connect Plus network must be enabled for Connect Plus operation.
- An Option Board must be installed in each Connect Plus-enabled SU. The Option Board must be loaded with MOTOTRBO™ Connect Plus Option Board firmware, which requires a purchasable license.
- Additional hardware for IP communications:
    - Single-site: At a minimum, this requires an Ethernet switch[3] and cables to connect the XRC 9000 Controller and MOTOTRBO repeaters to the switch.

Feature is disabled, the XRC 9000 does not support networking to other RF sites. It can be connected to one XRT 9000 Gateway only (which must be Site number 255).

[3] Connect Plus has been tested and validated with the **HP ProCurve 2510-24** Ethernet switch.

- Multi-site: In addition to the hardware required for single-site operation, a multi-site network requires additional IP infrastructure. This varies according to network configuration and the type of connections utilized.

2.2.1 XRC 9000 Trunking Controller

Each Connect Plus site requires at least one XRC 9000 Controller. If desired, the customer may purchase a second XRC 9000 Controller per site to serve as backup to the primary XRC 9000. The secondary XRC 9000 can be configured to assume site control if the primary XRC 9000 fails, provided that the secondary controller has IP connectivity with its local repeaters. The secondary controller provides backup capability, but it does not increase the number of repeaters and calls that can be managed per site.

The XRC 9000 site controller is the core of the Connect Plus infrastructure. The controller's primary responsibilities are outlined as follows:

Via the OTA interface, the XRC 9000 communicates with Connect Plus subscribers in order to

- Validate registrations and Call Requests
- Facilitate data transfer
- Assign RF resources
- Maintain a Busy Queue when no RF resources are available

Via its IP interface, The XRC 9000 communicates with all of the site's repeaters in order to

- Assign calls to available timeslots
- Decide which audio packets should be transmitted on the repeater downlink
- Assist repeater with FCC compliance (CWID, Level I and II Monitoring)

Via its IP interface, the XRC 9000 communicates with other network controllers in order to

- Track registrations and de-registrations throughout the Connect Plus network
- Facilitate network call set-up
- Duplicate and forward voice packets to any site where the Target ID is registered
- Route text messages and Location Requests to any site where the Target ID is registered

The XRC 9000 provides resources for network management[4] in order to:

- Validate and configure privileges for Connect Plus subscribers
- Configure site and network parameters

[4] Requires the MOTOTRBO™ XRC 9000 Connect Plus Network Manager software

- Monitor site RF activity in real time
- Monitor airtime usage and diagnostic information

2.2.2 Control Channel Operation

Each Connect Plus site utilizes a **dedicated** timeslot for Control Channel signaling. The XRC 9000 controller uses the Control Channel timeslot for the following operations:

- Receives and responds to registration requests
- Receives and responds to call requests
- Assigns calls to trunk-to timeslots
- Periodically re-sends information for calls-in-progress (thereby supporting late entry)
- Transmits information about surrounding sites (Multi-site operation only)
- Call exchanges that utilize Control Signaling Block (CSBK) Messages occur entirely on the Control Channel timeslot. Sometimes these are called “Command and Control” call features. They include:
    - Radio Check
    - Call Alert
    - Radio Disable
    - Radio Enable
    - Private Call confirmation prior to assigning a trunk-to timeslot
    - Remote Monitor confirmation prior to assigning a trunk-to timeslot

2.2.3 Control Channel Rollover

Beginning with Connect Plus Release 1.1, the Connect Plus System supports configuration of up to four Control Channel repeaters per site. Only one of these will be active as the Control Channel at any given time. When a repeater is the active Control Channel repeater, Timeslot 1 is used for Control Channel messaging and Timeslot 2 is available for call assignments. When a repeater is configured as a Control Channel repeater, but is not the currently active Control Channel, then both of its timeslots are used for call assignments. To determine which repeater is the site’s current Control Channel, connect to the site with the **MOTOTRBO™ XRC 9000 Connect Plus Network Manager**[5], and open the Real Time Display.

[5] For brevity, the **MOTOTRBO™ XRC 9000 Connect Plus Network Manager** will be referred to simply as Connect Plus Network Manager or as Network Manager from here on.

The Control Channel repeaters must be configured in both the XRC 9000 controller (using the Network Manager software) and in the Network Frequency File (configured in the SU using MOTOTRBO Connect Plus CPS). The site's list of Control Channel repeaters as configured in the Network Manager and the Network Frequency File must match exactly. Any and all frequencies flagged as Control Channel must conform to the "Control Channel Requirements" section.

When the controller rolls-over to a different Control Channel repeater, the event is captured in the XRC 9000 Event Log. There are three categories of triggers that will cause the XRC 9000 to rollover from one Control Channel repeater to another:

1. Scheduled 24-hour rollover: The daily rollover time is configured in the Network Manager.

2. Un-scheduled rollover due to Repeater Failure. This includes the following events:

    a. The XRC 9000 boots-up and cannot establish communication with the last-known Control Channel repeater prior to expiration of an internal timer (approximately 65 seconds).

    b. The XRC 9000 initially establishes communication with the Control Channel repeater, but subsequently fails to detect a repeater "keep alive" message prior to expiration of an internal timer.

    c. The XRC 9000 determines that the current Control Channel repeater has been disabled via a command from the RDAC application.

    d. The XRC 9000 boots-up and determines that the last-known Control Channel repeater has a significant active alarm (as defined in Table 2-1).

    e. The current Control Channel repeater reports a significant active repeater alarm to the XRC 9000 (as defined in Table 2-1). The Repeater Alarm Name and Hexadecimal Alarm Code are captured in the XRC 9000 Event Log.

Alarm Name	XPR Repeater Hexadecimal Alarm Code	MTR 3000 Repeater Hexadecimal Alarm Code
Transmitter Alarm	$01	$01
RX Alarm	$02	$02
PA EEPROM Corruption Type 3	Not applicable	$08
PA Voltage Major Alarm	Not applicable	$12
VSWR Major Alarm	$14 (32 MB hardware only)	$14
Transmitter Power Major Alarm (-3dB)	$17 (32 MB hardware only)	$17

Table 2-1 Repeater Alarms that will trigger Control Channel Rollover

It is important to know that if the Control Channel repeater reports any of the above alarms, but the site does not have another Control Channel repeater to rollover to (because there are no other Control Channels configured in the Network Manager, or because all other Control Channels are in error condition) the site will be without a Control Channel. This will cause the XRC 9000 to raise the "Control Channel Lost" Controller Alert, and subscriber radios will not be able to use this site

until the problem is rectified. The Real Time Display continues to show the site's last Control Channel repeater (if known).

3. Un-scheduled rollover due to excessive interference on the Control Channel uplink frequency. The operation is as follows:

    a. When the Control Channel repeater detects interference on its uplink frequency that exceeds the interference threshold configured with MOTOTRBO CPS, it sends the XRC 9000 a message stating "interference detected". Meanwhile, the repeater continues to send the XRC 9000 any SU messages received on the Control Channel uplink.

    b. When the XRC 9000 receives an "interference detected" message from the Control Channel repeater, the controller starts a 30-second debounce timer. This timer is only applied to interference on the Control Channel repeater. If the repeater forwards any valid SU messages prior to sending the "interference clear" message, the XRC 9000 will restart its debounce timer upon decoding the valid message. This has the effect of prolonging the debounce timer.

    c. While the controller's interference debounce timer is running, the controller continues to use the current Control Channel repeater.

    d. The repeater continues to listen for the interference. If the repeater doesn't detect interference for several seconds, it sends the XRC 9000 a message stating "interference clear".

    e. If the controller receives an "interference clear" message from the repeater prior to expiration of the XRC 9000 interference debounce timer, it will continue to use the same Control Channel repeater.

    f. If the controller's interference debounce timer expires, and the controller has not received an "interference clear" message from the repeater, the XRC 9000 will look for a different Control Channel repeater:

        i. If the XRC 9000 locates a different (and available) Control Channel repeater prior to receiving an "interference clear" message, this will cause rollover.

        ii. If the XRC 9000 does not locate a different (and available) Control Channel repeater prior to receiving an "interference clear" message, the controller will continue to use the same Control Channel repeater.

When the XRC 9000 rolls-over to an alternate Control Channel repeater, its preferred choice will be the next repeater in the round-robin list (as determined by the repeater's Radio ID). This will be the first repeater evaluated by the XRC 9000. However, if Timeslot 1 of the "preferred" rollover repeater is not immediately available, the XRC 9000 will evaluate the availability of the other Control Channel repeaters, and it will choose the first repeater that has Timeslot 1 available. For this reason, the next Control Channel repeater can potentially be any other repeater on the Control Channel list.

The scheduled Control Channel Rollover will not occur under the following conditions:

1. At rollover time, there is no available Control Channel repeater (because there are no other Control Channel repeaters on the Network Manager Control Channel list, or because all other repeaters on the list are not checked-in or are in error condition).

2. There is an emergency call in progress at the scheduled rollover time.

Following a scheduled rollover, both timeslots of the former Control Channel repeater will be available for call assignments. Following an un-scheduled rollover, the former Control Channel repeater will not be used for call assignments until it exits from the error condition that triggered the Control Channel change.

It should be noted that Control Channel rollover will cause a temporary loss of site communications by the Connect Plus SU. The radio must temporarily lose signal from the "old" Control Channel repeater before it will search for a new one. When this occurs, the Connect Plus radio looks at all the possible Control Channel frequencies for the last-registered site before it searches any other sites. If it locates an alternate Control Channel for the same site, and if the SU's Reacquire Timer has not expired, the radio will continue using the site without a new registration. If the SU's Reacquire Timer has expired, the radio will send a registration to the new Control Channel before it continues using the site. If the radio is in the Busy Queue when the Control Channel rolls-over, it will maintain its "busy state" provided that it locates a different Control Channel repeater for the same site and decodes a subsequent Busy Queue Grant from the new Control Channel prior to expiration of an internal radio timer. If these conditions are not met, the radio exits the "busy state" and the radio user may re-initiate the desired call (once the radio finds a new Control Channel).

If Control Channel rollover is triggered by a scheduled rollover, it is likely that the SU will remain on the same site. This is because the XRC 9000 can locate a different (and available) Control Channel repeater prior to taking the old Control Channel repeater off-line. For unscheduled rollovers, the SU may or may not remain on the same site. This is because the triggering event occurs before the XRC 9000 has looked for or located a new Control Channel repeater. If the SU searches all remaining Control Channels for the same site and cannot find one (because the XRC 9000 hasn't been able to bring a new Control Channel on-line yet), the SU will start to search the Control Channel repeaters for other network sites (assuming the SU is part of a multisite network). If the SU hears a Control Channel for a different network site with suitable signal strength, the SU will attempt to change sites by transmitting a registration attempt to the new site.

Note: Connect Plus Subscriber Units with Option Board firmware prior to Release 1.1 will only search the lowest-numbered repeater per site that has the Control Channel box checked in the Network Frequency File. The Option Board firmware of such radios does not support Control Channel Rollover. They must be upgraded before they will search more than one repeater per site.

2.2.4 Control Channel Requirements

- Each Connect Plus site requires a dedicated Control Channel timeslot
- The Control Channel timeslot will always be Timeslot 1 of the Control Channel repeater. Timeslot 2 of the Control Channel is a trunk-to resource for voice and data calls
- The downlink of the Control Channel timeslot transmits continuously. This minimizes the time the SU spends searching for service, and it allows the system to quickly respond to registrations and call requests. Any interruption to this continuous messaging adversely affects system performance. This requirement has the following implications:
    - Control Channel frequency pairs require a Protected Service Area. Non-exclusive licenses such as FB2 or FB6 are not suitable for Control Channel operation.

- Whenever possible, Base Station Identification (also called CWID) should be sent on trunk channel repeaters only. BSI on the Control Channel repeater interrupts control messaging, which is detrimental to system performance.

2.2.5 Connect Plus Subscriber Radio

In order for a MOTOTRBO subscriber radio to operate on a Connect Plus System, it must meet all of the following requirements.

- Connect Plus requires radio software version R01.06.30 or later
- A Motorola Option Board must be installed in the SU. Prior to the installation of MOTOTRBO™ Connect Plus Option Board firmware, the radio's Option Board is referred to as a Generic Option Board (GOB). Following installation of Connect Plus software, the Option Board is referred to as Connect Plus Option Board.
- In order for the Connect Plus Option Board to enable its OTA interface and "talk" to the XRC 9000 controller, it must first verify that the Connect Plus feature has been enabled in the MOTOTRBO subscriber unit. See "Enabling the Connect Plus Feature" in the "Connect Plus System Design Considerations" section for more information.

2.2.6 Connect Plus Option Board Functions

Connect Plus trunking logic for subscriber radio resides in its Connect Plus Option Board. The Connect Plus Option Board communicates with the MOTOTRBO SU to facilitate the following operations:

- Storing frequency information, and executing frequency changes
- Transmission and reception of Connect Plus control messaging
- Transmission and reception of audio
- Transmission and reception of IP data packets
- Executing Connect Plus features
- Providing ergonomic feedback to the radio user (LED, tones, radio display)

2.2.7 Configuring Connect Plus Subscriber Radios

Configuring a subscriber radio for Connect Plus operation involves the following:

- Using MOTOTRBO™ Customer Programming Software (CPS) to enable "Option Board Trunking" for each Connect Plus personality[6].

[6] See "Connect Plus System Design Considerations" section, for more detailed discussion on MOTOTRBO CPS programming.

- Using MOTOTRBO™ Connect Plus Option Board CPS for advanced configuration of Connect Plus parameters, which includes:
    - Creating Connect Plus Contacts
    - Assigning knob positions
    - Entering Network, Site, & Frequency information
    - Configuring Connect Plus feature options
    - Configuring Connect Plus Menu Operation

2.3 Connect Plus Channel Access

2.3.1 Polite and Impolite Operation

When programming the SU with MOTOTRBO CPS, Connect Plus requires that the Admit Criteria be set to “Always” for every Connect Plus channel. However, this does not mean that the Connect Plus SU will always use “Impolite” Channel Access. In fact, the Connect Plus subscriber radio uses a combination “Polite” and “Impolite” channel access, depending on the specific operation as discussed below:

- Control Channel Registration messages and Call Requests are transmitted impolitely. If the SU does not hear a response within the expected period, it sends retries at a random interval. If the first request was not decoded because it collided with a request from another radio, the random retry interval significantly decreases the chance of two consecutive collisions with the same radio.

- For the first voice transmission on a trunk-to channel, the initiating Connect Plus Option Board assumes the channel is available and will request the radio to transmit accordingly. When the radio receives the Option Board transmit request, it will act on the request per its programmed Admit Criteria. Because the Connect Plus system is in charge of channel assignment, it is unlikely that another radio will already be transmitting on the channel.

- For subsequent voice transmissions on a trunk-to channel, the Connect Plus Option Board acts politely. It will not request the radio to transmit if it is aware that another Connect Plus subscriber is already transmitting. When the Option Board determines that it can transmit and sends a transmit request to the radio, the radio will act on the request per its programmed In Call Criteria.

- When the Connect Plus Option Board requests the radio to transmit IP data packets, the radio always executes such requests in a polite manner. It must ascertain the channel is free prior to transmitting. Because the Connect Plus system is in charge of channel assignment, it is unlikely that another radio will already be transmitting on the channel.

2.3.2 Repeater Wake-up Provisioning

Just as in conventional operation, the radio cannot execute a transmit request until it synchronizes with the targeted timeslot. Also as in conventional operation, the radio will attempt to wake-up the repeater (by sending a wake-up message) if it receives a transmit request, but has not yet synchronized with the targeted timeslot. However, the radio rarely has to transmit a wake-up message in Connect Plus operation for the following reasons:

- The Control Channel repeater transmits continuously. This makes the wake-up message unnecessary for the Control Channel.

- When the controller assigns a call to an idle trunk-to repeater, the controller sends an IP message that causes the targeted repeater to activate its downlink for the duration of its SIT timer. By the time the Connect Plus subscriber changes to the assigned channel and timeslot, the repeater will already be transmitting idles. This allows the SU to forego the "wake-up" message and quickly align with the assigned slot.

2.4 Connect Plus Features

2.4.1 Registration & De-Registration

Before a Connect Plus subscriber can make or receive calls on the trunking system, it must successfully register with the XRC 9000 controller. Registration is also prerequisite for data services. The radio user doesn't need to do anything except power-up the unit and select a Connect Plus-enabled zone and channel. The SU automatically searches for a site and, upon detecting an acceptable site and signal, sends the registration request. The registration message exchange between the controller and the Connect Plus SU occurs on the site's Control Channel timeslot. The messages used are special Connect Plus CSBKs. Connect Plus does not use the MOTOTRBO Automatic Registration Service (ARS). In fact, MOTOTRBO CPS automatically disables ARS when "Option Board Trunking" is selected for a CPS personality.

The controller receives the Connect Plus registration request and checks three IDs contained in the registration request. These ID's must be configured into the controller's user database before the registration can be successful.

- Unit ID (also called Radio ID and User ID): Each radio in the Connect Plus system must have a unique[7] Radio ID, which is programmed into the radio with MOTOTRBO CPS. A record for this ID must be created in the controller's user database, and the Record Status must be set to "enabled".

- Each Unit Record in the controller database has a field called, "MOTOTRBO Serial Number". Before the unit can successfully register on the system, its MOTOTRBO S/N must be entered into this field. The MOTOTRBO Serial Number can be obtained by reading the radio with MOTOTRBO CPS, or by removing the battery and looking at the back of the radio. This number is not transmitted over-the-air "as is". Instead, the Connect Plus system converts the MOTOTRBO S/N to another number, known as the Connect Plus ESN, for OTA transmission. This conversion occurs behind the scenes and is transparent to the end user. The controller will not allow a registration request unless the ESN

[7] It is allowed to reuse a Connect Plus repeater radio ID (1 – 15) for a subscriber radio, although this is not recommended.

information transmitted by the SU matches what the controller expects through the programming of the MOTOTRBO Serial Number field on the Unit Record.

- Registration Group ID: For every Connect Plus registration, the registering unit must affiliate with a specific Group ID, known as the Registration Group ID (sometimes called the Selected Group ID). The Registration Group ID for each Connect Plus channel knob position (portable) or channel rocker position (mobile) is selected when programming the SU with Connect Plus CPS. Upon receiving the registration request, the controller checks this ID with its user database. There must be a record for the Group ID in the user database, and the Record Status must be set to "enabled". If the "Site All Call ID" is selected as the Registration Group, it is not necessary to create a record for this group, since it is already hard-coded into the controller.

If all of the IDs are valid in the database, the controller sends an affirmative response to accept the registration. The SU provides a successful registration tone to the radio user, which indicates that the SU is ready to make and receive calls. If any of the IDs are unknown or marked as "disabled", the controller rejects the registration by sending a response that disables the registering unit and causes the radio to provide the "disabled" tone to the radio user. See the section on "Control Channel CSBK Data Calls" for more information on "Disable" and "Enable".

The Connect Plus registration process has two main purposes: (1) It limits system access to authorized users, and (2) It provides the controller with the important information it needs to properly route calls and efficiently utilize RF and IP bandwidth. All of the following events cause a Connect Plus radio to transmit a registration request to the site controller:

- The Connect Plus SU will request registration after power-up.
- The Connect Plus SU will request registration when the radio user selects (or changes) a Connect Plus zone.
- The Connect Plus SU will request registration when it changes sites.
- The Connect Plus SU will request registration when it loses signal from a Connect Plus site, and then reacquires the same site after an extended period of fade.
- The Connect Plus SU will request registration when the radio user changes the position of the channel knob (portable) or the channel rocker (mobile). This requirement assures that the controller will affiliate the SU with the "Registration Talk Group" that has been programmed for each knob or channel rocker position.

The process of de-registration is also important because it tells the controller which SU's and Talk Groups no longer require system resources. The following events cause the controller to adjust its list of registered units:

- The controller adjusts its registration lists with each new registration request by the SU.
- The controller will de-register the unit from its former site when it registers with a new site.
- The controller de-registers the unit from its previous Talk Group affiliation when the SU registers with a different Talk Group.
- The controller adjusts its registration lists whenever a unit is de-registered from the network. There are two events that cause the controller to de-register a SU from the Connect Plus network:

- When the Unit is selected to a Connect Plus zone and registered to a site, and the radio user powers the radio down, the SU will automatically send a de-registration message on Control Channel timeslot prior to shutting off. If the controller decodes the message, it de-registers the SU from the network.

- The controller sends one or more controller-initiated Radio Checks to the SU after a period of inactivity and the SU fails to respond to any of the Radio Check attempts. The purpose of controller-initiated radio check is to identify and de-register units that no longer require system resources. The controller provides three programmable parameters that affect Control Initiated Radio Check:

    - The controller provides a programmable parameter called “SU Inactivity Time”. The timer is set on a site-wide basis, but is tracked for each individual SU. The timer is reset whenever an SU registers, sends a call request, keys-up during a voice call, or acknowledges a Control Channel Message. If the timer expires, the Controller schedules a Controller Initiated Radio Check at the earliest opportunity.

    - When the “SU Inactivity Timer” expires, the Controller will send at least one Controller Initiated Radio Check. Whether it sends additional retries depends on the value configured into the controller’s of “CSBK Call Retries” parameter (0-4). If the controller is programmed for retries, the interval between retries is determined by the “CSBK Call Retry Interval” setting. The target SU must acknowledge the Controller Initiated Radio Check to remain registered to the site. If the Controller finishes its Radio Check attempt (and any programmed retries), and receives no SU acknowledgement, the controller will de-register the SU from the network and decrement the number of unit’s registered to it’s “Registration Talk Group” by one.

2.4.2 Receiving & Validating Call Requests

The SU sends all Call Requests on the Control Channel timeslot. Upon receiving a Call Request, the controller performs several checks before it responds to the request. Every Call Request contains two Connect Plus IDs – the Source ID and the Destination ID. The Source ID is the Unit ID for the initiating radio. The Destination ID can be another Unit ID or a Group ID, depending on the type of call that is being requested. The controller checks whether there are records for both IDs in the user database, and that both IDs are configured as “enabled”. If the Source ID is not present or is “disabled” in the database, the controller denies the call request and disables the initiating unit. If the Destination ID is not present or is “disabled” in the database, or if there are insufficient privileges required for the call type, the controller denies the call request, but it does not disable the initiating unit.

If the IDs are valid, and all required privileges are in order, the controller checks calls currently in progress. The purposes of this check are (1) to see if the Destination ID is already active in a call and (2) for calls requiring a trunk-to timeslot – to see if a resource is currently available. If the controller sees that the Destination ID is already active in call, a response to this effect is returned to the source SU and the radio user will have to try again later. If a trunk-to timeslot is needed, but none is available, the controller informs the source SU that its call has been placed in the Busy Queue. If there are no problems with any of these checks, the controller proceeds with call set-up. The call set-up procedure varies depending on the call type, of which there are different categories for Connect Plus:

- Voice Calls that require no Control Channel acknowledgement from the Destination Radio(s)
- Voice Calls that require Control Channel acknowledgement from the Destination Radio(s)
- CSBK Control Channel Data Calls
- Trunk-to Channel IP Data Calls

2.4.3 Voice Calls with No Control Channel Acknowledgement

Calls in this category include Group Calls, Multigroup Calls and Site All Call (voice). All of these calls do not require a Control Channel acknowledgement from the target radio.

- **Group Call**: One or more voice transmissions heard by all available radios that are programmed with and registered to the same Talk Group ID. Group Calls are message trunking. At release of PTT the assigned trunk-to timeslot enters the Group Call Hang Time for a period of time determined through repeater programming. During the Group Call Hang Time, any Group member may transmit on the same trunk-to timeslot. If the Hang Time expires with no further transmissions the call ends. Radios already involved in a previous call on another timeslot will not be aware of the Group Call transmission(s).

- **Multigroup Call**: A one-way voice transmission heard by all available radios that are programmed with the same Multigroup ID. To initiate a Multigroup Call, the SU must have the “Multigroup Initiation” privilege on its SU record in the controller database. At release of PTT the assigned trunk-to timeslot enters the Group Call Hang Time for a period of time determined through repeater programming. During the Group Call Hang Time, only the call initiator may transmit again. If the Hang Time expires with no further transmissions the call ends. Radios already involved in a previous call on another timeslot will not be aware of the Multigroup transmission(s).

- **Site All Call (Voice):** A one-way voice transmission heard by all available radios registered to the same site where the transmission occurs. To initiate a Site All Call voice transmission, the SU must have the “Site All Call Initiation” privilege on its SU record in the controller database. At release of PTT the call ends immediately. There is no Call Hang Time. Radios already involved in a previous call on another timeslot will not be aware of the Site All Call transmission(s).

For these call types, the controller sends a Channel Grant assigning the Source and Destination IDs to a trunk-to timeslot. As long as the call is active on the trunk-to timeslot, the controller will periodically re-send the Channel Grant on the Control Channel timeslot. The repeated Channel Grants are sent for the benefit of late-joiners and radios that return to the Control Channel timeslot before the call ends due to fade. Figure 2-1 provides an example of a Group Call Initiation process.

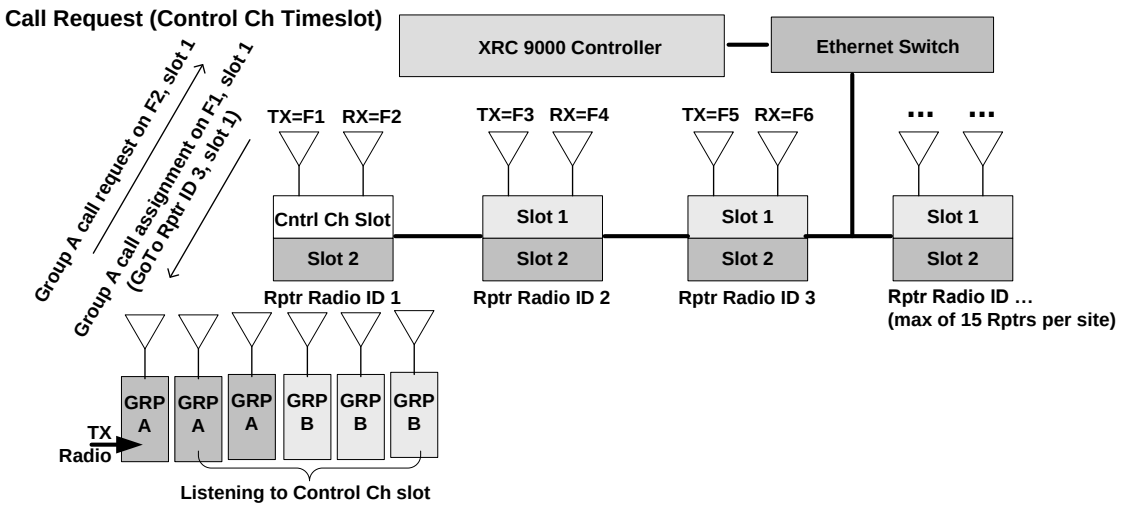


Figure 2-1 Group Call Initiation Example

2.4.4 Voice Calls Requiring a Control Channel Acknowledgement

Calls in this category include Private Calls and Remote Monitor. All of these calls require a Control Channel acknowledgement from the target radio.

- **Private Call:** One or more voice transmissions between two specific radios; the Source SU and the Destination SU. In MOTOTRBO digital conventional operation, Private Calls can be configured as "confirmed" or "unconfirmed" based on MOTOTRBO programming. In Connect Plus, a Private Call always requires a Control Channel acknowledgement from the destination SU before the controller will assign a trunk-to timeslot. In this sense, Connect Plus Private Calls are always confirmed. However, the "Private Call Confirmed" checkbox must not be enabled for any Connect Plus channel via MOTOTRBO CPS. This requirement prevents the participating radios from performing an additional and unnecessary CSBK exchange on the trunk-to timeslot prior to transmitting voice. In order for a Connect Plus Private Call to take place; all of the following must occur: (a) The Source ID must be enabled for the "Private Call Initiation" privilege on its SU Record in the controller database, (b) The Destination ID must be enabled for the "Private Call Receive" privilege on its SU Record in the controller database, (c) the Destination SU must be registered to a network site and not currently busy in a call, and (d) the Destination SU must acknowledge a Control Channel query before the controller will assign a trunk-to timeslot for the call. Private Calls are message trunking. At release of PTT the assigned trunk-to timeslot enters the Private Call Hang Time for a period of time determined through repeater programming. During the Private Call Hang Time, either party may transmit on the same trunk-to timeslot. If the Hang Time expires with no further transmissions the call ends.

- **Remote Monitor:** The Remote Monitor feature allows a remote user to activate a target radio's microphone and transmitter for a period of time. A call is silently set up on the target radio, and its PTT is controlled remotely without any indications given to the end user. The duration that the target radio transmits after receiving a Remote Monitor command is set in the target radio through Connect Plus CPS programming. When receiving the Remote Monitor command, the target radio initiates a single, one-way Private Call voice

transmission back to the originator of the Remote Monitor command. This feature is used to ascertain the situation of a target radio which is powered-on, but is unresponsive. This is beneficial in a number of situations including theft, incapacity of the radio user, or other situations necessitating a “hands-free” transmission. In order for Remote Monitor to take place; all of the following must occur: (a) The Source ID must be enabled for the “Remote Monitor Initiation” privilege on its SU Record in the controller database, (b) The Destination ID must be enabled for the “Remote Monitor Receive” privilege on its SU Record in the controller database, (c) the Destination SU must be registered to a network site and not currently busy in a call, and (d) the Destination SU must acknowledge a Control Channel query before the controller will assign a trunk-to timeslot for the Remote Monitor transmission.

For these call types, the controller repeats the Call Request CSBK on the Control Channel downlink as a query for the Destination SU. The Destination SU must send acknowledgement on the Control Channel uplink before the call assignment can proceed. If the Control Channel does not receive acknowledgement from the Destination SU, it looks to its programmable “CSBK Call Retry” parameter to see how many times it should resend the Call Request on the Control Channel downlink. If the controller receives no acknowledgement to any of these attempts, it sends a Negative Response to the source SU, which then informs the radio user that the call attempt was not successful. Once the controller receives acknowledgment from the Destination SU, it assigns a trunk-to timeslot for the voice call to proceed.

2.4.5 Other Voice Call Features

The following features are inherent to all Connect Plus Voice Calls:

- **Connect Plus Scan (responding to assigned calls):** When a registered Connect Plus SU is not involved in a call, it listens to all messages transmitted on the Control Channel timeslot. If it decodes any of the call assignments listed below, it responds by moving to the assigned channel and timeslot and joining the call. It will remain on the assigned trunk-to timeslot until the call ends, at which point the Connect Plus SU returns to the Control Channel timeslot. The Connect Plus SU responds to the following call assignments on a first-come, first served basis. In other words, it will not ignore one of these call assignments while it awaits another. Furthermore, while the Connect Plus SU is on the trunk-to timeslot, it will not be aware of (or respond to) Control Channel messages for other calls. Once the Connect Plus SU transitions back to the Control Channel it will respond to the following events:
    - The Connect Plus SU will respond to a call assignment targeting its Unit ID
    - The Connect Plus SU will respond to a call assignment targeting its “Registration Group ID” (sometimes called the Selected Group ID)
    - The Connect Plus SU will respond to a call assignment targeting its Multigroup ID (if configured with a Multigroup ID).
    - The Connect Plus SU will respond to a call assignment targeting the Site All Call ID.
    - The Connect Plus SU will respond to an Emergency Call targeting its Default Emergency Revert Group ID (if configured for a Default Emergency Revert Group).

If the Connect Plus is currently registered to its “Preferred Site” (as configured for the current Connect Plus zone with MOTOTRBO Connect Plus Option Board CPS), it will respond to any

Group ID is that is a currently enabled member of the configurable scan list programmed with MOTOTRBO Connect Plus Option Board CPS. For more information on configurable scan options for the Connect Plus SU, see "Group Scan in Connect Plus System".

- **Late entry for voice Calls:** For as long as a voice call continues on a trunk-to timeslot, the Control Channel will periodically repeat the call assignment message on the control channel timeslot. This supports late entry for the following circumstances:
    - A radio that registers after the call started can join the call late.
    - A radio that returned to the Control Channel from another call can join the call late.
    - A radio that faded from the call and returned to the Control Channel will attempt to rejoin the call.

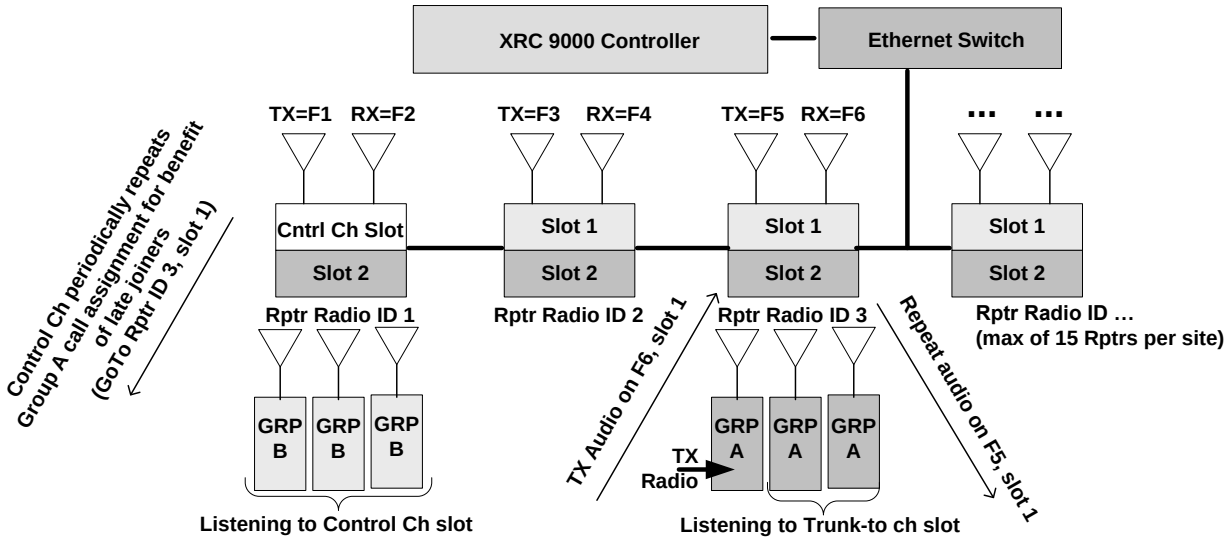


Figure 2-2 Late Entry Example

- **PTT ID and Aliasing:** This feature allows the target radio to identify the originator of a call. If programmed with the Connect Plus CPS, a user friendly alphanumeric name or "alias" can also be displayed. These user friendly aliases are also used when initiating voice calls and digital signaling features. The alias information in the transmitting radio should correspond with the alias information in the receiving radio. The transmitting radio ID is sent over the air and, if there is an alias for that ID in the receiving radio, the receiving radio displays the alias. If no alias is configured at the receiving radio for that ID, then only the transmitting radio's SUID is shown.

- **Call Hang Time**: When radios move to a trunk-to timeslot to participate in a voice call, the Call Hang Time allows an opportunity for talk-back using the same Call ID, without having to return to the Control Channel to request a new call. Besides providing an opportunity for talk-back on the assigned timeslot, the Call Hang Time helps provide continuity to the conversation and prevents the channel from being assigned to another call. The Call Hang Time is configurable per call type for "Group Call", "Private Call" and "Emergency Call". For Connect Plus releases prior to Release 1.1, the Call Hang Time settings are programmed into the repeater via MOTOTRBO CPS. Beginning with Connect Plus Release 1.1, the Call

Hang Time values programmed with MOTOTRBO CPS will be overwritten by the XRC 9000 when it establishes its link with the repeater. In doing so, the XRC 9000 uses the Call Hang Time values that have been programmed with the MOTOTRBO Connect Plus Network Manager. The repeater will use the Network Manager-configured values as long as it maintains its connection to the XRC 9000. Connect Plus does not recommend or support a value of zero for any Call Hang Time. Furthermore, the radio System Administrator must assure that the value chosen for each Call Hang Time setting is programmed the same into each Connect Plus repeater and site network-wide. The Hang Time starts at the end of a voice transmission (either due to release of PTT or fade by the transmitting radio). During the Call Hang Time, other parties in the call may transmit. If the Hang Time expires with no further transmission, the call is considered to be over and radios participating in the call return to the Control Channel timeslot. If a radio user presses PTT after the Hang Time expires, a new voice call will be started using the radio's selected Contact Name, which may be a different ID than the call which just expired. Multigroup Calls use the Group Call Hang Time, but only the initiating radio is allowed to key-up during the Call Hang Time for a Multigroup Call. Site All Call does not use a Hang Time. The call terminates when the first (and only) transmission by the initiating radio is finished.

2.4.6 Control Channel CSBK Data Calls

Calls in this category include Radio Check, Call Alert, Radio Disable, and Radio Enable. They are also known as "Command and Control" call features.

- **Radio Check:** The Radio Check feature checks if a radio is active in a system without notifying the user of the target radio. Besides the Busy LED, there is no other audible or visual indication on the checked radio. The receiving radio automatically and silently responds with an acknowledgement to the initiating radio. This feature is used to discreetly determine if a target radio is available. For example, if a radio user is non-responsive, Radio Check could be used to determine if the target radio is switched on and monitoring the channel. If the target radio responds with an acknowledgement, the initiator could then take additional action such as using the Remote Monitor command to activate the target radio's PTT. If the target radio is not reachable the initiator will receive an indication that the party is not available. The Radio Check message exchange takes place entirely on the Control Channel timeslot. To initiate a Radio Check, the SU must have the "Radio Check Initiation" privilege on its SU record in the controller database. "Controller-initiated Radio Check" is an automatic system feature that the controller uses to determine whether or not an inactive SU should remain registered to the site. Both the SU Inactivity Time and the number of required retries prior to de-registering the SU are programmable settings in the controller.

- **Call Alert:** The Call Alert feature allows a radio user to essentially page another user. To initiate a Call Alert, the SU must have the "Call Alert Initiation" privilege on its SU record in the controller database. When a radio receives a Call Alert, a persistent audible and visual alert is presented to the user. The initiator of the Call Alert is also displayed. If a user is away from his radio at the time of the reception, the alert remains until the user clears the Call Alert screen. If the user presses the PTT while the Call Alert screen is active, he/she starts a Private Call to the originator of the Call Alert provided the radio has Private Call Initiation privilege on its SU Record.

- **Radio Disable:** This feature allows for a radio, typically in a supervisory role, to disable another radio via over the air signaling. The Radio Disable feature can be used to stop an inappropriate use of a radio, or to prevent a stolen radio from making or receiving calls. All messaging related to the Disable feature occurs on the Control Channel timeslot. In order for one radio to remotely disable another, all of the following must occur: (a) The Source ID

must be enabled for the “Disable Command Initiation” privilege on its SU Record in the controller database, (b) The Destination ID must be enabled for the “Disable Command Receive” privilege on its SU Record in the controller database, and (c) the Destination SU must be registered to a network site and not currently busy in a call. When an authorized radio sends the “Disable” command, the controller automatically sets the status on the SU Record to “User Disabled”. This assures that even if the target radio doesn’t hear the Disable Command, it will be disabled by the controller the next time it attempts to register or initiate a call. Upon receiving the Disable Command, the disabled radio sounds the “disabled tone”. If the disabled unit has a display, it shows “Disabled”. A disabled radio is no longer able to make or receive calls in any Connect Plus zone. However, the radio still listens to the Control Channel, responds to certain Control Channel commands, and will search for another site if it loses acceptable signal. Unlike conventional operation, the Disable Command only affects the Connect Plus zones where the command is received. Non-Connect Plus channels are still operable. The radio remains disabled until one of the following occurs: (1) the radio is changed to non-Connect Plus zone, (2) the radio receives a Connect Plus Enable Command in the affected zone, or (3) The SU successfully completes a valid Connect Plus registration. In regards to the latter, the radio will attempt another Connect Plus registration if the user re-cycles power, changes to a Connect Plus zone, or if the radio roams to another Connect Plus site. However, if nothing has changed and SU record is still set to “User Disabled”, the controller will disable the SU again when it attempts to register. The controller will automatically disable a SU if (a) there is no SU Record, or (b) there is an SU Record, but it is set to “Disabled”. Because the SU Record can be set to “User Disabled” via the Network Manger software, the System Administrator can disable any SU via this mechanism. The “Disable Command Receive” privilege only comes into play when the Disable Command is initiated by another radio user.

- **Radio Enable:** This feature allows for a radio, typically in a supervisory role, to Enable another radio via over the air signaling. This assumes, of course, that the target radio was in the disabled condition prior to receiving the Enable command. All messaging related to the Enable feature occurs on the Control Channel timeslot. In order for one radio to remotely Enable another, all of the following must occur: (a) The Source ID must be enabled for the “Enable Command Initiation” privilege on its SU Record in the controller database, (b) The Destination ID must be enabled for the “Enable Command Receive” privilege on its SU Record in the controller database, and (c) the Destination SU must be listening to a network site and within range of Control Channel signaling. When an authorized radio sends the “Enable” command, the controller automatically sets the status on the SU Record to “User Enabled”. This assures that even if the target radio doesn’t hear the Enable Command, it will be enabled by the controller the next time it attempts to register. (The radio will make a registration attempt if (a) the user recycles power, (b) the user changes into a Connect Plus zone, or (b) the radio attempts to Roam to another Connect Plus site.) Upon receiving the Enable Command, the target radio resumes normal operation. Because the SU Record can be set to “User Enabled” via the Network Manger software, the System Administrator can Enable any SU via this mechanism. The “Enable Command Receive” privilege only comes into play when the Enable Command is initiated by another radio user.

For these call types, the controller repeats the Call Request CSBK on the controller channel downlink as a query for the Destination SU. The Destination SU must send acknowledgement on the Control Channel uplink and provide the user ergo associated with the call type (or for Radio Check no ergo indication at all). If the Control Channel does not receive acknowledgement from the Destination SU, it looks to its programmable “CSBK Call Retry” parameter to see how many times it should resend the Call Request on the Control Channel downlink. The interval between retries is determined by another programmable controller parameter, the “CSBK Call Retry Interval”. If the controller receives no acknowledgement to any of these attempts, it sends a Negative Response to the source SU, which then informs the radio user that the call attempt was not successful. If the controller receives acknowledgement from the Destination ID, it repeats the

acknowledgement on the Control Channel timeslot. Upon decoding the acknowledgement, the Source SU informs the radio user that the call attempt was successful.

When the SU attempts one of these call types, it will stay with the attempted call until all retries are finished or the call times out. During this time, the radio user will not be able to cancel the current call attempt or initiate a different type of call. To decrease the time that the radio remains in this state, reduce the number of “CSBK Call Retries”.

Note: The “CSBK Call Retry” and “CSBK Call Retry Interval” settings also control the retries when the controller queries the target SU prior to assigning a trunk-to timeslot for a Private Call or Remote Monitor.

2.4.7 Trunk-to Timeslot IP Data Calls

For these types of calls, the controller sends a control channel message that assigns the Destination ID(s) to a trunk-to timeslot for the IP data exchange between the controller and the SU(s). Calls that fall into this category include Text Messages, GPS Location Updates, and Over-the-air File Transfer. For more information, see Connect Plus Integrated Data.

2.4.8 Connect Plus Integrated Data

Just as in other MOTOTRBO digital modes, a Connect Plus radio can be used as an integrated voice and data unit.

While Connect Plus offers many of the same data features available in other digital modes – such as Text Messaging and GPS Location Updates – there are some differences in configuration and operation, which will be discussed in the sections that follow. There will also be a discussion of Over-the-air File transfer, an integrated data feature that is only available in Connect Plus mode.

2.4.9 Connect Plus Digital Emergency

Emergency is a special type of Group Call that is used for urgent communications during a crisis situation. Because the type of event that prompts an Emergency Call varies from one organization to another, it is the responsibility of the company or agency to define the circumstances that constitute an emergency, to train radio users regarding emergency communications procedures, and to conduct drills using the Emergency feature.

The XRC 9000 controller and the Connect Plus SU treat emergency calls in special ways. The controller, for example, gives Emergency the highest priority when assigning calls from the Busy Queue. The Connect Plus SU, for its part, allows the Emergency button press in circumstances where would it not allow a normal PTT – such as when the radio is Searching for service and not currently registered to any site. Although the SU will not be able to immediately send the Emergency Call Request in this scenario, it will buffer the request until it successfully registers with a Connect Plus site, after which the SU will immediately and automatically transmit the Emergency Call Request. When a receiving radio sees that Emergency has been invoked on a Group ID of interest, the Connect Plus SU employs special ergonomics to inform the radio user of the emergency condition.

2.4.9.1 Connect Plus Emergency Features

Just as in other MOTOTRBO digital modes, Connect Plus Emergency is really a set of features designed to facilitate emergency communications.

Connect Plus shares many of the same emergency features as other MOTOTRBO modes. These include the following:

- The ability to signal an emergency condition by pressing a configurable emergency button or pressing an emergency footswitch. The configurable button is available for both portables and mobiles. The footswitch is a purchasable accessory, and is available for mobiles only.

- Configurable options to determine SU operation when initiating an emergency call, including the following:

    - A programmable option to start the emergency call with “regular” or “silent” ergo from the initiating radio. Silent Emergency provides a means to suppress all indications of the emergency status on the initiating radio. This feature is valuable in situations where an indication of an emergency state is not desirable. Once the radio user breaks radio silence by pressing the PTT and speaking, the Silent Emergency ends, and audible and visual indications return.

    - A programmable option to send voice only upon PTT (Emergency Call), or to start the call with an automatic “Hot Mic” key-up by the initiating radio (Emergency Call with Voice to Follow). When selecting the latter option, the Hot Mic duration is controlled by a programmable timer.

    - A programmable option to send the Emergency on the selected Group ID, or on a specific Emergency Revert Group ID.

- Programmable Options to determine how a radio unit receives an Emergency Call. These options provide the following capability:

    - The ability to provide special ergo for the radio display. The special display ergo can be configured to automatically stop when the Emergency Call ends, or persist until manually cleared by the radio user.

    - The ability to provide a special Emergency Alert Tone that will persist until manually cleared by the radio user.

    - The ability to forego all special receive ergo so that Emergency Calls will be received in the same manner as other Group Calls.

- A configurable Emergency Hang Timer that can be set longer than the Group Call Hang Time and Private Call Hang Time, if desired. For Connect Plus Release 1.0A, the Emergency Hang Time is configured into the repeater with MOTOTRBO CPS. Beginning with Connect Plus Release 1.1, the Emergency Call Hang Time value that is programmed with MOTOTRBO CPS will be overwritten by the XRC 9000 when it establishes its link with the repeater. In doing so, the XRC 9000 uses the Emergency Call Hang Time value that has been programmed with the MOTOTRBO Connect Plus Network Manager. The repeater will use the Network Manager-configured value as long as it maintains its connection to the XRC 9000.

- The ability to send a special type of Location Update at the end of the Emergency Call. (Just as in other digital modes, this requires the involvement of a Location Tracking Application that must request the emergency update for an “SU of interest” prior to the emergency.)

In addition to the above features shared with other MOTOTRBO digital modes, Connect Plus also provides several emergency enhancements due to fact that it is a networked, trunking system. The Connect Plus emergency enhancements include the following:

- The XRC 9000 controller provides an individual acknowledgement to each emergency initiator, and it maintains an accessible list of all emergency initiators. The information – such as call initiator, talk group, and duration – on the ongoing Emergency Calls can be viewed in the Network Manager.

- The XRC 9000 controller assigns the repeater and timeslot used for the Emergency Call.

- When no repeater and timeslot is immediately available, the XRC 9000 controller places Emergency Calls at the top of the Busy Queue. Emergency Call receives the highest priority when assigning the next available slot.

- When an SU is configured with a “Default Emergency Talk Group ID” on its user record in the controller database, the XRC 9000 assures that audio for this group is routed to the SU’s registered site.

- If the Connect Plus SU receives no response to its Emergency Request from the registered site, it automatically searches for another network site so that it may continue its Emergency attempts.

2.4.9.2 Digital Emergency in Connect Plus vs. non-Connect Plus Mode

While there are many similarities between how Digital Emergency operates in Connect Plus and non-Connect Plus modes, there are also some differences. Most of these differences are due to one of the following reasons; (1) Connect Plus is a trunked radio system where ultimate responsibility for assigning emergency calls lies with the XRC 9000 site controller and (2) Emergency operation in the Connect Plus SU is largely controlled by logic residing in the Connect Plus Option Board. For this reason, the SU’s emergency settings are programmed using MOTOTRBO Connect Plus Option Board CPS.

The most important differences between Connect Plus and other MOTOTRBO digital modes are as follows:

Role of Connect Plus Option Board CPS: When the radio user has selected a Connect Plus zone and channel, the emergency operation is determined by the emergency settings that have been configured with MOTOTRBO Connect Plus Option Board CPS. The MOTOTRBO CPS Emergency Settings are not used in Connect Plus. Those settings affect only the non-Connect Plus digital channels. While there are many similarities between the Emergency settings in the two programs, there are also a few differences. These are discussed in greater detail in Section 4.

Role of the XRC 9000 Controller: In non-Connect Plus digital modes, the SU selects the repeater and slot for Emergency based on its MOTOTRBO CPS programming. In Connect Plus, the SU sends an Emergency Call Request to the XRC 9000 controller on the Control Channel timeslot. The XRC 9000 acknowledges the emergency, and assigns the repeater and slot for the emergency

call from its pool of available channels. If the site is currently busy, the call is placed in the Busy Queue. Emergency calls receive the highest priority when assigning the next available slot.

Emergency Revert: In non-Connect Plus digital modes, the SU's "Emergency Revert Channel" programmable setting determines not only which Group will be used for the emergency, but also the site, repeater and slot. In Connect Plus mode, the MOTOTRBO Option Board Connect Plus CPS "Default Emergency Revert Group" setting determines which Group ID will be used for emergency, but the repeater and slot is always assigned by the XRC 9000 controller of the SU's registered site.

Emergency Alarm: In non-Connect Plus digital modes, it is possible to configure the SU to send an Emergency Alarm only, with no Emergency Call to follow. This option is not available in Connect Plus. In Connect Plus, pressing the "Emergency On" Button always tells the radio to request an Emergency Call. Other differences in Emergency Alarm functionality are as follows:

- In other digital modes, the SU's "Emergency Alarm" receive ergo starts when the receiving radio decodes the Emergency Alarm transmitted by the Source SU. In Connect Plus, the "Emergency Alert tone" ergo is prompted by the controller's downlink message to acknowledge the emergency and assign the channel and slot. This distinction is fairly minor, however, since the emergency receive ergo on the Connect Plus SU is very similar to non-Connect Plus digital modes.

- In other digital modes, the SU's emergency alarm is acknowledged by an authorized supervisor radio. If the authorized supervisor radio is not listening to the emergency channel, or is not currently within range of the system, the Emergency Alarm can go unacknowledged. In Connect Plus, the XRC 9000 controller individually acknowledges each and every Emergency Call Request heard by the system. Over-the-air acknowledgement by other radios is neither required, nor supported, in Connect Plus.

- In other digital modes a supervisor radio keeps a list of multiple Emergency Alarms from different radios provided that (a) the Alarm is heard by the supervisor radio and (b) the Alarm ergo is not cleared by the radio user. In Connect Plus, only the XRC 9000 controller is assured of hearing all Emergency Call Requests received by the system. Therefore, it is each controller's responsibility to keep a list of all SU's that have transmitted notification of an emergency condition on its site. The list remains in the controller, even when the emergency is over.

Cancelling Emergency Calls and exiting Emergency Mode: In other digital modes, when an SU is configured for Emergency Call, and when the user presses the "Emergency On" button the radio remains in Emergency Call mode until the user presses the "Emergency Off" button. This can be for seconds, minutes, hours, or even days. Until the "Emergency Off" button is pressed, every press of PTT results in a new emergency call. In Connect Plus, the SU automatically exits Emergency Call mode at the completion of the emergency call. (In other words, after the channel and slot have been assigned and then the Emergency Hang Time expires with no further transmissions.) If the radio user feels that the emergency condition still persists after the Emergency call ends, he/she should press the Emergency button again to re-initiate the process.

There is also a difference in how the Emergency Off button operates in Connect Plus. In other digital modes, the radio user can press Emergency Off at any time, which makes the radio immediately exit Emergency Call mode. In Connect Plus, the radio will stay in Emergency Call mode until the completion of its assigned emergency call ends and the Emergency Call Hang Time expires with no other key-ups. Pressing the "Emergency Off" button during the Emergency Call will not make the radio exit Emergency Call mode any sooner. Neither will it terminate an Emergency Hot Mic transmission prior to expiration of the programmable timer for "Hot Mic Duration". In Connect Plus, the primary function of the Emergency Off button is to prevent the radio from

transmitting an Emergency Call request in circumstances where the request cannot be immediately sent (such as when the user presses Emergency On while the radio is "Searching"). Once the radio has transmitted an Emergency Call Request to a site, the radio user cannot cancel the Emergency Call by pressing "Emergency Off". Furthermore, in most normal scenarios it isn't possible to cancel Emergency prior to the SU transmitting the Emergency Call Request. This is because the SU normally transmits the Emergency Call Request within milliseconds after the radio user presses "Emergency On". Once the XRC 9000 decodes an Emergency Call Request, it's not possible to cancel the controller's Emergency Response. Since other radios will be alerted of the emergency condition, it is best to proceed with the call and let the radio user verbally explain that the situation is not an actual emergency. The Emergency Call can then be allowed to expire with no further transmissions.

For more information on Connect Plus Emergency Calls, see "Emergency Calls in Connect Plus" in section 4, which addresses the following topics:

- Making an Emergency Call in Connect Plus
- Emergency Calls on the SU's Multigroup ID
- Programmable Emergency Settings in MOTOTRBO Option Board Connect Plus CPS
- Programmable Emergency Settings in MOTOTRBO Connect Plus Network Manager
- Programming the repeater's Emergency Call Hang Time
- Emergency Handling Considerations
- Conducting Emergency Drills

For more information on Connect Plus Emergency Location Update, see section "Emergency Location Update".

2.4.10 Connect Plus "Man Down" Feature

The Connect Plus Option Board is capable of detecting tilt, movement, and lack of movement. Based on this ability, the Connect Plus Man Down feature can be configured to automatically initiate an Emergency Call from a portable radio when certain conditions are satisfied.

Man Down is a purchasable Connect Plus feature that allows organizations to meet their individual communication needs over and above the standard products feature set. The Man Down features work 'silently' in the background, enabling the user to utilize his/her portable radio as normal. The Man Down feature set is available for portable radio models with and without displays. It is not available for mobile radios.

The Man Down feature set has been developed for a variety of situations, and in particular where radio users work alone, in isolated environments or in hazardous areas. Radio users that can benefit from this feature set include security guards in commercial buildings, forestry workers, agricultural workers, utility workers, and industrial plant workers.

Pre-requisites to utilizing Man Down

The following are pre-requisites for utilizing the Man Down feature set:

1. The Connect Plus Man Down purchasable feature must be enabled in the subscriber unit before the radio can utilize the Man Down feature set. The feature can be purchased through the Motorola Online (MOL) website. After purchasing the feature, an Entitlement ID (EID) will be issued. The EID is used when activating the feature in the subscriber radio with MOTOTRBO CPS. After enabling the Connect Plus Man Down feature with MOTOTRBO CPS, it is necessary to recycle power on the radio. Upon power-up, the

Option Board discovers that the Man Down is now enabled. **Important**: Do not enable the Connect Plus Man Down feature until the Option Board firmware has been upgraded to Connect Plus Release 1.1 (or later). If the Man Down feature is enabled prior to upgrading the Option Board firmware, the next time the radio is powered up in a Connect Plus zone (or a Connect Plus zone change occurs) the LED will blink red, the radio will play a momentary tone, and the display will show "*Connect Plus Unauthorized*". Upgrading the Option Board firmware to Connect Plus Release 1.1 (or later) should return the Option Board to normal operation.

2. Subscriber radio firmware must be MOTOTRBO System Release 1.8, or later.
3. Connect Plus Option Board firmware must be Connect Plus Release 1.1, or later.
4. When programming the Connect Plus Option Board with MOTOTRBO Connect Plus CPS, the Emergency Type must be set to Regular, Silent, or Silent with voice. This is configurable per Connect Plus zone.
5. The Man Down parameters must be configured per customer requirements. The Man Down settings are configurable per Connect Plus zone.

How Movement Type can be configured to automatically initiate an Emergency Call

The **Movement Type** setting determines which movement and/or angle conditions will cause the radio to automatically initiate an Emergency Call:

- **None**: This indicates that no Movement Type has been selected, and the radio will not automatically initiate an Emergency Call due to the Man Down feature set.
- **Tilt Alarm**: When the portable radio is tilted at or beyond the configured Activation Angle, it starts a configurable timer. If the configurable timer expires, and if the portable radio is still tilted at or beyond the configured angle, a second timer starts and the radio sounds an Alert Tone (if so configured). If the second timer expires, and if the portable radio is still tilted at or beyond the configured angle, the radio automatically initiates an Emergency Call. The Tilt feature can be used by itself, or in conjunction with the Anti-Movement feature. The Movement feature is not available when Tilt is enabled.
- **Anti-Movement Alarm**: When the portable radio is motionless, it starts a configurable timer. If the configurable timer expires, and if the portable radio is still motionless, a second timer starts and the radio sounds an Alert Tone (if so configured). If the second timer expires, and if the portable radio is still motionless, the radio automatically initiates an Emergency Call. The Anti-Movement feature can be used by itself, or in conjunction with the Tilt feature. The Movement feature is not available when Anti-Movement is enabled.
- **Movement Alarm**: When the portable radio senses movement, it starts a configurable timer. If the configurable timer expires, and if the portable radio is still moving, a second timer starts and the radio sounds an Alert Tone (if so configured). If the second timer expires, and if the portable radio is still in motion, the radio automatically initiates an Emergency Call. The Tilt and Anti-Movement features are not available when the Movement feature is enabled.

When the Connect Plus portable radio automatically initiates an Emergency Call due to one of the Movement Type features, the Emergency Type, Emergency Mode, Emergency Revert Group, the number of Emergency Attempts, and the Hot Mic duration (if applicable) are determined by the Emergency settings configured with Connect Plus CPS for the selected Connect Plus zone.

Note: Acceleration or negative acceleration (deceleration) is detected as movement. Steady, uniform movement over a period of time is not detected as movement, and may be interpreted as lack of movement.

Preventing the radio from automatically initiating an Emergency Call

There are several ways that the radio user can prevent the radio from automatically initiating an Emergency Call due to a Movement Type feature:

1. Correct the triggering event before both the Alarm Tone Delay Time and Alarm Activation Time expire.
    a. If the Tilt feature is the triggering event, return the radio to the vertical position. (The radio doesn't have to be perfectly vertical, but it must be tilted less than the configured activation angle).
    b. If the Anti-Movement feature is the triggering event, move the radio.
    c. If the Movement feature is the triggering event, stop the radio's motion.
2. Turn the Man Down features off via a programmable button and/or Utilities Menu Option.
3. Reset the Man Down features via a programmable button and/or Utilities Menu Option. This stops any active Alert tone and resets the Movement Type timers. It does not turn the Man Down features off.

Audible and Visual Beacon

To assist a search team in the rescue, the radio can be configured to emit an audible and visual beacon after it automatically initiates an Emergency Call due to one of the Man Down features. The Beacon feature, which is part of Man Down functionality, has several configurable options.

1. In regards to the type of beacon that will be used, the configurable options are:
    a. No Beacon
    b. Audible Beacon only. The Audible Beacon is a high-pitched, periodic tone that plays approximately once every 10 seconds, but less often if the radio user is talking. The Beacon tone is temporarily suspended while the radio is transmitting.
    c. Audible Beacon plus Visual Beacon. If Visual Beacon is enabled, the backlight illuminates for several seconds when the Beacon tone is played.
2. If Audible Beacon is enabled, there is a programmable option to start the Audible Beacon at maximum speaker volume. This affects all audio heard through the speaker. If the Audible Beacon max volume is disabled, then the Audible Beacon volume is determined by the current volume knob setting. (Even if the Audible Beacon starts at max volume, it can still be turned down by the radio user.)
3. Connect Plus CPS provides a programmable button and/or Utilities Menu option that can be used to turn the Beacon feature on and off.
4. Connect Plus CPS provides a programmable button and/or Utilities Menu option that can be used to reset the Beacon. This stops the Beacon without turning the Beacon feature off.

Once the Beacon tone starts, it will continue to periodically play until one of the following occurs; (a) the radio user stops or resets the Beacon by using the programmable button or menu option, (b) radio user changes zones, (c) radio is turned off, or (d) battery expires.

2.5 MOTOTRBO CPS Data Configuration

The System Design Section has a thorough discussion of how a Connect Plus radio should be programmed with MOTOTRBO CPS. The following section discusses how MOTOTRBO CPS Data parameters impact Connection operation. Some MOTOTRBO CPS data settings carry through to Connect Plus personalities, operating the same way in Connect Plus as they do in other digital personalities. Other MOTOTRBO CPS data settings affect only non-Connect Plus modes of operation.

Unless specifically stated otherwise, the settings on the following list affect Connect Plus data operation in the same way as they affect other digital modes.

MOTOTRBO CPS Screen	**Setting/Parameter affecting Connect Plus operation**
General Settings	Radio ID. Connect Plus supports Radio IDs in the range of 1 to 16776351. 16776352 through 16776415 are configurable with MOTOTRBO CPS, but must not be used for Connect Plus radios.
General Settings	TX Preamble Duration (In Connect Plus, the TX Preamble precedes IP data transmissions only. It does not precede Connect Plus CSBKs. If the radio is used for Connect Plus operation only, the TX Preamble should be set to zero. If the radio contains non-Connect Plus channels that require a TX preamble, it should be set as short as possible. Otherwise, it may adversely affect Connect Plus operation.)
Network Screen	Radio IP. This is usually left at default setting of 192.168.10.1. Connect Plus will still operate correctly if value is changed.
Network Screen	CAI Network. Must be left at default value of 12.
Network Screen	CAI Group Network. Must be left at default value of 225.
Network Screen	Maximum Transmit PDU Size. Must be set large enough to accommodate the largest text message or LRRP Report transmitted by the radio while operating in a Connect Plus zone. Recommend 500 bytes or larger.
Channel Screen	Compressed UDP Data Header (do NOT enable for Connect Plus personalities)
Channel Screen	Data Call Confirmed Checkbox (Must be enabled for Connect Plus personalities)

Due to the Connect Plus Option Board's role in providing data services, there are some MOTOTRBO CPS parameters that affect non-Connect Plus personalities only. The settings listed in the following table are important for other digital modes, but they have no effect on Connect Plus operation, provided that programmable port numbers are not set to ports already used by Connect Plus Option Board. To avoid conflicts with Connect Plus, the programmer must NOT use any of the following ports for the configurable port settings shown below; 4061, 4062, 4063, 4004.

MOTOTRBO CPS Screen	**Setting/Parameter that does not affect Connect Plus operation**
General Settings	Persistent LRRP Requests: Checkbox labeled "save"
General Settings	Persistent LRRP Requests: Checkbox labeled "delete"

Network Screen	Telemetry UDP Port
Network Screen	“Forward to PC” checkbox
Network Screen	ARS Radio ID
Network Screen	ARS Radio Port
Network Screen	TMS Radio ID
Network Screen	User Defined UDP Port #1
Network Screen	User Defined UDP Port #2
Network Screen	User Defined UDP Port #3
Text Messages	Text Messages (programmed “Quick Text” messages are entered via Connect Plus CPS, not MOTOTRBO CPS)
Telemetry	Settings on these screen are not used in Connect Plus operation
Channel screen	ARS (grayed-out when Option Board trunking is enabled)

2.6 Connect Plus Text Messaging

2.6.1 Text Messaging Services

In many regards, Connect Plus Text Messaging Service (TMS) operates the same as other MOTOTRBO digital modes. This includes all of the following points:

- A radio user can create a text message in one of two ways; Quick text or limited free-form text messages.
- Connect Plus CPS supports entry of 10 Quick Text Messages.
- The Connect Plus user can send a Text Message to a Text Message Dispatch Call ID, to an individual Connect Plus radio, or to a Connect Plus Group ID.
- When receiving a text message, the user is notified of a new message by an icon, display string, and an audible tone if enabled in the codeplug via the Connect Plus CPS.
- A Connect Plus radio can store up to 30 received or sent text messages at a time.
    - The user is notified once the Inbox and sent folder storage becomes full.
    - Once full, subsequent new messages automatically cause the oldest messages to be deleted.
    - Messages are not deleted when the radio is turned off.
- A user can store up to 10 draft text messages in the Drafts folder at a time.
    - Once full, subsequent new drafts automatically cause the oldest draft(s) to be deleted. A user can opt to Send, Edit, or Delete the drafts in the Drafts folder.
    - The user can opt to Save a text message that is being written or edited to the Drafts folder.
    - If a high priority event causes the radio to exit the text message editing screen, the current text message is automatically saved into the Drafts folder.
    - A draft that is sent is deleted from the Drafts folder and stored to the Sent folder.
- The user can scroll through messages stored in the various Text Message folders, and can select a specific message for various options such as delete, forward, reply, etc. Available options vary by folder.
- If the Connect Plus SU receives a text message containing a subject line, the radio will preserve the Subject Line and automatically include it in any reply message. (The subject line is not displayed when the user creates a reply, but it will be seen by the recipient of the reply.)

Non-display and limited display radios have very limited Text Message capability. They can send a Quick Text message (the Quick Text Message, Destination ID, and One-touch-call button

assignment must be configured with Connect Plus CPS), but they cannot send a limited free form text message, or receive a text message.

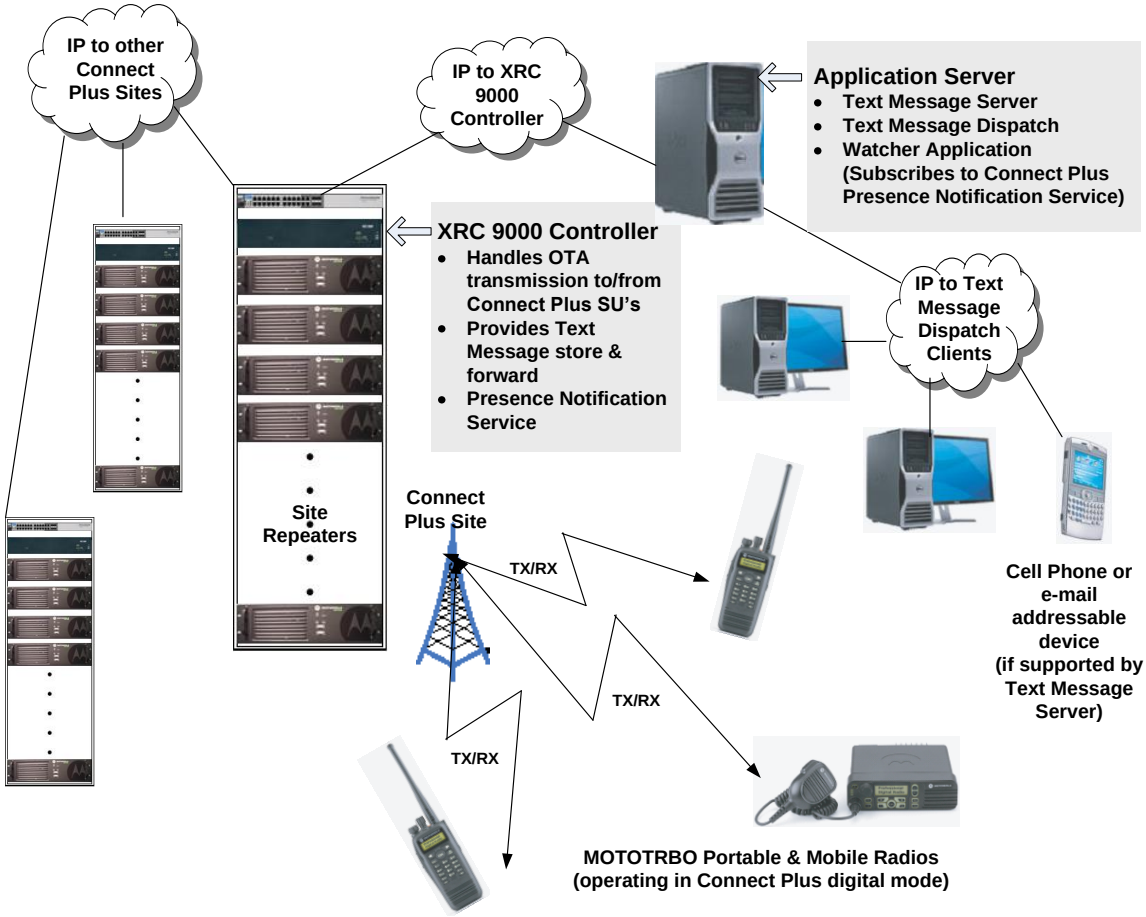


Figure 2-3 Connect Plus Text Messaging Services

Figure 2-3 provides a sample Connect Plus Text Messaging Services configuration. The Text Messaging features are outlined in more detail in the following sections.

2.6.2 Text Messaging features only available in Connect Plus

Connect Plus provides several text messaging features not available in other digital modes:

- **Mail Boxing:** In Connect Plus, text messages are never transmitted directly from one SU to another. Instead, they always pass through the Connect Plus controller. This approach provides significant advantages to the end user. In other digital modes, the text message cannot be successfully sent unless the destination SU is available and listening to the same open channel as the source SU. In Connect Plus, the source SU sends the text message regardless of whether the destination SU is currently available. The controller receives the text message on behalf of the destination SU, places the message in the subscriber's mailbox, and delivers the message at the earliest opportunity. In this regard, the Connect Plus system emulates how text messages are sent on a cellular telephone network. In the controller, each SU has a mailbox that can store up to ten undelivered messages. If a radio or Text Message Service (TMS) Client attempts to send a message to an SU with a full controller mailbox, the source will be notified "mailbox full", and will

have to try again at a later time. Any text message older than 168 hours will be automatically deleted by the controller[8].

- **Store and Forward Capability:** In a multi-site Network, the text message source does not need to know where in the network the destination SU is currently located. The controller will forward the text message to the registered site and attempt delivery at the earliest opportunity. For a text message to an individual SU, the controller requires OTA acknowledgement from the receiving radio. If OTA acknowledgement is not received, the message is re-queued, and delivery is re-attempted at a later time. If the unit changes sites, the controller will forward the message to the new site to attempt delivery. This process continues until the message is acknowledged, or it times out. Text Messages to a Group ID receive no OTA acknowledgement. They are transmitted (in "unconfirmed" mode) at every network site where the Group ID is registered at the time the message is received by the controller.

- **Text Message to a Multigroup ID:** When the Source radio has been configured with the proper initiation privilege, Connect Plus supports text message transmission to a Multigroup ID. The text message will be sent to all SU's network-wide that share the same Multigroup ID, and who are not already occupied in another call-in-progress. Like all Text Messages to a Group ID, the text message is transmitted "unconfirmed".

- **Text Message to a Site All Call ID:** When the Source radio has been configured with the proper initiation privilege, Connect Plus supports text message transmission to a special Site All Call ID. The text message will be sent to all SU's that are currently registered to the same site where the source radio is located, and who are not already occupied in another call-in-progress. Like all Text Messages to a Group ID, the text message is transmitted "unconfirmed".

2.6.3 Text Message Transmission & Delivery

In other MOTOTRBO digital modes, a Text Message to a Group ID is always sent "unconfirmed" and a Text Message to an Individual (Unit) ID can be sent "confirmed" or "unconfirmed", depending on CPS programming. Connect Plus also uses "unconfirmed" delivery for Text Messages to a Group ID, but it always uses "confirmed" delivery for individual ID's. For this reason, the "Data Call Confirmed" checkbox must always be enabled for Connect Plus channels via MOTOTRBO CPS. However, note that "confirmed" delivery does not imply end-to-end confirmation from the source to the target SU. The confirmation is from the controller to the source SU.

In other digital modes, text messages are always transmitted directly from the source SU to one or more destination SU's. In Connect Plus, text messages are never transmitted directly from one SU to another. They always go through the Connect Plus controller. This means that Connect Plus text message transfer is a two-step process. In the first step, the Source SU requests an available timeslot for text message transmission. The controller assigns a trunk-to timeslot. The Source SU moves to the trunk-to timeslot and transmits the text message to the controller as an IP datagram. The controller receives the text message on behalf of the destination SU, and places the message in the subscriber's mailbox. The controller sends OTA acknowledgement upon receiving the message, and the source SU displays, "Message Sent".

[8] This is not a configurable option for the current release.

When a timeslot and the Destination ID are both available, the controller initiates the second step in the process, text message delivery, by sending a Control Channel message to assign the trunk-to timeslot. On the trunk-to timeslot, the controller delivers the text message(s) to the Destination ID. When the controller delivers a text message to an individual ID, it expects to receive OTA acknowledgement for each transmitted message. If OTA acknowledgement is not received, the message is re-queued, and the controller re-attempts delivery at a later time. For text messages to a Group ID, the controller does not expect to receive OTA acknowledgement since the message is transmitted in "unconfirmed" mode.

2.6.4 Controller Programming for Text Messaging Services

The XRC 9000 controller has several parameters that affect Text Messaging. These are configured with the **MOTOTRBO™ Connect Plus Network Manager**[9] software:

- In order for a radio to receive text messages, the radio must have a display, and the "Text RX Capable Radio" checkbox must be enabled on the SU's user record in the controller database.

- In order for a radio to send a text message to its Multigroup ID, the "Multigroup Call Init" checkbox must be enabled on the SU's user record in the controller database. Otherwise, the controller will deny the request.

- In order for a radio to send a text message to the Site All Call Text ID, the "Site All Call Text Init" checkbox must be enabled on the SU's user record in the controller database. Otherwise, the controller will deny the request

- The next two settings affect Text Message exchange between the Connect Plus setting and a Text Message Server:

    - The Site Configuration screen has a field called, "Text UDP Listen Port". This setting determines which UDP port the controller utilizes to listen for incoming messages from the Text Message application. Unless it creates UDP port conflict, this should be left at the default setting of UDP Port 4007.

    - The XRC 9000 can be configured with a Destination IP address and Port for the Text Message Server. This is only necessary when there are multiple Connect Plus sites, but all sites do not share the same (IP address) perspective back to the TMS server. Otherwise, the controller can use the Server IP address and port that was provided in a special message sent by the Text Message Server.

2.6.5 SU Programming for Text Message Services

The System Design Section has a thorough discussion of how a Connect Plus radio should be programmed with MOTOTRBO CPS. The following section discusses how specific MOTOTRBO CPS settings affect text message operation on Connect Plus channels:

- The Connect Plus **Radio ID** is set with MOTOTRBO CPS. Select a Radio ID between 1 and 16776351 that has not been used for any other radio in the Connect Plus network.

[9] For brevity, the **MOTOTRBO™ Connect Plus Network Manager** will be referred to simply as **Network Manager** from here on.

This is used as the Source ID for text messages created by this Connect Plus SU and as the Destination ID for text messages created by other SU's and destined for this radio.

- Connect Plus requires that the **CAI Network** and **CAI Group Network** settings must be left at the default values.

- In order for the radio to transmit a maximum size text message plus overhead, the **Max TX PDU** size should be 500 bytes or larger.

- **TX Preamble Duration** determines the length of the preamble that is sent before all text messages, regardless of digital mode. If the radio is used for Connect Plus only, this value can be set to zero. If the radio contains non-Connect Plus channels that require a TX preamble, it should be set as short as possible. Otherwise, it may adversely affect Connect Plus operation.

- For Connect Plus digital channels, **Compressed UDP Data Header** should be disabled (unchecked)

- For Connect Plus Channels, **Data Call Confirmed** should be enabled (checked)

The following MOTOTRBO settings affect Text Message operation when the radio is selected to non-Connect Plus digital channels, but they are not used by Connect Plus. If the Connect Plus radio is also used for non-Connect Plus digital operation (Digital Conventional, IP Site Connect, Capacity Plus), the MOTOTRBO parameters immediately below should be set according to the requirements of those operations. They have no affect on Connect Plus Operation:

- Pre-programmed (quick text) messages that are programmed with MOTOTRBO CPS.

- TMS Radio ID

- TMS UDP Port

- Forward to PC checkbox

- Digital Contacts created with MOTOTRBO CPS

The following settings in Connect Plus CPS affect text messages

- Create Digital Contacts to represent other radios that this SU may send a text message to, or receive a text message from. Failure to create a digital contact will not keep a display radio, provisioned for Manual Dial, from sending messages to SU's that aren't on the Contact list (or receiving messages from SU's that aren't on the Contact list), but the ID information will be displayed by number only, not by alias. The, "Dispatch Call" contact type, is used exclusively for text messages exchanged between the SU and Text Message Dispatch Clients. A Text Message Dispatch Client is a non-radio entity, such as a Text Message Dispatcher PC.

- Use the Text Messages screen to create programmed (quick text) messages, if desired.

- If desired, use the Buttons screen to set a "One Touch Call", which can be used to send a configured Quick Text message to a specific Destination ID.

2.6.6 Connect Plus Interface to Text Message Application

Just as in other MOTOTRBO digital modes, Connect Plus supports text message transfer between Connect Plus SU's and non-Connect Plus entities, such as a Text Message Dispatch PC. The text message transfer is facilitated via the controller's IP connection to a Text Message application, sometimes referred to as the "Text Message Server". Connect Plus supports the following services for its interface to the Text Message application:

- A Text Message Dispatch Client can send a text message to a Connect Plus SU.
- A Text Message Dispatch Client can send a text message to a Connect Plus Group ID.
- A Text Message Dispatch Client can send a text message to a Connect Plus Multigroup ID.
- A Text Message Dispatch Client can send a text message to the Connect Plus Site All Text ID.
- A Connect Plus SU can send a text message to a TMS Dispatch Client.
- The Connect Plus controller provides mailboxing for text messages, which allows for store and forward.
- The Connect Plus controller provides automatic retries for text messages sent from a Text Message application to individual Connect Plus ID's, and for text message sent from a Connect Plus SU to a Text Message application.
- The Connect Plus controller sends a "Confirmation of transmission" text message to a Text Message Client when a message is delivered OTA.
- The Connect Plus controller sends an "Undeliverable Notification" text message to a Text Message Client when a message cannot be delivered OTA.

While many of the Connect Plus services to the TMS application are also available in other MOTOTRBO digital modes, the system architecture for providing these services is different in Connect Plus.

In other digital modes, the Text Message application resides on a PC that has a USB connection to a mobile radio. The control station radio acts as peer to other subscriber units in the field via the Common Air Interface. Connect Plus does not use this architecture. In Connect Plus, the Text Message application resides on a PC that is connected via IP to a XRC 9000 Controller. This can be any Connect Plus controller on the radio network. The controller is the application's gateway to the Common Air Interface. This architecture provides several significant advantages:

- The controller supplies immediate acknowledgement upon receiving the text message via IP. The Text Message application is not responsible for the possible complications of over-the-air delivery. The controller – not the Text Message application – manages over-the-air retries for confirmed text messages.
- By sending the message to the Connect Plus controller, the application is handing it to the central intelligence of the Connect Plus system. The controller is the system component with the required knowledge to locate the destination SU, identify an available RF resource, and deliver the message to its intended target.

- The application can send the text message to any controller at any time. It does not need to worry about where the Destination SU is currently registered, whether the destination SU is currently busy or idle, whether there is a channel currently available for text message transmission, etc. Upon receiving the text message, the controller places the message in the mailbox of the destination SU, and will deliver the message at the earliest opportunity.

- When the controller delivers a text message from a Text Message Dispatch Client to an individual Connect Plus ID, the controller expects to receive OTA acknowledgement that the message has been received from the destination SU. Upon receiving this acknowledgement, the controller sends a "confirmation of transmission" text message to the Text Message Dispatch Client. Or, if transmission cannot be completed successfully, the source Dispatch Client receives an "undeliverable" notification.

- The Motorola Multi-Channel Device Driver (MCDD) is not required, nor used in Connect Plus.

Just as in other digital modes, the "Dispatch Call" Contact type is used to facilitate Text Message exchange between an SU and a TMS Dispatch Client. To illustrate how the Connect Plus system uses this contact type, the following steps are provided:

1. The Connect Plus radio is programmed (via Connect Plus CPS) with one or more "Dispatch Call" entries in its Contact List. When creating the contact, a "Call ID" must be entered for the record (1-16776351). An alias (such as "Central Dispatch", for example) may be entered as well.

2. The Connect Plus user follows the normal procedure to create a text message (or use a programmed "quick text message") and selects a target ID from the Contact List. The Dispatch Call ID ("Central Dispatch, for example) is available as a target. The radio user presses OK.

3. The Source radio requests a timeslot for text message transmission and sends the text message to the controller. The controller knows through a couple of different mechanisms that message is destined for a TMS Dispatch Client. However, the message itself does not include the IP address of the TMS Server, or the TMS Dispatch Client.

4. The controller looks up the Destination IP address and port number for the Text Message Server, and forwards the message accordingly via its IP connection. There are two different ways the controller can determine the Text Message Sever IP.

    a. The Text Message server can send a special message to the controller called the "Text Message Service Availability Message". The message targets a specific SU, and it provides the IP address of the Text Message Server. Upon receiving the message, the controller stores this information on behalf of the targeted SU. When the SU sends a message to the Text Message Server, the controller can use this stored IP address when forwarding the text message to the Text Message Server. This approach allows different SU's to have different Text Message Servers, but it cannot be used in a multisite network when different sites have a different (IP address) perspective back to the TMS Server. In that case, the controller must use a programmed IP address for the Text Message Server as discussed in the next paragraph. Which approach is actually used (Service Availability Message or programmed Text Message Service IP address) is determined through controller programming.

    b. The XRC 9000 controller can be programmed with a Destination IP address and port for the Text Message Server. Because this is a site-wide setting (which means that the controller will use the same Text Message Server IP for all SU's),

programming the Text Message Server IP address into the controller provides somewhat less flexibility than obtaining this address from the Service Availability Message. This approach is required in a multisite network when different sites have a different (IP address) perspective back to the TMS Server. Regardless of which approach is used, it should be noted that Connect Plus does not support multiple Text Message Servers for messages sourced by the same SU.

5. The server receives the text message and decodes the "Dispatch Call ID" that was selected by the radio user. The server has a lookup table to translate the Call ID to a user name, destination IP address and port. This tells the Text Message server how to route the message to the destination Dispatch Client. If supported by the Text Message Server, the Dispatch Call ID can be translated into an email address; thereby providing a text message interface between Connect Plus SU's and email clients. It should be noted that all text messages exchanged with the Connect Plus system have a maximum length of 138 characters, which is the same as other MOTOTRBO digital modes.

When a Text Message Dispatch Client sends a Text Message to a Connect Plus SU, the process described above is followed in reverse. In order to receive a text message from a Dispatch Client, the SU doesn't necessarily have to be programmed with the Dispatch Call ID used by the Text Message server, but this is highly recommended. It is required in order to display a programmed alias, and it is also required for the SU to source a text message to the Dispatch Client (unless the SU is replying to a previously received message).

2.6.7 Text Messaging Features not Available in Connect Plus

The following Text Message features are not available in Connect Plus:

- In other digital modes, Text Messages to an individual SU can be sent either confirmed (acknowledgement requested) or unconfirmed (no acknowledgement requested). This is a programmable option with MOTOTRBO CPS. In Connect Plus, all Text Messages to an individual SU must be transmitted in confirmed mode. This means that the "Data Call Confirmed" checkbox must enabled for all Connect Plus personalities when programming the radio with Connect Plus CPS.

- In other digital modes, the SU can be configured so that it will forward text messages received OTA to a connected PC. This option is not available for Connect Plus operation.

- In other digital modes, the radio will transmit text messages that were received from a directly connected PC. This is not available for Connect Plus operation.

2.7 Connect Plus Location Services

Just as in other MOTOTRBO digital modes, Connect Plus Location Services support "single" and "periodic" Location Updates for GPS-equipped SU's. Just as in other digital modes, these updates are initiated at the request of a Location Server. However, the system architecture for the Location Request Response Protocol (LRRP) interface in Connect Plus is different from other digital modes.

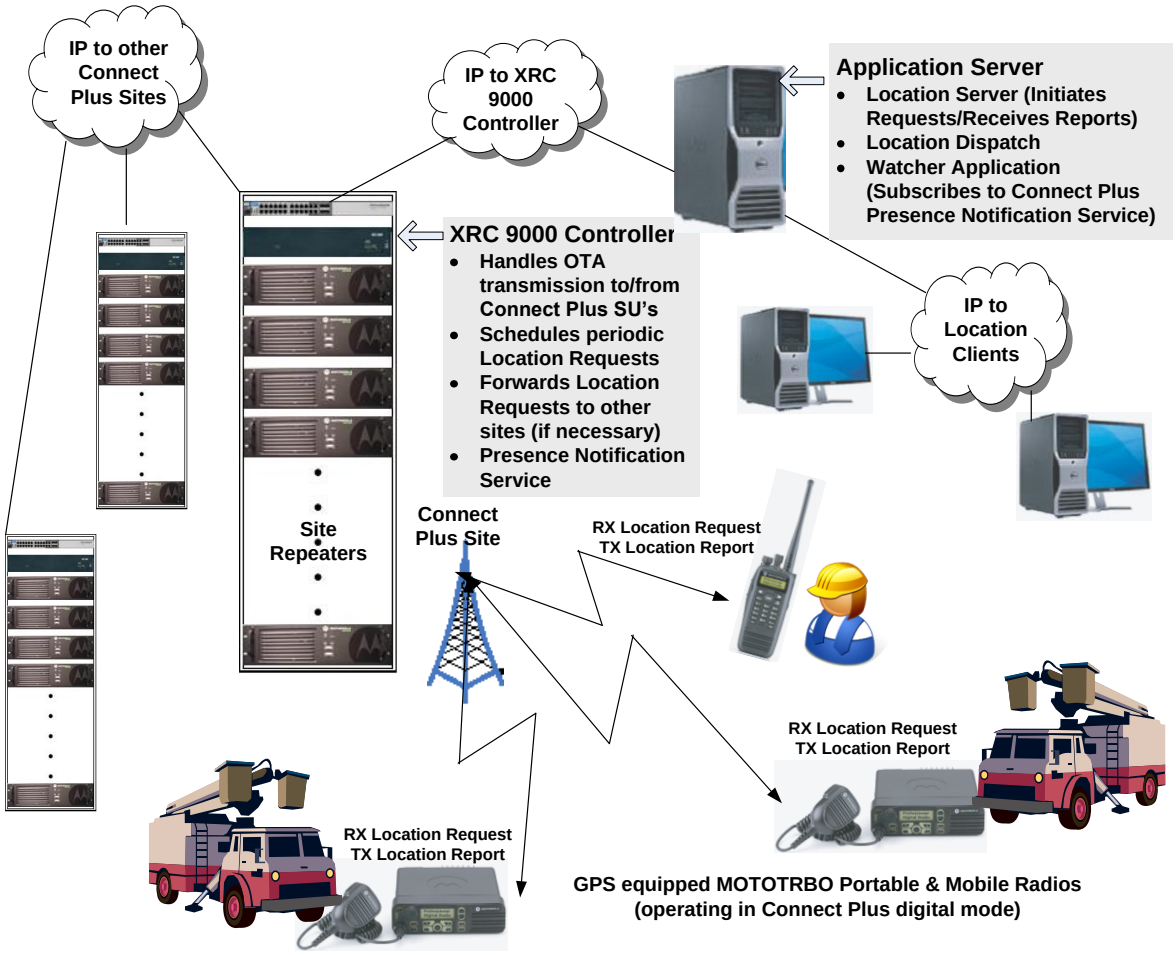


Figure 2-4 Connect Plus Location Services

In other digital modes, the Location application software resides on a PC that has a USB connection to a mobile radio. The control station radio acts as peer to other subscriber units in the field via the Common Air Interface. Connect Plus does not use this architecture. In Connect Plus, the Location application resides on a PC that is connected via IP to a XRC 9000 Controller. This can be any Connect Plus controller on the radio network. The controller is the application's gateway to the Common Air Interface. Figure 2-4 shows the described Location Service configuration. This architecture provides several significant advantages:

- By sending the Location Request to the Connect Plus controller, the application is handing it to the central intelligence of the Connect Plus system. The controller is the system component with the required knowledge to locate the destination SU, identify an available RF resource, and send the Location Request to its intended target. The application does not need to worry about the destination SU is currently busy or idle, whether there is a channel currently available for Location request transmission, etc. Upon receiving the Location Request, the controller will transmit the Request to the destination SU at the earliest opportunity.

- Because the controller assigns which timeslot will be used for Location Requests and Reports, it can utilize any available timeslot. Connect Plus does not use a “GPS Revert Channel” or a “Data Revert Channel”[10].

- In other digital modes, the SU runs a timer to track its “periodic interval”, and transmits its Location update to the “Selected Channel” or its “GPS Revert Channel” (depending on CPS programming) when the timer expires. This approach is susceptible to collisions that occur when two or more SU’s pick the same time and channel to transmit their location update. In Connect Plus, the controller tracks both the periodic interval and assigns the timeslot for the Location Update. This allows the Connect Plus system manage resource assignment in an orderly manner, and to provide a collision-free environment for periodic Location updates.

- The Multi-Channel Device Driver (MCDD)[11] is not required for the Location Server when interfacing to the Connect Plus network. The application sends the request to any XRC 9000 controller in the network. The application does not need to be concerned about what site or channel the SU is currently using. Tracking the SU between sites is the responsibility of the controller. The Location Report might not come from the same controller that received the Location Request.

2.7.1 Single Location Update

When the XRC 9000 controller receives a Single Location Update request for a registered SU, the operation is as follows:

- The controller forwards the request to the registered site (if different from the site receiving the request).

- The controller of the registered site checks SU and timeslot availability. At the earliest opportunity, it sends a Control Channel message to move the destination SU to a trunk-to timeslot.

- On the trunk-to timeslot, the controller transmits the Location Request, using confirmed data transfer.

- On the same trunk-to timeslot (during the same session), the SU transmits its Location Report, also using confirmed data transfer.

- The controller forwards the Location report to the requesting Location application.

- After completing the process, the controller deletes the Request and its corresponding Report.

[10] The reader can refer to the MOTOTRBO System Planner regarding the GPS Revert Channel and Data Revert Channel features.
[11] The reader can refer to the MOTOTRBO System Planner regarding the Multi-Channel Device Driver.

2.7.2 Periodic Location Update

When the XRC 9000 controller receives a Periodic Location Request (also called a “Triggered Request with Periodic Interval”) for a registered SU, the operation is as follows:

- The controller sends a message to the requesting application verifying receipt of the periodic Location Request.
- The controller forwards the request to the registered site (if different from the site receiving the request).
- The controller converts the request to a Single Location Request, making note of the requested periodic interval.
- The controller of the registered site checks SU and timeslot availability. At the earliest opportunity, it sends a Control Channel message to move the destination SU to a trunk-to timeslot. The controller tells the SU that it should store the imminent Location Request.
- On the trunk-to timeslot, the controller transmits the Location Request, using confirmed data transfer.
- On the same trunk-to timeslot (during the same session), the SU transmits its Location Report, also using confirmed data transfer.
- The controller converts the Single Location Report to a Periodic Location Report (to match the original request), and forwards the Location report to the requesting Location application.
- The controller tracks the requested periodic interval. When the requested interval expires, the controller of the registered site checks SU and timeslot availability. At the earliest opportunity, it sends a Control Channel message to move the destination SU to a trunk-to timeslot. The controller tells the SU that it should use its stored Location Request. This speeds up the data transfer on the trunk-to timeslot.
- On the assigned trunk-to timeslot the SU transmits a Location Report based on its stored Location Request. It is important to point out that the combined duration for Location Request from the controller and the corresponding Location Report from the SU is about 2-3 seconds (assuming no retries). After receiving the Location Report the controller resets the timer for the periodic interval for the given SU. The net effect of this approach is that the actual periodic interval is increased by 2-3 seconds.
- The controller converts the Single Location to a Periodic Location Report (to match the original request), and forwards the Location report to the requesting Location application.
- The process described above is repeated at each periodic interval until in one of the following occurs:
    - The requesting Location application cancels the periodic request, or
    - The requesting application sends a new periodic request, or
    - The request times out. To prevent the request from timing out, the application must resend the request prior to expiration of the controller’s Location Request Time Out (24 hours).

- The SU de-registers from the network

The Connect Plus system supports just one periodic request at a time for any SU (and therefore just one requesting application at a time for any SU).

2.7.3 Sending Reports to the Location Application

When the XRC 9000 controller sends the Location Report to the requesting application, there are two different ways the controller can determine what IP address and port it should use for the Location application:

- Upon receiving a Location Request from a Location application, the controller stores the Source IP and Port from the received request. When the SU sends the Location Report to the XRC 9000, the controller can use this stored IP address when forwarding the report to the requesting application. This approach provides the most flexibility. Because the controller uses the IP address stored from the request, multiple Location servers can request a single location update from same SU (but just one a time). For periodic updates, this approach allows different SU's to have different Location Servers (but all periodic updates for the same SU will be sent to the same Location Server). This approach (using the IP address stored with the request) cannot be used in a multisite network when different sites have a different (IP address) perspective back to the LRRP Server. In that case, the controller must use a programmed IP address for the Location Server as discussed in the next paragraph. Which approach is actually used (using the IP address from the request or using a programmed Location Server IP address) is determined through controller programming.

- The XRC 9000 controller can be programmed with a Destination IP address and port for the Location Server. Pre-configuring the Location Server IP address into the controller provides somewhat less flexibility than obtaining this information from the received request. Because this is a site-wide setting, all location reports (both "single" and "periodic" reports), for all SU's, go back to the same Location Server. This approach is required in a multisite network when different sites have a different (IP address) perspective back to the LRRP Server.

2.7.4 Location Services and Presence Notification

The Connect Plus system does not retain any type of Location Request when the destination Connect Plus SU de-registers from the network. Also, if the controller receives a Location Request for an un-registered SU, it does not store the request. The Location application must send the request while the SU is registered with the network. For these reasons, it is highly recommended that Location application take advantage of the controller's Presence Notification services. By implementing this interface, the Location application can send the Location Request when it receives a message from the controller (acting as Presence Notifier) which indicates that the SU is "present" in the network. For more information, see "Connect Plus Presence Notifier" section.

2.7.5 Controller Programming for Location Services

The XRC 9000 controller has several parameters that affect Location Services. These are configured with the MOTOTRBO Connect Plus Network Manager software:

- In order for a radio to respond to Connect Plus location requests, the radio must be GPS-equipped, and the "GPS capable radio" checkbox must be checked on the SU's user record in the controller database.

- The Site Configuration screen has a field called, "LRRP UPD Listen Port". This setting determines which UDP port the controller utilizes to listen for incoming Location requests from the Location application. Unless it creates UDP port conflict, this should be left at the default setting of UDP Port 4001.

- The XRC 9000 can be configured with a Destination IP address and Port for the Location Server. This is only necessary when there are multiple Connect Plus sites, but all sites do not share the same (IP address) perspective back to the LRRP server. Otherwise, the controller can use the Server IP address and port that was provided in the location request.

2.7.6 SU Programming for Location Services

The System Design Section has a thorough discussion of how a Connect Plus radio should be programmed with MOTOTRBO CPS. The following section discusses how specific MOTOTRBO CPS Settings affect Location Services for the Connect Plus SU:

- For a GPS equipped radio, the "GPS" checkbox must be enabled on the General Settings screen with Connect Plus CPS. This enables the GPS receiver and causes a display radio to show the GPS icon. In Connect Plus mode, the GPS icon is visible while the Option Board is idle and monitoring the control channel. The icon is not shown during a call-in-progress.

    - The absence of this icon indicates that the location service is disabled.

    - The icon shows a full satellite dish when good GPS signals are detected.

    - The icon shows an empty satellite dish when the radio is receiving poor GPS signals. If the SU has previously acquired the satellite, and then lost it, it may transmit its last known location even though the GPS coordinates may no longer be valid.

- The Connect Plus **Radio ID** is set with MOTOTRBO CPS. Select a Radio ID between 1 and 16776351 that has not been used for any other radio in the Connect Plus network. This ID must be configured into the Location server, along with the requested attributes (location, velocity, etc.) The Radio ID is used as the Destination ID for Location Requests sent to this Connect Plus SU, and it is used as the Source ID for Location reports received from this SU.

- Connect Plus requires that the **CAI Network** and **CAI Group Network** settings must be left at the default values.

- The **Max TX PDU** must be large enough to accommodate the largest Location Report expected from this SU. Recommended value is 500 bytes or larger.

- **TX Preamble Duration** determines the length of the preamble that is sent before the IP datagram containing the SU's Location Report. If the radio is used for Connect Plus only, this value can be set to zero. If the radio contains non-Connect Plus channels that require a TX preamble, it should be set as short as possible. Otherwise, it may adversely affect Connect Plus operation.

- For Connect Plus digital channels, **Compressed UDP Data Header** should be disabled (unchecked)

- For Connect Plus Channels, **Data Call Confirmed** should be enabled (checked)

Due to the Connect Plus Option Board's role in providing Location services, there are some MOTOTRBO CPS Location parameters that affect non-Connect Plus personalities only. The settings listed below are important for configuring Location updates in other digital modes, but they have no effect on Connect Plus operation:

- The **Persistent LRRP Requests "Save"** checkbox does not affect Connect Plus operation.

- **The Persistent LRRP Requests "Delete"** checkbox does not affect Connect Plus operation.

- **ARS** checkbox. ARS is not used in not used in Connect Plus. This checkbox is grayed out when "Option Board Trunking" is enabled for the digital personality.

- **GPS Revert** field. Connect Plus does not use a GPS Revert Channel. Because this setting is tied to the ARS Checkbox, it will be grayed out when "Option Board Trunking" is enabled for the digital personality.

The following Connect Plus CPS Settings affect Location Services for the Connect Plus SU:

- At the present time, there are no programmable settings in Connect Plus CPS specifically for Location Services.

2.7.7 Connect Plus GPS Performance Specifications

The Connect Plus is subject to the same performance specifications as other MOTOTRBO digital modes in regards to the following:

- Cold Start

- Hot Start

- Time to First Fix (TTFF)

- Horizontal Accuracy

For more information on these topics, see "Performance Specifications" in *Location Services* section of [1].

2.7.8 Location Report Rates in Connect Plus

Because all Location requests go through the controller in Connect Plus trunking, this additional step will add some additional time for the Location Request-Report process when compared to the best-case scenario for other digital modes. The trade-off is that Connect Plus virtually eliminates collisions for Location Requests and Reports and provides a highly managed environment for channel assignments. Even so, it should be noted that the controller will process all requests on a best effort basis that will be influenced by factors such as channel availability, the number of other calls in process (both voice and data), and the number of requests being processed. Immediate Requests may not always receive an Immediate Report. Periodic reports may not always come at the exact, requested interval. On a "quiet" Connect Plus site, the controller can use every trunk-to timeslot for Location Updates, resulting in a very high update rate. The rate will decline as requests for other types of calls increase.

2.7.9 Location Features not Available in Connect Plus

The following Location features are not available in Connect Plus:

- In other digital modes, a Location application may obtain presence information by subscribing to the MOTOTRBO Presence Notifier or a 3rd Party ARS application. In Connect Plus, a Location application obtains presence information by subscribing to the Presence Notification services of the XRC 9000 controller. This is the only supported presence interface for Connect Plus operation.

- GPS Revert is not necessary in Connect Plus, and it is not available while operating in a Connect Plus personality.

2.7.10 Emergency Location Update

Connect Plus supports Emergency Location Update, a special type of "Triggered Location Request".

In Connect Plus, the 3rd party Location Application sends the Triggered Request for Emergency to any of network's XRC 9000 controllers when an "SU of interest" registers into the network. (If the 3rd party Location Application has subscribed to the XRC 9000's "Presence Notification" services, it will be notified when the SU of interest registers or de-registers with the Connect Plus network.)

The XRC 9000 will acknowledge the Emergency Location Request on behalf of the Destination SU, and then store the request for the SU until it is needed.

Whenever the XRC 9000 receives an Emergency Call Request from an SU, the controller checks to see if a 3rd party LRRP application has requested an Emergency Location Update for this SU. If so, the XRC 9000 takes the following actions:

- Upon decoding the Call Request CSBK for the Emergency Call, the XRC 9000 sends a message to the LRRP application that an emergency condition has been detected for an SU of interest. This message does not contain the SU's location information. The Emergency voice call must conclude prior to the Emergency Location Update. The XRC 9000 sends this message one time for each Emergency Call request that it decodes from

the SU of interest. It is up to the receiving application as to how it processes this message (if at all).

- In its response to the SU initiating the emergency, the Controller informs the SU that an Emergency Location Update should occur at the end of the Emergency voice call.

When the Emergency call is over, the SU sends a message to XRC 9000 controller requesting a trunk-to timeslot for the Emergency Location Update. The controller assigns a timeslot for the Emergency Location Update, or places the request in the Busy Queue if none is available. When assigning calls from the Busy Queue, only Emergency Calls (emergency voice) have precedence over Emergency Location Updates (emergency data).

After assigning a trunk-to timeslot for the Emergency Location Update (which may or may not be the same timeslot used for the Emergency Call), the controller transmits the stored Triggered Location Request (Emergency) to the Destination SU. The Connect Plus SU responds by sending the requested information. Upon receiving the Emergency Location Update, the controller forwards the report to the requesting application.

If the Emergency Location Update session fails on the trunk-to timeslot, the controller will not have a report to send to the 3rd party application. As a courtesy to the Location application, the controller sends a Triggered Location Report on behalf of the destination SU with a failure code indicating, "Query Info Not Attainable". Upon receiving this report, the LRRP application can send an Immediate Location Request for the destination SU, if so desired.

Another situation when the Emergency Location Update may not convey the real location of the emergency initiator is in the case when the SU does not have a GPS lock during the emergency event. In this scenario the Emergency Location Update received by the controller will contain stale GPS coordinates, but will be forwarded to the 3rd party application as it is. The LRRP application needs to evaluate the Location Report "quality" and decide how to present the information to the user.

2.8 Connect Plus Over-The-Air File Transfer

For certain types of Connect Plus files, the Connect Plus system provides two options for transferring the file to an SU:

- Connect Plus CPS can be used to transfer the file from a PC to the SU, utilizing the standard MOTOTRBO radio programming cable. This approach, sometimes referred to as "tethered programming", is the recommended method for initial set-up and programming. It can also be utilized following deployment to the field.

- The file can be uploaded to the Connect Plus controller, and then transferred over-the-air (OTA) to Connect Plus SU's. This feature, available only in Connect Plus, can reduce radio down time when the SU needs to be updated with a new file version after it has already been deployed to the field.

The following sections explain how OTA File Transfer works in this Connect Plus release. In the future, additional file transfer options may be offered.

2.8.1 Supported File Types

The following file types are supported for Connect Plus OTA File Transfer:

- Connect Plus Network Frequency File
- Connect Plus Option Board firmware
- Connect Plus Option Board Codeplug

2.8.2 OTA File Transfer Settings for MOTOTRBO CPS

Even though OTA File Transfer is only available in Connect Plus mode, there are some MOTORBO CPS settings that are important to its operation. This is because Connect Plus uses MOTOTRBO data transfer as the transport mechanism for file packets. The following MOTOTRBO CPS settings affect Connect Plus OTA File Transfer:

- The Connect Plus **Radio ID** is set with MOTOTRBO CPS. Select a Radio ID between 1 and 16776351 that has not been used for any other radio in the Connect Plus network. The Radio ID is used as the Destination ID for OTA File packets sent to this Connect Plus SU.
- Connect Plus requires that the **CAI Network** and **CAI Group Network** settings must be left at the default values.
- The recommended value for **Max TX PDU** is 500 bytes or larger.
- **TX Preamble Duration** determines the length of the preamble that is sent before IP datagrams transmitted by the SU. If the radio is used for Connect Plus only, this value can be set to zero. If the radio contains non-Connect Plus channels that require a TX preamble, it should be set as short as possible. Otherwise, it may adversely affect Connect Plus operation.
- For Connect Plus digital channels, **Compressed UDP Data Header** should be disabled (unchecked)
- For Connect Plus Channels, **Data Call Confirmed** should be enabled (checked)

2.8.3 OTA File Transfer Settings for Connect Plus CPS

There are several programmable parameters in the Connect Plus codeplug for OTA file transfer. The following parameters are configurable per Connect Plus SU (using Connect Plus CPS). They must be configured prior to field deployment.

- **Enable OTA File Transfer**: This setting defaults to off, meaning that OTA File Transfer is disabled for Option Board Firmware File and Network Frequency File. Because these OTA file types are targeted at the general radio population, and not at specific SU's, they can unexpectedly prevent a radio user from receiving calls for a period of time. For this reason, it may be advisable to leave this setting disabled for some Mission Critical users. When disabled, file transfer for Option Board Firmware and Network Frequency File can only occur via the traditional method using Connect Plus CPS and a programming cable. When

enabled, the Connect Plus SU can acquire these file types via OTA File Transfer. This setting does not affect OTA Transfer of the Option Board codeplug. The System Administrator grants permission for Option Board codeplug OTA transfer to take place by acknowledging a Network Manager message when uploading a new Option Board codeplug for a specific radio. Although the Codeplug File OTA transfer can also prevent the SU from receiving calls, it is the System Administrator's responsibility to communicate with the radio user, and to perform the Codeplug File Transfer when a temporary interruption to service can be tolerated.

- **OTA Update Upon Completion**: When the radio completes OTA Option Board Firmware file transfer, this setting determines when the radio will update (upgrade) to the newly acquired firmware file. When enabled, the Option Board shall upgrade immediately upon completing the OTA File Transfer. If not enabled, the upgrade will be automatically performed the next time the radio is powered-up in an Option Board zone. While the radio is updating (upgrading) to the newly received firmware file, the user will not be able to make or receive calls. For the Network Frequency File and the Option Board Codeplug File, the Option Board always automatically and immediately upgrades to the new file after completing OTA File Transfer and verifying the integrity of the received file. Automatically upgrading to a new Network Frequency File received OTA does not typically interrupt service (provided that the frequencies currently being used by the SU haven't changed). Automatically upgrading to a new Option Board Codeplug File received OTA does result in a temporary interruption of service as the Option Board loads the new codeplug and re-registers with the network. For this reason, it is the System Administrator's responsibility to communicate with the radio user, and to perform the Codeplug File Transfer when a temporary interruption to service can be tolerated.

- **Unconfirmed File Transfer Dwell Time**: During Unconfirmed File Transfer this value determines how long the radio will remain on the trunk-to timeslot without decoding any valid file packets. If the timer expires and no valid packet is decoded, the radio returns to the Control Channel timeslot. If the OTA File Transfer was for Option Board Firmware or the Network Frequency File, the Option Board starts its "File Transfer Attempt Interval Time" upon returning to the Control Channel timeslot.

- **File Transfer Attempt Interval Time**: When the radio has been involved in an Option Board Firmware or Network Frequency File OTA Transfer, and it leaves the trunk-to timeslot with an incomplete file (for any reason), the radio starts the File Transfer Attempt Interval Time. The timer must expire before the radio will automatically attempt to resume the file transfer. A display radio user can request the radio (via the menu) to resume the file transfer prior to expiration of the timer.

2.8.4 OTA File Transfer Configuration in the XRC 9000 Controller

The first step to configuring OTA File Transfer in the XRC 9000 controller is to acquire the file that will be uploaded to the controller for OTA transfer. The file should be placed in a known location on the PC that will be used to upload to the controller. The PC must have the MOTOTRBO Connect Plus Network Manager software, and it must be configured to talk to the desired Connect Plus site(s).

Once the file is placed in a known location on the PC, the steps are as follows:

1. Launch the Connect Plus Network Manager Connection Tool and connect to the Connect Plus Site.

2. From the Main Menu, select Site Control/Upload, and then the desired File Type.

3. Press “File to Send”. This opens a window used to locate the file on the PC.

4. Browse to the directory containing the file for upload, select the file, and press “Open”.

5. For the Option Board Codeplug File, the user may then press, “Upload”. The Network Manager will perform several checks prior to uploading the file. The user will be informed whether or not the upload was successful.

6. For the Option Board Firmware File and the Network Frequency File, it is necessary to configure several additional parameters prior to pressing “Upload”:

- **Time to Beacon:** Determines how long the controller will “beacon” a special control channel message to inform SU’s of file availability. This time must be equal to “Time to Dedicate”. This message should not be confused with the IP Site Connect Beacon, which is not used in Connect Plus.

- **Time to Start:** Tells the controller when to start sending the File Beacon message (date and time). The controller also starts the dedicated channel file transfer at the configured date and time. Enter a date and time by typing over the current information. As a convenience, click the arrow to view a drop-down calendar that can be used to select the desired date. The time can only be entered by typing over the current time. The date and time values configured into “Time to Start” are based on PC local time. When uploading the file to the XRC 9000, the Network Manager converts the configured values to UTC time. The controller will then start the file transfer at the requested UTC date and time according to the controller’s internal clock. The PC used to upload the file must be in synch with the XRC 9000 in regards to UTC time. If they are not in synch, the file transfer may start at a different time than is expected by the Network Manager user. If the configured time is in the past according to the controller’s clock, the file transfer will not take place at all. In order for the PC and the XRC 9000 to be in synch, both of the following must be true: (a) The PC date and time must be correct for the Time Zone that is configured on the Microsoft Window’s Date and Time Properties screen, and (b) the XRC 9000 clock must have the correct date and time in UTC. The controller’s date and time in UTC can be viewed with the Network Manager (*Settings>Date & Time*).

- **OK to Downgrade:** When checked, the controller sets a bit in the File Beacon message telling the Connect Plus SU that it is OK to downgrade to this file from a higher version. By default, “OK to Downgrade” is not enabled, and this is usually the recommended setting. Even if the box is checked, the Option Board is coded with certain rules that may not allow a downgrade in some circumstances.

- **Dedicated Channel (checkbox)**: Check this box to enable a Dedicated Channel file transfer. This is the only type of OTA File Transfer currently supported for Option Board Firmware File and Network Frequency File. During Dedicated Channel transfer, the controller will dedicate a specific repeater and timeslot for unconfirmed file transfer for the period of time specified. The file will be sent on the dedicated timeslot over and over until the “Time to Dedicate” expires. When checked, the software activates the Dedicated Channel options (Repeater Radio ID, Repeater Slot, and Time to Dedicate). **Note**: For Option Board Codeplug File OTA Transfer, it is not necessary (or possible) for the user to select the repeater and slot. The XRC 9000 automatically selects the repeater and slot.

- **Repeater Radio ID:** Enter the Radio ID (1-15) of the repeater that will be used for the dedicated channel transfer.

- **Repeater Slot:** Enter the Repeater Timeslot (1 or 2) of the trunk-to timeslot that will be used for the dedicated channel transfer. The Control Channel timeslot cannot be used.

- **Time to Dedicate:** Determines how long the repeater and timeslot configured above will be used for the dedicated channel file transfer. From “Time to Start” until “Time to Dedicate” expires, the dedicated slot will not be available for regular calls. SU’s may join or leave the dedicated channel transfer at various times (the radio user can cancel out of the transfer). It is recommended that “Time to Dedicate” should be set at least long enough so that the controller can send (at a minimum) three complete iterations of the file. The longer this value is set, the greater the chance that the largest possible number of radios can acquire the file via unconfirmed data transfer. A setting of 65,535 minutes tells the controller that the dedicated channel transfer should never expire. **Important**: “Time to Beacon” must be equal to “Time to Dedicate”.

7. Press “Upload” to begin uploading the file to the controller. **Note**: This process must be completed at each site where the file will be available for OTA File Transfer.

Note: The XRC 9000 processes one Beaconed File Transfer (Option Board Firmware File or Network Frequency File) at a time. Do not upload a second file of either type until the XRC 9000 has either transmitted or deleted (in the case where it cannot transmit or finish transmitting) any previously uploaded file.

2.8.5 Controller File Handling for OTA Transmission

After receiving the uploaded file, the controller breaks the file into multiple IP data packets for OTA transmission. The number of data packets depends on the file size. File packets do not have to be collected in order, and the Connect Plus radio will not attempt to use the new information until it has received all file packets and checked the integrity of the received data.

2.8.6 OTA File Transfer: Unconfirmed File Transfer

Unconfirmed File Transfer refers to a method of transferring data over-the-air where the receiving radio does not individually acknowledge each received packet. This method of data transfer provides the highest available Forward Error Correction (FEC) rate. In Connect Plus, unconfirmed file transfer can be broken two categories:

1. **Beaconed File Transfers**: Files in this category are the Option Board Firmware File and the Network Frequency File. This type of File Transfer is intended for all members of the general radio population that need the “Beaconed” file. Because it is intended for multiple radios, there is no OTA acknowledgement of received packets, and there is no OTA acknowledgement that the SU has received the entire file.

2. **Targeted File Transfers**: This type of OTA File Transfer is targeted to a specific Radio ID. At the current time, the Connect Plus Option Board Codeplug is the only supported file type for Targeted File Transfer. Although the radio does not acknowledge each received packet (which places it in the category of unconfirmed data), it does send an OTA message to confirm receipt of the entire file.

2.8.6.1 Beaconed File Transfers

Beaconed File Transfer (Option Board Firmware File and Network Frequency File) allows many radios to receive file packets at the same time on the same trunk-to timeslot. It is initiated when the

Network Administrator uploads a file for OTA Transfer that has been configured with the following attributes (see OTA File Transfer Configuration in the XRC 9000 Controller for more information on these settings):

- Time to Beacon has been set to indicate how long the Beacon message should be sent to announce file availability.
- A dedicated repeater and timeslot has been configured for the dedicated channel file transfer.
- Time to Start has been set to indicate when the controller should start sending the Beacon message on the Control Channel Timeslot and when the controller should start transmitting the file on the dedicated repeater and timeslot.

The following steps describe how the Beaconed File Transfer process works:

1. The SU is idle and monitoring the Control Chanel timeslot. It decodes a File Beacon message announcing file availability. It checks the File Type and version against what it currently has. If the version in the Beacon message is older than what the radio already has, it will NOT proceed to acquire the file unless the “OK to Downgrade” flag is set in the File Beacon message.
2. If the SU determines that it needs the file, it looks to see if the Beacon message gives a dedicated repeater and slot. If so, the SU will automatically move to the dedicated timeslot and start to acquire file packets.
3. On the trunk-to timeslot, the SU begins to acquire and store file packets. Because this is an unconfirmed transfer, possibly involving many radios, the controller does not request or expect OTA acknowledgement for transmitted packets. As long as a display-capable SU remains on the dedicated channel collecting packets, its display toggles between the Selected Contact Name and “File Transfer”. The collection of packets continues until one of the following occurs:
    a. The radio user starts a call. This causes the SU to leave the file transfer.
    b. The SU collects all file packets.
    c. The Time to Dedicate Repeater expires and the File transmission ends.
    d. The SU’s “Unconfirmed File Transfer Dwell Time” expires and the SU hasn’t decoded a valid packet
4. When the SU leaves the dedicated timeslot, for any reason, it returns to the Control Channel timeslot.
    a. If the SU leaves the dedicated timeslot without collecting all needed packets, it starts its configurable “File Transfer Attempt Interval Timer”. The SU will not automatically re-join an ongoing dedicated channel transfer until this timer expires. If the timer expires, and the Beacon message indicates that a dedicated channel transfer is still in progress, the SU will rejoin the transfer exactly as described above. Depending on factors such as signal conditions and how often the radio user wishes to initiate calls, this process may have to be repeated several times before the radio collects all necessary packets.

b. If the SU leaves the dedicated timeslot after collecting all necessary packets, it will not update (upgrade) to the new file until it has checked to verify the integrity of the received data.

Note: If the Dedicated Channel Unconfirmed File Transfer expires before all radios have collected the complete file (display radios have a menu option to show whether the Connect Plus SU has collected all of the file packets), there are two options for completing the file transfer; (a) re-start the Dedicated Channel Unconfirmed File Transfer by re-configuring and re-uploading the desired file, or (b) update the radio(s) with the desired file via the traditional method using a programming cable and MOTOTRBO Connect Plus Option Board CPS.

2.8.6.2 Targeted File Transfer

Targeted File Transfer provides the ability to send files OTA to specific Destination ID(s). At the current time, Option Board Codeplug File Transfer is the only type of supported Targeted File Transfer.

Option Board Codeplug File Transfer

Option Board Codeplug File Transfer provides the ability to update the Option Board codeplug of a specific Connect Plus SU over-the-air. The discussion on OTA Option Codeplug File Transfer will be divided into four parts:

1. Creating the Option Board Codeplug File for OTA Transfer
2. Locating the destination SU and initiating Option Board Codeplug File Transfer
3. The Option Board Codeplug File OTA Transfer Process
4. Determining whether or not the Codeplug File Transfer was successful

Creating the Option Board Codeplug File for OTA Transfer

The process begins by using MOTOTRBO Connect Plus CPS to create and save the codeplug that will be sent OTA. The process is outlined below:

1. There are two saved formats for Option Board Codeplug Files, and each format has a different file extension, as shown below. In preparing a codeplug file for OTA Transfer, you can start with a saved codeplug in either format. After you open the codeplug and make any desired changes, you must save the file to the .efc file extension (by selecting Save As>OTA Codeplug).

    - **.cno** file extension: This type of codeplug file can be sent to the Option Board using a PC, the programming cable, and Connect Plus CPS. When saving to this format with Connect Plus CPS, the user defines the file name.

    - **.efc** file extension: This type of codeplug file can be sent to the Option Board over-the-air, after first uploading the file to the XRC 9000 using the MOTOTRBO Connect Plus Network Manager. When saving to this format with Connect Plus CPS, the software automatically names the file, using a specific format. It must not be changed by the user.

2. It is not necessary to start with a codeplug that matches the destination radio's SUID exactly. It is allowable to start with a sample codeplug, or with a saved codeplug from a

different radio, provided that the starting codeplug exactly matches the Model Number Index of the destination SU. The best way to determine the Model Number Index of the destination SU is to instruct the radio user to look on the menu under *Utilities>Radio Info>Model Index*. If this is not possible, and if there is a recent saved Option Board codeplug available for the same SU, the Model Number Index is displayed on the Connect Plus Option Board screen when viewing the saved codeplug with Connect Plus CPS.

3. Every Option Board codeplug has a Codeplug Version Number. The codeplug that will be sent OTA must be the Option Board Codeplug Version required by the destination unit. The unit's Option Board Firmware level determines what Codeplug Version it needs. The best way to determine the necessary Option Board Codeplug Version is to instruct the radio user to look on the menu under *Utilities>Radio Info>Opt Bd CP Ver*. If this is not possible, and if there is a recent saved Option Board codeplug available for the same SU, then open the saved codeplug. The Option Board Codeplug Version is displayed on the Connect Plus Option Board screen when viewing the codeplug with Connect Plus CPS. However, it is important to realize that the saved codeplug might not contain the Option Board's current information. For this reason the Menu display is preferable. After determining the Codeplug Version that the Option Board needs, confirm that the current Connect Plus CPS saves codeplugs to this Codeplug Version. If it doesn't, it may be necessary to locate an older or newer version of Connect Plus CPS.

4. Although it is not necessary to start from a saved codeplug that matches the Radio ID (SUID) of the destination unit, it will be necessary to enter the destination SUID when saving the codeplug for OTA transfer. Connect Plus CPS will automatically include the Destination SUID as part of the file name. The saved codeplug can only be utilized for the specific SU indicated in the file name. Therefore, if there are multiple SU's that need to be updated OTA with new codeplugs, it will be necessary to create a separate saved Option Board Codeplug File for each SU.

The guidelines shown above must be followed exactly for the OTA Codeplug Transfer to be successful. Because of this, the System Administrator is advised to maintain a spreadsheet or database for each deployed radio that contains, at a minimum, the following information for each unit; MOTOTRBO Serial Number, Radio ID, Radio Model information, current Option Board Codeplug Version, current MOTOTRBO and Option Board software versions. This information will prove invaluable when creating Option Board Codeplugs for OTA Transfer.

When saving a file to the OTA Codeplug format (.efc file extension), Connect Plus CPS automatically names the file, using a specific format. It must not be changed by the user. An example of the file name as set by Connect Plus CPS is as follows: SU_204_7_A1B2C3D4.efc.

- **SU**: This indicates that the saved file is for a SU.

- **204**: This indicates that the saved file is for Radio ID 204

- **7**: This is an example of the Radio Model Index Number. It will likely be different for different radio models.

- **A1B2C3D4**: This is an example of the hexadecimal CRC of the saved codeplug. This information is useful for determining whether the destination Option Board successfully receives this Codeplug File OTA. Following the transfer, request the radio user to check the CRC of the Option Board OTA Codeplug File: *Utilities>Radio Info> OB OTA CPcrc*. This menu option is available on display radios when the Option Board's current codeplug was received OTA. Selecting this option causes the Option Board to display the OTA Codeplug CRC in hexadecimal. If the displayed CRC matches the CRC of the saved file, this provides assurance that the information in the two codeplugs is the same

(with the exception of the settings that can be modified by the radio user after receiving the codeplug).

- **.efc**: This is the file extension for the OTA version of the Option Board Codeplug.

After Connect Plus CPS creates the file name for the saved OTA Option Board codeplug (.efc file extension), do not edit or change the file name! The file name must remain exactly as created by Connect Plus CPS, or the Network Manager will deny the file upload with a "File Name Error".

Locating the destination SU and initiating Option Board Codeplug File Transfer

After creating the saved codeplug for the destination SU, the steps for initiating the Codeplug File Transfer are as follows:

1. Place the saved codeplug in a known location on a PC that has the MOTOTRBO Connect Plus Network Manager software. This PC will be used to connect to the SU's registered site and to upload the saved file.

2. Because the saved codeplug must be uploaded to the specific Connect Plus site where the SU is currently registered, the Network Manager provides a "Find User" tool. Any network site can provide this information. After determining the SU's registered site, use the Network Manager to connect to that site. (Note: The registered site information returned by the "Find User" tool tells where the XRC 9000 thinks the SU is located, based on the SU's most recent registration. The XRC 9000 does not do a radio check to confirm communications with the SU. It is possible that the SU has faded since its last registration.)

3. Communicate with the radio user to determine if this is good time to initiate the OTA Codeplug Transfer. Do not upload the file until the following can be verified:

    a. Confirm that the radio user can tolerate a temporary interruption to service in order to receive the new codeplug. The best chance for successful transfer is when the radio user knows the codeplug transfer is imminent and does not attempt to initiate calls for a period of time.

        i. The best case scenario for interruption to service is thirty seconds (when the codeplug has 1 Option Board zone and the file needs to be sent just one time).

        ii. The worst case scenario for interruption to service is ten minutes (when the codeplug has 16 Option Board zones and the file needs to be sent three times).

        iii. The average interruption to service, which depends on the number of Option Board zones and RF conditions, will fall somewhere between these two extremes.

    b. Confirm that the radio is in a strong signal area (on a display radio, request the user to look at the number of bars on the signal strength icon).

    c. For a portable radio, confirm that the radio has an adequate battery charge (on a display radio, request the user to look at the number of lines on the battery strength icon).

4. After determining that this is a good time for the Codeplug File Transfer, use Network Manger to upload the Option Board Codeplug File. Connect to the SU's registered site. From the Main Menu, select Site Control>Upload, and then select the desired File Type. Press "File to Send", browse to the desired file, select the file, and press "Open". When the file name appears in the "File to Send" box, press "Upload".

5. Prior to uploading the file, the Network Manager will conduct several checks. If all checks are passed the file will be uploaded to the connected site. If any check fails, the file will not be uploaded, and a message will be provided to indicate why the Network Manager cannot proceed.

6. Before the Network Manager uploads the file, it provides a warning message stating that the Codeplug File Transfer can cause the radio user to miss calls. Acknowledge this message to proceed.

7. After successfully uploading the file, the XRC 9000 will begin the OTA file transfer as soon as possible, depending on several factors, such as the availability of resources, the number of queued data sessions, etc. The XRC 9000 does not store uploaded OTA Codeplug files to persistent memory. If the XRC 9000 reboots for any reason, it will be necessary to re-upload any undelivered OTA Codeplug file.

8. It is recommended to open the Network Manager's Real Time Display, and to watch for the Codeplug File Transfer to begin. Once the Codeplug File Transfer begins on the Real Time Display (RTD), it will continue for a period of time. How long depends on several factors. The System Administrator is encouraged to continue watching the RTD session until completion. When the session ends, the session "Shutdown Reason" in the RTD history panel will show whether or not the XRC 9000 considered the session to be successful.

9. If a session ends with an incomplete transfer, the XRC 9000 will not automatically re-initiate the session. The System Administrator must re-initiate the session by repeating the steps on this list.

The Option Board Codeplug File OTA Transfer Process

Once the Option Board Codeplug has been successfully uploaded to the controller, and when the controller has located an available repeater and timeslot, the OTA File Transfer process is as follows:

1. The SU is idle and monitoring the Control Chanel timeslot. It decodes a controller message assigning a trunk-to timeslot for Codeplug File Transfer.

2. On the trunk-to timeslot, the XRC 9000 and the SU exchange messages to confirm communication with one another, and the Option Board performs some checks. If communication cannot be established, or if the Option Board determines that the uploaded codeplug file does not have the correct Codeplug Version or Model information, or if the Option Board's current codeplug has the same CRC as the uploaded codeplug, the session will end prior to transferring packets. If this occurs, the RTD History Panel and the Event Log will contain information regarding the reason for the early termination.

3. If the file transfer process passes the preceding step, the controller begins to transmit file packets. The controller does not expect acknowledgement for each transmitted packet, but it does listen to the repeater uplink for messages from the destination Option Board.

4. As long as a display-capable SU remains on the assigned timeslot collecting packets, its display toggles between the Selected Contact Name and “File Transfer”.

5. The collection of packets continues until one of the following occurs:

    a. The SU collects all file packets, verifies the file integrity, and transmits a message to inform the controller of successful file transfer. The SU will then upgrade to the new codeplug.

    b. The SU collects all file packets, but cannot verify the file integrity. The SU transmits a message to inform the controller that all packets were collected, but the file CRC could not be verified. In the case, the SU will discard the codeplug.

    c. Emergency Call is started on the SU’s selected Group ID, Multigroup ID, or Emergency Revert Group ID. This will cause the controller to terminate the file transfer so that the SU can return to the Control Channel, and then join the Emergency Call.

    d. The radio user attempts to start a call. This will cause the radio to return to the Control Channel timeslot and transmit a Call Request. Upon receiving the Call Request, the XRC 9000 will end the Codeplug File Transfer.

    e. The SU’s “Unconfirmed File Transfer Dwell Time” expires and the SU hasn’t decoded a valid packet. This usually indicates the SU in is a fade condition, and it will cause the SU to return to the Control Channel timeslot when the timer expires. The SU will subsequently enter Search if it doesn’t hear anything from the Control Channel. The controller will continue to transmit file packets until one of the following occurs:

        i. The SU re-registers with same site, or registers with different network site.

        ii. The SU requests to start a call.

        iii. Emergency Call is started on the SU’s selected Group ID, Multigroup ID, or Emergency Revert Group ID.

        iv. The controller completes the current file iteration, but doesn’t decode any response from the destination SU.

6. The controller will transmit the Codeplug File for up to three consecutive iterations, but it won’t start a new iteration unless it receives a “go ahead” from the Destination SU. The SU transmits the “go ahead” between iterations when it has decoded some, but not all, of the packets.

7. If the controller has transmitted three complete iterations of the Codeplug File, it will terminate the Codeplug File Transfer, regardless of whether the SU has collected all packets or not.

It is important to understand the following additional points about how Codeplug File Transfer operates:

- When the trunk-to session ends, for any reason, the controller will show the Shut Down Reason in the RTD History (if the RTD is open), and it will create an Event Log entry indicating whether the Codeplug File Transfer was successful. The controller’s logged information can possibly be wrong. For example, if the Option Board transmits a message saying that it collected all packets and verified CRC, but the controller doesn’t decode this

message, the controller will log this as an “incomplete transfer”, when it was actually successful.

- Once the trunk-to session ends, for any reason, the controller deletes the uploaded Codeplug File. The controller will not automatically initiate a new session. It is the responsibility of the System Administrator to initiate a new session by re-uploading the file.

- If the Option Board leaves a trunk-to session with an incomplete codeplug file, for any reason, the Option Board will not automatically re-join the same trunk-to session. Furthermore, any collected packets will not carry-over to the next codeplug file session. For the next codeplug file session, the Option Board starts collecting packets from scratch. This is different than how the Option Board operates for other OTA File Transfers.

- When the Option Board has received all file packets and verified CRC, it will automatically and immediately upgrade to the new codeplug. This will prolong the interruption to service by a few additional seconds. After upgrading to the new codeplug, the Option Board must re-register back into the network.

Note: When the Option Board upgrades to the new codeplug, the information in the new codeplug completely replaces the old codeplug. This means that codeplug edits performed by the radio user (such as contacts that were added via the menu) will be lost unless the same edits were also incorporated into the new codeplug.

Determining whether or not Codeplug File Transfer was successful

It is important for the System Administrator to determine if the Codeplug File transfer session was successful or not. If the session was unsuccessful, the system does not automatically re-initiate the Codeplug File Transfer. The System Administrator must re-initiate the transfer by re-uploading the desired Option Board Codeplug File.

The System Administrator can determine whether the transfer was successful by the following means:

1. Look at the Shut Down Reason in the Real Time Display History to see if the Codeplug File Transfer was successful.

2. Look at the Event Log entry to see if the Codeplug File Transfer was successful.

3. Communicate with the radio user to see if the CRC of the current Option Board codeplug matches the CRC of the uploaded codeplug file. Instruct the radio user to look on the menu under *Utilities>Radio Info> OB OTA CPcrc*. This menu option requires a display radio, and only appears when the Option Board’s current codeplug was received over-the-air.

4. Communicate with the radio user to see if the Option Board is operating with its old or new settings. This option is available to both display and non-display radios.

5. As a last resort, there is the option to “read” the codeplug in the traditional manner using the programming cable and Connect Plus CPS. Then, compare the settings between the current codeplug and the uploaded codeplug.

2.8.7 OTA File Transfer Effects on Call Transmissions

Over-the-air File Transfer affects the SU's ability to receive calls.

- Option Board Codeplug File Transfer affects the destination unit's ability to receive calls.
- Option Board Firmware File Transfer and Network Frequency File Transfer can potentially affect all units on the site.

For this reason, it is important to understand how OTA File Transfer can impact the normal operation of the radio user:

Receiving Calls: Any time that the SU is acquiring file packets on a trunk-to timeslot, it will not see any call set-up messages that are transmitted on the Control Channel downlink. While this is true for any type of call that is received on a trunk-to timeslot, the duration of some Connect Plus File Transfers means that the SU can be "out of touch" with Control Channel messaging for an extended period of time. During this time, the SU will not receive calls.

Initiating Calls: OTA File Transfer will not prevent a SU from initiating a call. To initiate a voice call, the user must press and release the PTT button. This causes the radio to request a call on the selected Contact Name. If the radio was previously involved in a Codeplug File Transfer, it will also cause the XRC 9000 to end the file transfer session.

Even though the Connect Plus System allows call initiation during OTA File Transfer, it is important to realize that:

- The call set-up will not occur as quickly as it does when the SU is idle and monitoring the Control Channel timeslot.
- The target SU(s) might be engaged in the file transfer also. This is especially true if a Beaconed File Transfer is occurring on the site. If a target SU is involved in file transfer, it will not see the call set-up messages, and will not respond when a timeslot is assigned for the call.
- Initiating a call during Codeplug File Transfer will cause the file transfer session to end. The System Administrator will have to re-upload the file to start a new session. For this reason, it is important to communicate with the radio user prior to uploading the Codeplug File and to verify that the user can tolerate a temporary interruption to service.

2.8.8 Interaction of OTA File Transfer and Emergency Call

The Connect Plus SU allows the radio user to press the "Emergency On" button while the SU is receiving an OTA File Transfer on a trunk-to timeslot. This action will send the SU back to the Control Channel timeslot where it will transmit its Emergency Call Request on the Control Channel uplink.

Upon receiving any Emergency Call Request, the XRC 9000 performs some checks:

- If the Emergency Call is sent on the Selected Group ID, Multigroup ID, or Emergency Revert Group of any SU currently involved in OTA Option Board Codeplug File Transfer, the XRC 9000 will end the File Transfer session.

- The XRC 9000 checks to see if there is any Beaconed File Transfer (Option Board Firmware File or Network Frequency File) currently in progress. If so, the controller terminates the File Transfer. The XRC 9000 takes this action because it does not know which specific SUs are listening to the Beaconed File Transfer. When the controller terminates the File Transfer, all of the SUs that were involved in the transfer return to the Control Channel timeslot. This allows the SUs to see the call set-up messages on the Control Channel downlink and join the Emergency Call if it happens to be on a Group ID of interest.

The XRC 9000 does not automatically resume the interrupted OTA File Transfer when the Emergency Call ends. If the Network Administrator wishes to re-start the OTA File Transfer, he/she must re-upload the desired Connect Plus OTA file.

2.8.9 Selecting Optimal Conditions for OTA File Transfer

While OTA File Transfer provides many potential benefits to Connect Plus network management, it is extremely important for the Radio System Administrator to understand how it affects system and radio operation, so that he/she can select the optimal conditions for scheduling OTA File Transfer.

To provide the best opportunity for successful file transfer, and to minimize impact to normal system communications, OTA file transfers should be scheduled to occur during the trunking system's quiet hours. If possible, the radio should be placed in a stationary location with good reception and reliable power. Do not attempt to program the radio with MOTOTRBO CPS or Connect Plus CPS during an ongoing OTA file transfer.

A previous section discussed the optimal conditions for conducting a successful Codeplug File Transfer. As discussed in that section, it is important to discuss an impending Codeplug File Transfer with the radio user prior to uploading the Codeplug File.

The following sections are primarily intended to describe the optimal conditions for Beaconed File Transfers (Option Board Codeplug File and Network Frequency File).

Recommendations for the radio user:

- Leave radio on.
- For portable radio, utilize a fresh battery, or place radio in battery charger or use a "battery eliminator".
- Verify radio is in a good coverage location.
- If possible, do not pick-up the radio or make calls during OTA File Transfer.

Recommendations for the Network Administrator:

- When selecting the dedicated repeater and timeslot, consider the following:
    - Select a clear frequency that is not prone to interference.

  - If possible, select a repeater that will not have to send Base Station Identification during the File Transfer process.

- Dedicate the repeater timeslot for as long as possible. The more times the repeater sends the file, the greater the chance the file will be acquired by the largest possible number of radios.

- "Time to Begin" should be set for a date and time where the system is as quiet as possible. "Off-hours" transfers provide the best opportunity for success.

2.8.10 Assigning Repeater for OTA File Transfer

When using a dedicated channel for unconfirmed file transfer, it is recommended that "Time to Dedicate" should be set at least long enough so that the controller can send (at a minimum) three completion iterations of the file.

For this reason, it is helpful to know how long it takes the controller to transmit a single iteration of the file. Because this is related to the file size, it will take much longer to transmit a Connect Plus Option Board firmware file than a Network Frequency File.

The following equations can be used to make a rough calculation of how long it will take the controller to transmit a single iteration of a file in unconfirmed file transfer.

File size in bytes/180 = number seconds to send the file

Number of seconds to send file/60 = number of minutes to send the file

When the "Time to Dedicate Repeater" expires, the controller will complete the current file iteration prior to ending the dedicated channel transfer.

2.8.11 Special Considerations for the Network Frequency File

Special considerations for the Network Frequency File in OTA file transfer include the following:

- The Network Frequency File version number (which determines whether or not the SU will acquire an updated Frequency File OTA) is set by the individual that creates the Network Frequency File (using Connect Plus CPS). It is recommended that a single individual, such as the Network Administrator, has the responsibility for creating the Network Frequency File and managing version numbers.

- When setting a dedicated Repeater & Timeslot for OTA Network Frequency File transfer, Connect Plus recommends that the programmer configure Timeslot 2 of the Control Channel repeater as the dedicated repeater and slot.

For further recommendations and other important information about the Network Frequency File, see the section on Network Frequency File.

2.8.12 Radio User Request to Re-join OTA File Transfer

The Connect Plus Utilities Menu can be used to view its (Pending) “Updates”. The “Updates” option applies to the Option Board Firmware File and the Network Frequency File only. A “pending update” is any file that the SU is aware of, and needs, but hasn’t collected all file packets. It is also any file where the SU has received all packets, but has not yet upgraded to the new file. The “pending updates” option shows the file type and (when there is a pending file) the percentage of packets collected so far. When there is a pending file, but the Option Board has not collected all file packets, the Menu allows the radio user to request that the SU re-join an ongoing Beaconed File Transfer, even though the “File Transfer Attempt Interval” has not expired.

2.9 Busy Queue

If subscriber makes a Call Request requiring a trunk-to timeslot, the Call Request will be granted if a timeslot is available. Otherwise, the controller shall place the call in the Busy Queue and send the source radio a Busy Queue Grant on the Control Channel timeslot. The controller shall periodically re-send the Busy Queue Grant as long as the call remains in the Busy Queue. The Busy Queue Grant allows the source radio to know that its requested call is still in the queue. If the queued call is a Group Call, the Busy Queue grant also has the effect of inhibiting call requests by other radios on the same Group ID. When a trunk-to timeslot becomes available, the calls are assigned from the Busy Queue according to the following rules:

- If requested, the Emergency Call[13] is assigned to the trunk-to timeslot.
- If requested, the Emergency Location Update[14] is assigned to the trunk-to timeslot.
- The highest non-emergency priority call is assigned to the trunk-to timeslot.
- For calls of equal priority, voice calls have priority over data calls.
- For voice calls of equal priority, calls are assigned “first in, first out”.
- For data calls of equal priority, calls are assigned “first in, first out”.

When the Busy Queue is clear of all Emergency Calls and Emergency Location Updates, non-emergency calls are assigned from the queue according to the configurable priority level of the IDs involved in the call. Every Connect Plus User Record (both the Unit Record and the Group Record) has a programmable priority level, with 2 being the highest programmable priority level and 8 being the lowest programmable priority level. When the controller assigns calls from the Busy Queue, it does so according to the priority levels of the IDs contained in the Call Request. Every Call Request has a Source ID and a Destination ID. The call is assigned from the Busy Queue according to the higher of the two priorities. Site All Call requests are prioritized according to the priority of the Source ID only.

It should be noted that for non-emergency calls, a source SU can “cancel” its Busy Queue status, which allows the radio user to initiate a different type of call. Once a call request has been placed in the Busy Queue, the radio will stay in “Busy” mode until the call is assigned, or until the user

[13] Emergency Calls are placed on “Top of Queue”. When multiple Emergency Calls are in the Busy Queue, they are assigned to available timeslots on a “first in, first out basis”.

[14] When multiple Emergency Location Updates are in the Busy Queue, they are assigned to available timeslots on a “first in, first out basis”.

presses the Busy Queue Cancellation button (if programmed by the radio dealer or system administrator). If the user does not “cancel” the call request, it is likely that such call request will eventually be granted a timeslot. However, if the radio user doesn’t initiate the call, the granted call will probably will be processed as a brief, failed call, but the user will most likely not be aware of such event.

The Busy Queue cancellation button does not apply to Emergency Calls. Once accepted to the Busy Queue, the Emergency Call remains in the queue until assigned to a timeslot. The source SU will respond to the call assignment. If the emergency condition no longer exists, the radio user should verbally explain this, and then allow the Emergency Call to expire.

2.10 Network Frequency File

The Connect Plus subscriber radio stores frequency information in the Network Frequency File. This file, which is created with Connect Plus CPS, must contain the Network ID, a customer-settable version number, and the following information about each repeater in the Connect Plus network.

- Which site the repeater is located at.
- The repeater’s Radio ID (1-15). In the Connect Plus system, this equates to the channel (repeater) number.
- SU TX (Repeater RX) Frequency
- SU RX (Repeater TX) Frequency
- The repeater’s Color Code
- A checkbox to indicate if the repeater can operate as the Control Channel. Connect Plus Option Board CPS allows up to four repeaters to be checked as Control Channel repeaters, but only one of these will be active at any given time as the site’s Control Channel. When active as the Control Channel repeater, Timeslot 1 is used for Control Channel messages and Timeslot 2 is available for call assignments. When not active as the Control Channel repeater, both timeslots are available for call assignments. For more information on how the XRC 9000 determines which repeater will be the active Control Channel, see the Section, “Control Channel Rollover”. **Note**: Do not check more than one repeater as Control Channel until all Connect Plus Subscriber Units have Option Board firmware that is compatible with the Control Channel Rollover Feature (Connect Plus Release 1.1 or newer).

2.10.1 Importance of Network Frequency File

The Network Frequency File plays a crucial role in both trunking and roaming. When the Connect Plus is idle and monitoring the control channel, it continually looks for channel assignments on the control channel downlink. Among other things, these messages are used to move radios to trunk-to timeslots for Connect Plus calls. The message does not give the actual repeater frequency, because this is too long to be efficiently communicated in a short message. Instead, it gives the Repeater Radio ID (1-15) as programmed with Connect Plus CPS, as well as the assigned timeslot (1 or 2). To determine which frequency it should use, the Connect Plus SU looks up the given

Repeater Radio ID on its Network Frequency File table for the registered site. This tells the SU which frequency pair and Color Code it should use when moving to the assigned repeater and timeslot. For information on how the Connect Plus SU uses the Network Frequency File when searching for service (roaming between sites), see the "Frequencies Searched" section.

For proper operation, the Connect Plus SU's Network Frequency File must match the actual network configuration at all times. It is recommended that a single individual, such as the Network Administrator, have the responsibility for creating the Network Frequency File and managing version numbers. There are two ways the SU receives the Network Frequency File.

- During initial Connect Plus CPS programming, the SU should be loaded with the most recent Network Frequency File.
- If the Network Frequency File is changed after initial programming, there are two ways to update the file:
    - Load the updated file via the programming cable and Connect Plus CPS.
    - Update the radios via an Over-the-air File (OTA) Transfer. For more information about how the Network Frequency File is sent over-the-air, see the "Connect Plus Over-The-Air File Transfer", and specifically the "Special Considerations for the Network Frequency File" section.

2.10.2 Changes Impacting the Frequency File

Sometimes it is necessary to make changes to frequency information in the Connect Plus network. This occurs when frequency information changes, repeaters are added or removed, sites are added or removed, Control Channel information changes, Color Code information changes, etc. When this occurs, the Network Frequency File will have to be updated with the new information (and issued a higher version number). When changes such as these occur, the order that things happen is very important. For example, all radios should have the frequency information for a new repeater (via an updated Network Frequency File) before the repeater is brought on line. Recommendations are provided for some of the most common scenarios:

The recommended procedure for adding a new repeater to a site is as follows:

- Determine the frequency information, color code setting, and MOTOTRBO Radio ID (1-15) for the new repeater.
- Update the Network Frequency File with this information and increment the Network Frequency File version number.
- Upload the updated Network Frequency File to the site(s) and begin OTA File Transfer.
- Allow sufficient time for deployed radios to update to the new Network Frequency File.
- Configure and align the new repeater and connect it to the Ethernet switch shared with the trunking controller. The repeater will establish a link with the controller, after which the controller will begin assigning calls to the new repeater.

The recommended procedure for changing the frequency or Color Code configuration of an existing non-Control Channel repeater is as follows:

- Determine which information needs to be modified.
- Update the Network Frequency File with this information and increment the Network Frequency File version number.
- Prior to uploading the Network Frequency File to the network, disable the affected repeater to keep the controller from using it as a trunk-to resource. This can be done by physically disconnecting the repeater from the Ethernet switch. This will terminate communications with the controller, causing the controller to quit assigning calls to the repeater.
- Upload the updated Network Frequency File to the site(s) and begin OTA File Transfer.
- Allow sufficient time for deployed radios to update to the new Network Frequency File.
- Change the repeater configuration to match the revised information in the Network Frequency File, and connect the repeater to the Ethernet switch shared with the trunking controller. The repeater will establish a link with the controller, after which the controller will begin assigning calls to the repeater.

The recommended procedure for adding a new site to the network is as follows:

- Determine the Site Number, Repeater Radio IDs (1-15), frequency information, frequencies, repeater color codes, and control channel information for the new site.
- Update the Network Frequency File with this information and increment the Network Frequency File version number.
- Upload the updated Network Frequency File to the network and begin OTA File Transfer.
- Allow sufficient time for deployed radios to update to the new Network Frequency File.
- Configure the controller and repeaters for the new site. Connect the repeaters to the controller via the Ethernet switch.
- Update the network multi-site information (in the other Connect Plus sites) to include the Site Number and IP address of the new controller.
- In the RF-adjacent sites, add the new site number to the Neighbor Site List. This allows the RF-adjacent controllers to beacon the new Site Number in the Neighbor Site message.
- When the Option Board has the updated Network Frequency File, and has collected the new Neighbor List information, it will be ready to use the new site.

2.11 Controller Multi-Site Features

Multi-Site operation is available as a purchasable, factory-enabled permission in the Connect Plus controller. It can be activated at time of initial purchase, or remotely activated at a later date. When enabled, the controller activates certain parameters pertaining to multi-site operation that are not available single-site operation. The most of important of these settings is the ability to configure a list of networked sites.

2.11.1 Registration & De-Registration in a Multi-Site Environment

When a Connect Plus subscriber registers or de-registers with one of the site controllers, the controller forwards this information to all other site controllers. This allows all controllers to have the same information about which IDs are (or are not) currently registered into the network.

2.11.2 Call Processing & Set-up in a Multi-Site Environment

When the controller receives a Call Request, it must know if the Destination ID is registered into the network, and – if so – at which site(s). The controller has this information because a registration or de-registration received by any site controller is forwarded to all other site controllers.

It's quite possible that multiple controllers will have a role in Connect Plus call set-up. Calls to an individual ID can involve up to two sites, the source site and the destination site. Calls to Group IDs will involve every network site where the Group ID is presently registered. Multi-site call set-up is initiated via TCP/IP control messages that are exchanged between the involved sites.

A site that receives a voice transmission must duplicate the received UDP/IP voice packets and forward them to every network site where the Destination ID is currently registered. It is possible that multiple radios involved in the same call (but located at different sites) will begin to transmit at the same time, or at nearly the same time. For this reason, the controllers involved in a multi-site voice call follow a key-up arbitration procedure. The arbitration process necessitates a brief (configurable) delay before a controller forwards received voice packets to one of its connected repeaters for OTA transmission, but it greatly increases the chances that the same audio will be heard at each participating site.

When a controller has an undelivered text message for an SU, and the controller learns via network messaging that the SU has registered to a different site, the controller will forward the text message to the SU's new site. The controller at the new site will attempt delivery at the earliest opportunity.

When a controller has Location Request for an SU, and the controller learns via network messaging that the SU has registered to a different site, the controller will forward the Location Request to the SU's new site. For a single request, the new site will transmit the request at the earliest opportunity. For a periodic request, the new site will transmit the first request at the earliest opportunity, and then repeat the request at the requested interval.

2.12 Roam (Site Search) in Connect Plus System

The Connect Plus subscriber unit will automatically roam (search for service), and upon locating an acceptable site, will automatically request registration with the Connect Plus site.

2.12.1 Events that Initiate Site Search

The following events cause the subscriber to initiate the search process:

- Radio is powered-up in a Connect Plus zone.
- Radio user selects a Connect Plus zone (or changes from one Connect Plus zone to a different Connect Plus zone).

- Radio is registered to a Connect Plus site, but does not decode a Control Channel message before its programmable “CSBK Roam Delay Time” expires. This can occur for a number of reasons, such as (1) radio is in a low-signal location, (2) site is doing Control Channel Rollover, and (3) site equipment is experiencing problems.

- Radio is registered to a Connect Plus site, but RSSI from the Control Channel repeater is at or below the programmable “RSSI Minimum” threshold. This causes the SU to start its programmable, “RSSI Roam Delay Timer”. If this timer expires and the Control Channel RSSI has not risen above the “RSSI Minimum”, the SU initiates the search process.

2.12.2 When Connect Plus Radio Will not Initiate Search

The Connect Plus SU will not initiate Search in the following circumstances:

- The Connect Plus SU will not initiate Search while it is attempting to initiate a call on the Control Channel timeslot. If RF conditions are poor, it is possible that the call attempt will fail – after which the SU may initiate search for one of the previously described reasons.

- The Connect Plus SU will not initiate Search while it is Busy Queue Wait State on the Control Channel timeslot. The SU’s (non-configurable) Busy Queue Wait timer must first expire.

- The SU will not initiate Search while participating in a call-in-progress on a trunk-to timeslot. If the SU loses signal from the trunk-to timeslot, it will return to the Control Channel timeslot. If the Control Channel signal does meet the previously discussed requirements, the radio will initiate Search.

2.12.3 Frequencies Searched

The Connect Plus SU stores frequency information in the Network Frequency File. The Network Frequency File is used both for single-site and multi-site networks. For general information about the file and how it is created, see the “Network Frequency File” section. This section will discuss its role in search process only.

When the SU is searching for service, it only searches frequencies that are flagged in the Network Frequency File as “Control Channel”. The general rule is that the Connect Plus SU searches all of a site’s possible Control Channels (as flagged in the Network Frequency File) before it proceeds to search the next site. The order that sites are searched depends on several variables. This includes the following:

- **Preferred Site:** For each Connect Plus zone, the SU is configured with a “Preferred Site”. The Control Channel(s) for the “preferred site” receive a heavier weighting in the search algorithm (meaning that it is searched more frequently). The Preferred Site is searched in the following circumstances:

    - After initial Connect Plus CPS programming, it is the first site searched when the user first powers-up in (or selects) that Connect Plus zone.

- It remains the first site searched (power up, zone selection, losing signal from a site, etc), if “Preferred Last Registered” has not been enabled via Connect Plus CPS programming for that Connect Plus zone.

- Even if “Preferred Last Registered” Site has been enabled via Connect Plus CPS programming for that Connect Plus zone, the “Preferred Site” is searched more frequently than other sites (except for the Last Registered site).

- **Last Registered:** The Connect Plus SU stores the Site Number where it last successfully registered. This information is stored in persistent memory, so that it will be maintained through a power cycle. This Last Registered Site receives a heavier weighting in the search algorithm. This weighting can be increased even further by enabling “Prefer Last Registered” via Connect Plus CPS (a programmable option per Connect Plus zone). When “Prefer Last Registered” is enabled, the Last Registered Site becomes the first site searched upon power up, zone selection, losing signal from a site, etc. Of course, this assumes that radio has successfully registered somewhere. If not, the “Preferred Site” is searched.

- **Neighbor List Collection:** When a Connect Plus SU is registered to a site, it collects the “Neighbor List” that is transmitted by the site’s control channel. The Neighbor List consists of up to 5 site numbers for sites that are RF-adjacent to the site transmitting the Neighbor List. This Neighbor List is configured by using the XRC 9000 Network Manager Software. When a Connect Plus SU loses signal from a site, it first searches the “Preferred” or “Last Registered” site (as determined through Connect Plus CPS programming). If an acceptable signal is not found, the SU proceeds to search the Control Channels of the most recently collected Neighbor List. In doing so, the sites are searched in the order that they configured via the Network Manager. The Connect Plus SU can store Neighbor Lists collected from up to 10 different Connect Plus sites. The lists are searched in “last collected, first searched order”. If the SU should ever collect Neighbor Lists from more than 10 different sites, the oldest Neighbor List will “fall out” to make room for the most-recently collected Neighbor List. An example of a Neighbor List configuration is shown in Figure 2-5.

- **Other Sites pulled from the Network Frequency File:** As the Connect Plus SU searches for service, it will periodically search the Control Channel(s) for other Connect Plus sites pulled from the Network Frequency File. If a search goes on long enough (without locating an acceptable site and signal), the SU will eventually search every Control Channel for every site in the Connect Plus network.

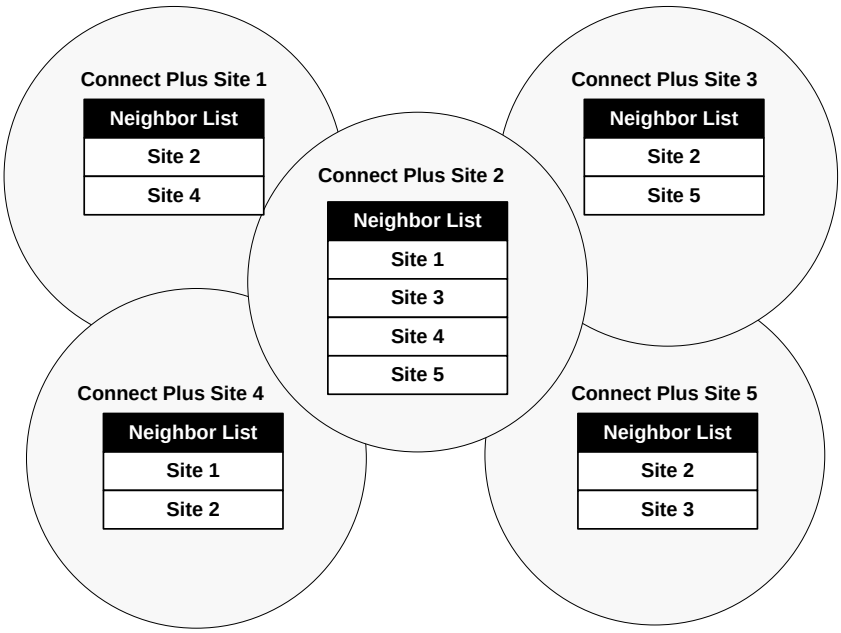


Figure 2-5 Connect Plus Neighbor List Example

2.12.4 Qualifying Searched Sites

As the Connect Plus SU moves through the frequencies on its search list, it listens to each frequency for the "Roam Dwell Time" as configured via Connect Plus CPS programming. This setting is configurable per Connect Plus zone. Because Control Channels transmit continuously, this is a fairly short timer (240 to 1200 ms). If digital signaling is detected, the radio waits an additional time to identify the site and network (via Connect Plus control channel messaging) and to measure RSSI. If this time expires and the radio has not detected digital signaling, it then proceeds to search the next frequency on the list. It should be noted that the IP Site Connect Beacon message is not used in Connect Plus. The IP Site Beacon Duration should be set to "Disabled" in the CPS codeplug of all Connect Plus repeaters.

If digital signaling is detected, the SU will wait on the frequency long enough to determine the Network ID and the Site Number of the Control Channel it is hearing. This information is sent every 120ms on the Control Channel downlink. If the Network ID transmitted by the Control Channel agrees with the Network ID programmed into the SU via Connect Plus CPS, the SU proceeds to measure the Control Channel RSSI. If the RSSI is equal to or greater than the "Preferred RSSI" as programmed for the Connect Plus zone via Connect Plus CPS, the SU will transmit a registration request to the site controller on the Control Channel uplink. Because the Network ID and RSSI are important parts of qualifying a site, they are discussed in greater detail in the sections that follow.

2.12.5 Roam Request

"Roam Request" can be enabled via a programmable Connect Plus button press. Roam Request allows the radio user to request the radio to enter "Search" mode and look for another network site, even when the signal from the currently registered site is acceptable according to the currently programmed Roam parameters. When Roam Request is activated, the SU will search all possible sites until an acceptable site is found. In doing so, the radio will not search the current site until all other sites have been exhausted.

2.12.6 Radio Operation during Search

A Connect Plus radio cannot make and receive calls unless it registered to a Connect Plus site. When the Connect Plus SU is searching for service, it is not registered with any Connect Plus site. If the user attempts to initiate a non-emergency call by pressing PTT, the radio will give a denial tone. If the user attempts to initiate a non-emergency call via the Menu, the display will show "Not Registered".

The Connect Plus SU does allow the radio user to press the "Emergency On" button while the radio is Searching. Although the SU will not be able to immediately send the Emergency Call Request in this scenario, it will buffer the request until it successfully registers with a Connect Plus site, after which the SU will immediately and automatically transmit the Emergency Call Request. If the radio user changes his/her mind about the Emergency before the SU locates a site, registers, and sends the Emergency Call request, he/she should press the "Emergency Off" button to cancel. Once the radio registers with a site and sends the Emergency Call request, the user will not be able to cancel by pressing "Emergency Off". When the Emergency Call is assigned to a trunk-to timeslot, the radio user should verbally explain that there is not an actual emergency, and then allow the Emergency Call to expire.

While the Connect Plus SU is searching, the top LED blinks yellow in a "double flash" pattern.

While the Connect Plus SU is searching, display-enabled radios activate the Roaming icon and display the word "Searching".

2.12.7 Indications of Successful Registration

When a Connect Plus radio successfully registers with a site, it sounds a short registration beep and briefly displays the registered Site Number in the radio display. The LED flashes green while the radio is monitoring the Control Channel downlink. If not currently engaged in another Menu Display, the radio display shows the "Contact Name" for the selected channel knob position (portable) or rocker knob position (mobile).

After completing registration with a site, the Connect Plus SU does not continue to display the registered site number. However, selecting the *Utilities>Radio info>Site Number* menu option causes a display-equipped radio show the registered site number (or "Not Registered", if the SU is searching for service).

2.12.8 Reacquiring the Same Site after Period of Fade

When the radio loses acceptable signal from its current site and begins searching, a countdown timer is set to the value configured in the “Reacquire Time” setting. This is a programmable Zone parameter with Connect Plus CPS. If during the search process the radio again finds the site it just lost and this timer has not expired and the radio has not attempted to register at another site, the radio returns to the registered state without transmitting a registration request (or sounding the registration beep). If the Reacquire Time has expired, the radio must complete a normal registration before it can use the site. This feature can help reduce registration traffic on the Control Channel and extend portable battery life.

2.12.9 Site Restriction

Beginning with Release 1.1, Connect Plus provides the ability to configure, via the Connect Plus Network Manager, which network sites can (and cannot) be used by the Connect Plus Subscriber Radio. The Site Restriction feature is useful for cases when a Connect Plus SU should not be allowed to use certain network sites (such as when the disallowed sites are under different ownership.) The feature provides the ability to update the list of allowed/disallowed sites via the Network Manager without having to re-program the Subscriber Unit. The terms “restricted site” and “disallowed site” are used interchangeably.

Each SU record in the Network Manager user database provides a “Site Privileges” tab with a list of sites that have been configured in the Connect Plus network. Each site number with a checkmark next to it is an allowable site for that SU. Each site number without a checkmark is a disallowed site for that SU. By default, all sites are allowed for every SU.

For any Connect Plus SU with legacy Option Board firmware (prior to Connect Plus Release 1.1), all sites must remain as allowed sites. Attempting to disallow a site for a Connect Plus SU with legacy Option Board firmware will result in undesirable operation. It will be necessary to upgrade the SU to Option Board firmware that is Release 1.1 or newer prior to disallowing any network sites.

A Connect Plus SU must make at least one attempt to register with a disallowed site in order to learn that it is not allowed to use the site. When the XRC 9000 receives a registration request from a Connect Plus SU, its first check is whether the radio’s UID and Group ID exist in the controller’s database. If not, the controller sends a message to disable the SU. If the UID and Group ID exist in the database, the next check is to see whether the present site is allowed or disallowed for the registering SU. If disallowed, the XRC 9000 responds to the registration by informing the SU that it is attempting to register on a disallowed site. When the Connect Plus SU receives this response, it provides a special tone to inform the user that the site is not allowed. Display radios also briefly show a message that “Site ‘x’ is Not Allowed”. Then, the Connect Plus SU goes back into Search to look for another site. The Option Board places the disallowed site on an internal blacklist. As long as the site remains on its internal blacklist, the Connect Plus SU will not make any further attempts to register with the disallowed site.

By design, the SU keeps its list of disallowed sites in volatile memory only. The SU clears the list of disallowed sites upon any event that causes an Option Board reset. This includes power cycling the radio, programming the radio or Option Board, etc. After the Option Board clears its internal site blacklist, it will once again attempt to register with any network site. If the user record still shows that the site is “disallowed”, the process starts over. However, if the user record has been updated so that the site is now listed as an “allowed site”, the registration will be allowed, provided that the radio passes all of the normal registration checks.

It is important to understand the following about how the Site Restriction feature works in Connect Plus:

1. If the Connect Plus SU is currently registered to a site, and the user record is edited to make it a disallowed site, the SU will remain registered to the site until its next registration attempt. Any event that normally causes a new Connect Plus registration (such as the user changing the selected Talk Group), will cause the SU to be informed that the site is now disallowed.

2. If the Connect Plus SU has been informed, via the registration response, that a site is disallowed, and then the System Administrator subsequently changes the user record to make it an allowed site, the Connect Plus SU will still not attempt to use the site until the internal site blacklist is cleared. The following actions will clear the blacklist; cycling power on the SU, replacing the battery, programming the radio or Option Board, etc.

3. If the controller sees that a SU is attempting to register on a disallowed site, it informs the SU of this in its registration response. The controller does not perform the other database checks for the SU (such as the ESN check). These checks are only performed and enforced when the XRC 9000 receiving the registration request is an allowed site for the SU.

4. It is important to understand the interaction between Connect Plus Site Restriction and other Connect Plus features that limit Roaming:

    a. **Disable Roam checkbox in Connect Plus CPS**: Checking the “Disable Roam” checkbox in Connect Plus CPS tells the SU that it can only Search its “Preferred Site” number (also configured with Connect Plus CPS) while selected to that Connect Plus zone. If the Connect Plus SU has been programmed in this manner, do not restrict this same site number in the SU’s user record with the Network Manager. Doing so would prevent the SU from using any network site.

    b. **Site Lock button**: Connect Plus CPS provides the ability to configure a Site Lock button. When the SU is registered to a site, and Site Lock is engaged, the SU will not search any other site number until Site Lock is disengaged. If a SU is registered to a site, and then the same site is configured as disallowed on the SU’s site list in the Network Manager, the SU will discover this on its next registration attempt with the site (such as when the radio user selects a different Talk Group). If this were to occur, the radio would then be “locked” to a disallowed site (and therefore not using any site) until the Site Lock button is disengaged. Power cycling the radio also disengages Site Lock.

5. When viewing an SU’s Site Privilege list via the Network Manager, sites normally display in black text. If a site displays in red text, this indicates that the Site Number on the SU’s Site Privilege list is not found on the Multisite Table of the connected site. This would most likely occur when the site in red is being added to (or removed from) the network.

    a. If the site in red is being added to the network, add the site information to the Multisite Site table of the connected site.

    b. If the site is red is being removed from the network, delete the site from the SU’s Site Privileges list. (To view the delete option, right click on the site number displayed in red text.)

2.12.10 Disable Roam

There are some applications in which the system administrator does not want a subscriber unit to roam between Connect Plus sites. Possible examples are when the Connect Plus system consists of only a single site, or when the SU is being used as stationary dispatch radio. In these instances, the desired behavior is for the SU to remain on the “Preferred Site” that has been configured for the selected Connect Plus zone. When “Disable Roam” is enabled with Connect Plus CPS, the radio will search only the Preferred Site. It is important to remember that even when the “Disable Roam” box is checked, the SU may still enter a state where “Searching” will be shown on the display. This occurs prior to registration with the Preferred Site, or when the SU experiences a loss of Control Channel messaging and the “CSBK Roam Delay” expires, or if Control Chanel RSSI qualifications are not met. However, in this state, the SU will only be searching for its Preferred Site. It will not search any sites that may have been acquired through a Neighbor Site message or the Network Frequency File. Because “Disable Roam” is configurable for each Connect Plus zone, it is possible to restrict searching to the Preferred Site in some zones, while allowing normal roam functionality in others.

2.12.11 Site Lock

In certain situations, the user may have the desire to lock on to a registered site and to prevent the subscriber unit from searching other sites. For example, if the user enters an elevator, the user has knowledge that the radio will have reduced signal strength for a brief period of time. In this scenario, the user may wish to enable Site Lock. Site Lock does not prevent the radio from entering search if the signal from the registered site becomes unacceptable, but it does restrict the radio’s search to the site where the radio was registered at the time Site Lock was engaged. This can help the radio return to the registered state (on the desired site) more quickly when the radio re-enters acceptable coverage. Site Lock can be enabled through a configurable short or long button press. When Site Lock is activated, display radios briefly show the message, “Site Locked”. When Site Lock is de-activated, display radios briefly show the message “Site Unlocked”. Site Lock cannot be activated unless the radio is currently registered to a Connect Plus site. If the user attempts to activate “Site Lock” while in the un-registered state (searching for service), the radio will not activate the feature or display, “Site Locked”. When power is recycled, or when the radio user selects a different Connect Plus zone, the SU automatically returns to the “Site Unlocked” state, which allows the radio to search normally. While the Site Lock feature can be helpful in situations such as the one described in this example, a potential drawback is that the radio user may forget to disable “Site Lock”, thereby preventing the radio from searching other sites in scenarios where this operation would be desirable.

2.12.12 Connect Plus Performance While Roaming

The Connect Plus radio’s ability to automatically search for an acceptable Connect Plus site provides obvious and substantial benefits to the radio user. Even so, it is important to remember that the radio is not registered with any site from the time it initiates Search until it registers with a new site (or re-acquires the previous site). During this time (while the radio is searching), the radio user cannot make or receive calls. For this reason, RSSI thresholds and other Roam settings should be determined with consideration and care. Once the desired settings have been determined, they should not be programmed into large numbers of radios until the desired operation has been confirmed in a smaller set of test radios.

2.12.13 Programmable RSSI Settings

Received Signal Strength Indication (RSSI) is used by the Connect Plus radio to measure Control Channel signal strength. It is determined by measuring the received signal on the Control Channel downlink. RSSI is measured in dBm. Because RSSI is reported using negative numbers, it essentially uses a "reverse" scale where smaller numbers indicate greater signal strength. Connect Plus CPS provides two configurable RSSI Thresholds (RSSI Preferred and RSSI Minimum) and a programmable timer, the RSSI Wait Time. These programmable parameters are utilized by the Connect SU in the following manner:

- The Connect Plus SU will not attempt registration with a site unless the Control Channel RSSI is at the "RSSI Preferred" value, or higher, as configured in the selected Zone Parameters with Connect Plus CPS. When the SU is searching and detects a site that meets "RSSI Preferred", the radio stops its Search and transmits a Registration Request to the site. The Connect Plus SU will not bypass a site that meets "RSSI Preferred" to see if there is a stronger site further down the search list.

- Once registered to a site, the Connect Plus SU continues to measure the Site's RSSI every 3 seconds anytime that the SU is idle and monitoring the Control Channel frequency. If the reported RSSI is ever less than or equal to the "RSSI Minimum" as configured in the selected Zone Parameters with Connect Plus CPS, the Connect Plus SU starts the "RSSI Wait Time" as configured in the selected Zone Parameters with Connect Plus CPS. If the RSSI rises above "RSSI Minimum" prior to expiration of this timer, the radio remains on its registered Control Channel and site. If the "RSSI Wait Time" expires, and the reported RSSI is still less than or equal to the "RSSI minimum", the Connect Plus radio enters search, even if "CSBK Roam Delay Time" has not expired.

There are several common site configurations that are employed when installing a two-way radio communication system.

1. **Dense Overlapping Coverage (Urban)** – This type of RF coverage consists of sites located close to each, which necessitates utilizing different frequencies for the neighboring sites; refer to Figure 2-6. The non-overlapping sites may reuse the frequencies, but must use different color codes to be identified by the subscribers during roaming. A radio user transitions from one site to another within 10-15 minutes.

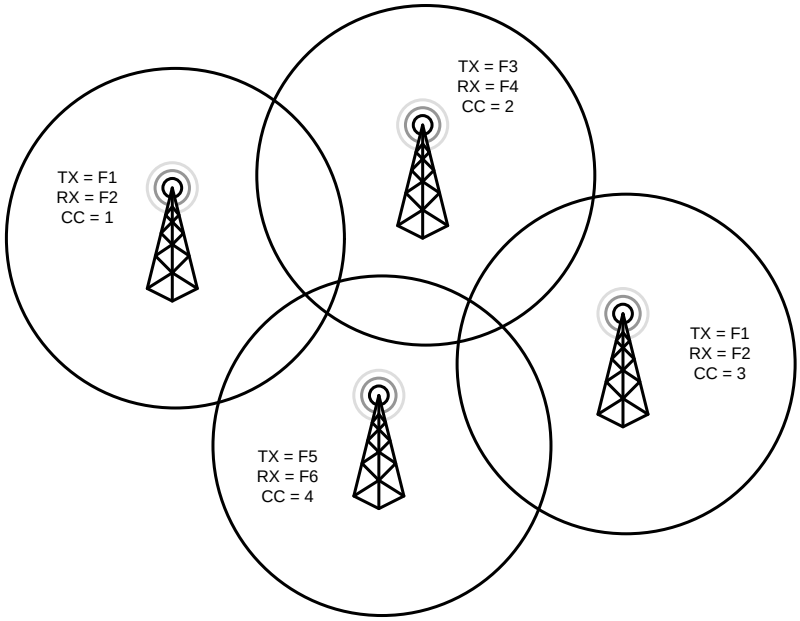


Figure 2-6 Dense Overlapping Coverage (Urban)

2. **Isolated Non-Overlapping Coverage (Rural)** – This type of coverage is representative for rural communities, where sites are separate by considerable distance thus proving non-overlapping RF coverage; refer to Figure 2-7. The non-overlapping sites may reuse the frequencies, but must use different color codes to be identified by the subscribers during roaming. A subscriber will only be with coverage of one site at a time. A radio user transitions from one site to another within several hours.

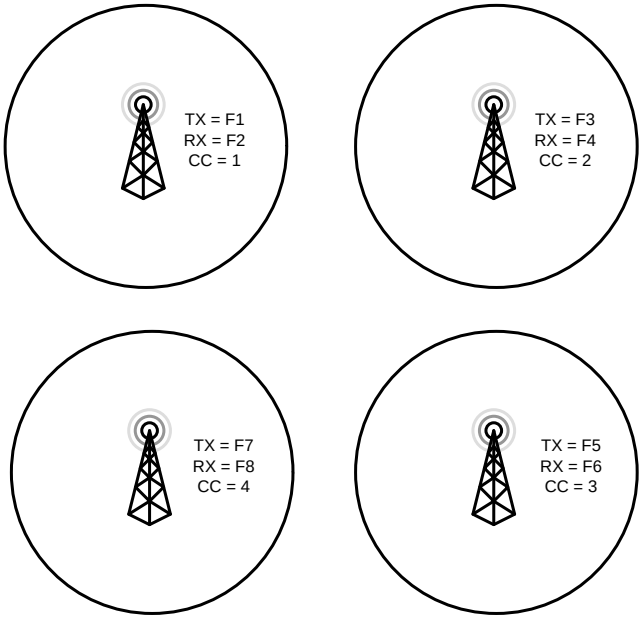


Figure 2-7 Isolated Non-Overlapping Coverage (Rural)

3. **Corridor Coverage** – This type of coverage consists of sites that are placed along various transportation passages, such as roads, train tracks, shore lines, rivers and canals. In such site configuration a pair of adjacent sites overlaps in RF coverage; refer to Figure 2-8. The non-overlapping sites may reuse the frequencies, but must use different color codes to be identified by the subscribers during roaming. A radio user transitions from one site to another within an hour.

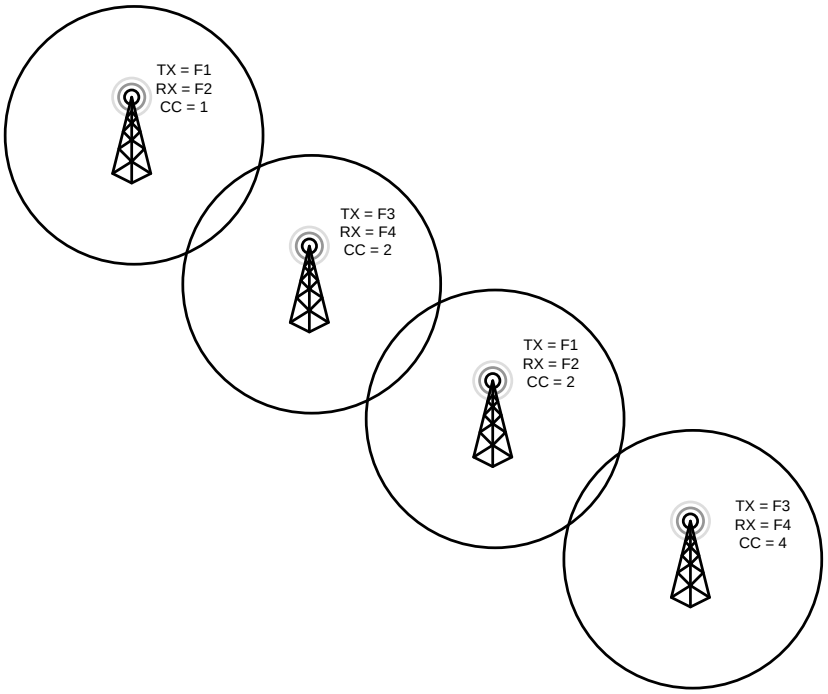


Figure 2-8 Corridor Coverage

4. **Multi-Story Building Coverage** – This type of coverage consists of sites that are situated extremely close to each other with short range coverage and overlap across all sites; refer to Figure 2-9. Such coverage is mostly utilized in multi-story buildings, but can be encountered in other man-made structures, such as tunnels, large vessels or underground passageways. Frequency reuse is not common due to the small coverage footprint usually implemented with in-building radiax antenna systems. Users in such RF coverage also often experience quick signal strength drop offs due to the nature of in building coverage. A radio will only be within coverage of one to two sites at a time. The time it takes a radio user to move from the coverage of one site to another is in the range of one minute.

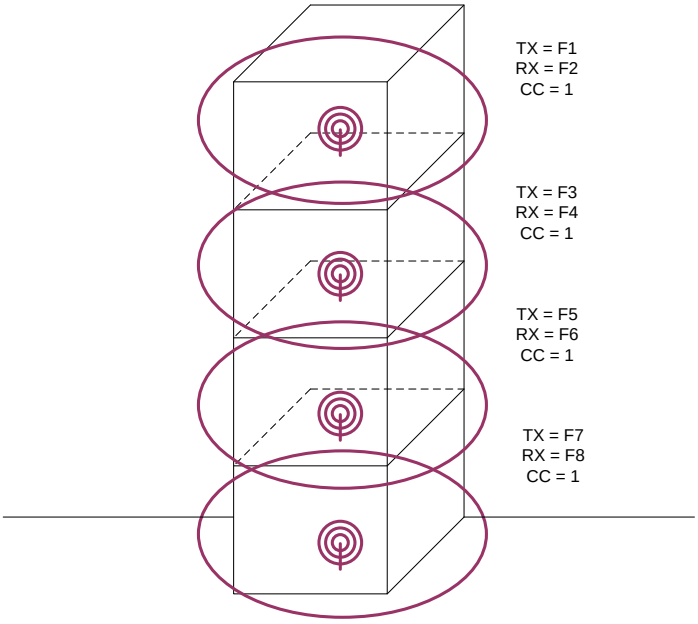


Figure 2-9 Multi-Story Coverage

Depending on the site configuration, the RSSI Preferred and RSSI Minimum values will be set differently; RSSI Wait Time[15] should be set accordingly as well, such that it does not exceed the expected site transition time corresponding to the coverage configuration.

For example, if the customer has a “Isolated Non-Overlapping Coverage” the RSSI Preferred and RSSI Minimum can be set to lowest values allowed by Connect Plus CPS (-120dBm). Since there is no overlap, there is no reason for the radio to start roaming until well outside of the coverage range of the Control Channel repeater. For extremely close sites with large overlap and quick signal drop off like the “Multi-Story Coverage”, it might be better to set to these to higher values, so that the radios will search for stronger sites closer to the repeater. However, note that for such configuration the system designer may take the approach of installing a single site where the Control Channel repeater can be placed in the center of the desired coverage (e.g. middle floor). This of course would be possible when 15 repeaters, or in other words 29 channels, can satisfy the customer communication needs.

The following table provides the suggested settings for each basic site configuration. Many radio systems will have a combination of site configurations so the system designer will need to take all configurations into consideration and choose an appropriate value.

[15] Also refer to CSBK Roam Delay Time.

Site Configuration	Recommended RSSI Preferred	Recommended RSSI Minimum	Recommended RSSI Wait Time	% of Outer Range Radio will Scan
Isolated Non-Overlapping Coverage (Rural)	-120 dBm	-120 dBm	120 seconds	Out of Range
Corridor Coverage	-110 dBm	-115 dBm	90 seconds	10 %
Dense Overlapping Coverage (Urban)	-108 dBm	-113 dBm	30 seconds	20 %
Multi-Story Coverage	-102 dBm	-107 dBm	10 seconds	50 %

Table 2-2 Recommended RSSI Settings

Note that the listed RSSI settings assume the outbound and inbound RF coverage of the system is balanced. In other words, when a radio is within good outbound coverage of the repeater the radio's inbound transmission can reach the repeater. Since the roaming algorithm uses the outbound transmission to determine when to roam, having an unbalanced system can cause radios not to roam even though they can no longer reach the repeater. This can lead to radio transmissions that do not reach the repeater and are therefore not repeated.

One method to rectify this problem is to lower the output power of the repeater. This decreases the outbound coverage area, but ensures that if a subscriber can hear the repeater well, it can respond successfully. If lowering the output power is not desirable, the RSSI threshold values need to be raised higher (less negative) than the recommended values. This forces the radios to roam to another site within very good RF coverage of another. This value may be different for portables and mobiles since they have different output power and therefore different inbound coverage. Portables may need a higher (less negative) RSSI threshold than mobiles.

Also note that there is one set of RSSI values per Connect Plus zone. This means that if one zone has an inbound outbound imbalance and another does not, it may be difficult to find the optimal RSSI settings to accommodate both zones.

2.12.14 CSBK Roam Delay Time

The Connect Plus radio has another configurable timer that affects when the radio starts to Search. It is called the "CSBK Roam Delay Time", and is programmable per Connect Plus Zone with Connect Plus CPS. This programmable setting determines how long the radio will continue to listen to the current Control Channel when it doesn't decode any valid Control Channel messages. If the timer expires, and the radio hasn't decoded a valid message, the radio starts to search, even if "RSSI Wait Time" has not expired.

2.13 Group Scan in Connect Plus System

MOTOTRBO Connect Plus supports a Group Scan feature. The Group Scan feature allows the subscriber unit to monitor and join calls for Groups other than its Registered Group(s). With conventional radio (non-trunked), the term "scan" usually refers to the ability to scan through a list of channels (i.e. frequencies) and then park on a channel when activity is found. This is NOT what the Connect Plus trunking subscriber unit does while scanning. Connect Plus scan is more akin to the feature known as "Group Scan" in other MOTOTRBO digital modes. In Connect Plus, the SU monitors a single frequency and slot (the Control Channel), as it listens for a number of different Group IDs. Once it detects a channel assignment message for a Group of interest, the Connect Plus subscriber unit moves to the frequency and slot indicated in the message. This process is described in greater detail in subsequent sections.

There are two types of Group Scan in Connect Plus:

- Automatic Group Scan
- Selectable Group Scan

2.13.1 Automatic Group Scan

Automatic Group Scan is the *default operating mode* of the Connect Plus SU. This means that this is how the Connect Plus SU normally functions and requires no user intervention to activate. In addition, this mode cannot be disabled by the user.

All Connect Plus subscriber units continuously monitor the control channel timeslot when not actively engaged in a call (receiving or transmitting on a trunk-to timeslot). While scanning, the subscriber unit listens for and responds to call assignment messages for the following IDs:

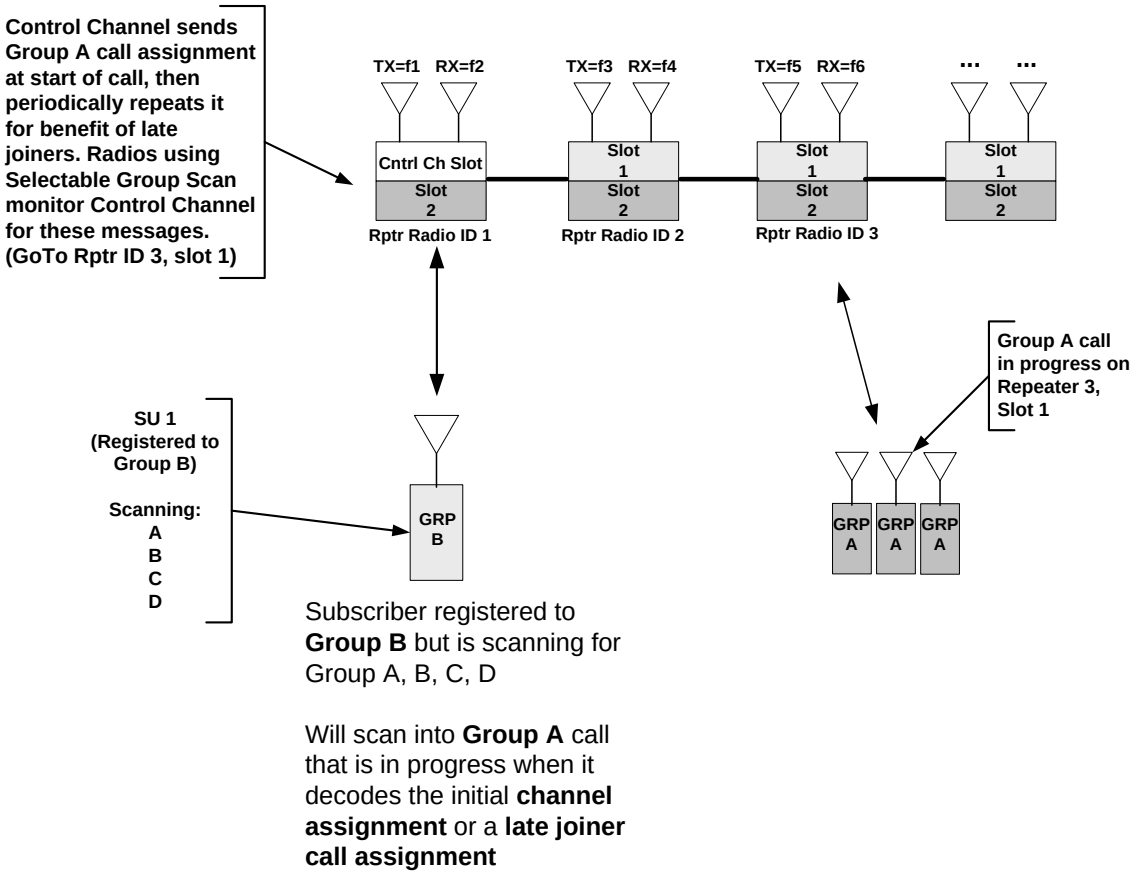
1. Its Unit ID (private calls, text messages, etc)
2. Its Registered Group ID
3. The Site All Call ID
4. Its Multigroup ID (if configured)
5. Emergency Calls on its Default Emergency Revert Group ID (if configured)

This type of scanning is automatic, continuously active, and is called “Automatic Scan”.
If the Connect Plus SU detects an active call (either in-progress, or during call setup) for one of these IDs, it will join the call. This is the normal, default mode for the Connect Plus SU. This feature cannot be turned off.

In addition to Automatic Group Scan, the subscriber unit may be programmed for *Selectable Group Scan*. This scanning functionality is what most users would normally associate with the term “Group Scan”. The remainder of this section will detail Selectable Group Scan.

2.13.2 Selectable Group Scan

Selectable Group Scan can be configured for each subscriber unit in MOTOTRBO Connect Plus Option Board CPS and is an optional configuration item. This type of scanning allows the Connect Plus SU to monitor additional Groups to those normally monitored using automatic scan (see above for details on automatic scan). Each Connect Plus zone may have a scan list configured.



Subscriber registered to **Group B** but is scanning for Group A, B, C, D

Will scan into **Group A** call that is in progress when it decodes the initial **channel assignment** or a **late joiner call assignment**

Figure 2-10 Connect Plus Selectable Group Scan

When Selectable Group Scan is enabled for a subscriber unit, the SU is programmed with a scan list. This scan list determines which Groups that the Connect Plus SU will be able to scan into.

When scanning, the radio will scan into calls on a first-come, first-served basis. Upon decoding a call assignment message for any of the IDs in its scan list, the Connect Plus SU will move to the trunk-to timeslot provided in the message. Scanning is “first come, first-served” in that the Connect Plus SU responds to the first of these messages for any ID in its scan list. While on the trunk-to timeslot, the subscriber unit will not hear calls on the other IDs. This is because the trunk channel timeslot does not transmit messages about calls-in-progress on other timeslots.

Figure 2-10 above shows a Connect Plus SU that is registered to Group B and is monitoring the control channel timeslot. If this subscriber unit decodes a call assignment message for any of its configured scan groups it will switch to the repeater and trunk-to timeslot in the assignment and monitor the call.

2.13.3 Participating in Selectable Scan Calls

While scanned into a call that is not its registered Group, the Connect Plus SU can participate as would any other user by pressing the PTT during the call hang time period. When transmitting, the SU will use the same ID as the scanned call. However, if the radio user presses PTT after the call hang time expires, the SU will request to start a new voice call on its currently selected Contact Name. This may be a different ID than the scanned ID of the previous call.

2.13.4 Radio Indications during Selectable Group Scan

When Selectable Group Scan is turned-on, the Connect Plus SU has the following indications:

- When scan is turned on via the programmable button or menu option, the display will show "Scan On" momentarily (display radios only).
- The radio provides a tone that ascends in pitch
- The display shows the scan icon (display radios only).
- While the radio is monitoring the control channel timeslot with Selectable Group Scan active, the top LED blinks orange. While listening to a call on a trunk-to timeslot, the LED operates as it normally does for the call type.

2.13.5 Radio Indications when turning off Selectable Group Scan

When Selectable Group Scan is turned-off, the Connect Plus SU has the following indications:

- When scan is turned off via the programmable button or menu option, the display will show "Scan Off" momentarily (display radios only).
- The radio provides a tone that descends in pitch
- The display no longer shows the scan icon
- While the radio is monitoring the control channel timeslot with Selectable Group Scan turned off, the top LED blinks green.

2.13.6 Rules Governing Selectable Group Scan

There are a number of rules that govern Selectable Group Scan. If these are not well understood, then some system behavior might be interpreted as malfunctions or nuisances.

2.13.6.1 Limited to "Preferred Site"

Each Connect Plus zone has a programmable parameter called "Preferred Site", which is configured into the Connect Plus SU using MOTOTRBO Connect Plus Option Board CPS.

The Connect Plus SU must be registered at its Preferred Site for the currently selected zone for Selectable Group Scan to function. If the radio is registered to any site that is not its Preferred Site, the radio scans only those IDs discussed in the Section, "Automatic Group Scan".

Since "Preferred Site" is a zone parameter in Connect Plus, different Connect Plus zones can be configured with a different "Preferred Site". This is especially useful for a subscriber unit that will be utilizing multiple single-site systems. Each of these systems can be programmed into a different

Connect Plus zone. In this configuration each single site can be treated as a “Preferred Site” with Selectable Group Scan available.

2.13.6.2 User Notification at Non-Preferred Sites

In Connect Plus multisite, the subscriber unit is not typically programmed with a different Connect Plus zone for each site. The most common configuration is for the Connect Plus SU to automatically roam to multiple sites while selected to a single Connect Plus zone. In this configuration, the subscriber unit will be visiting sites that are not its “Preferred Site” for the currently selected zone. If the user attempts to enable Selectable Group Scan when not registered to the Preferred Site, the SU will provide an error tone and the display will momentarily show “Scan Not Available”. Non-display radios will receive only the error tone.

Selectable Group Scan is also automatically disabled if the Connect Plus SU enters search mode due to low RSSI or loss of signal while registered on the Preferred Site. Once the subscriber unit returns to the Preferred Site, the Selectable Group Scan feature is re-enabled automatically.

2.13.6.3 Must Assign Groups to a Knob Position

The Connect Plus Option Board CPS enforces the requirement that a contact must be assigned to a Channel Selector Knob position (portable radio) or Channel Rocker position (mobile radio) in order for it to be placed on the scan list. If a contact is not assigned to a channel selector knob position, it will not appear in the “Add” column of the “Zone > Scan” configuration window (see “Enabling Selectable Group Scan” below). This requirement ensures that the radio user will be able to select and start a call on the scanned Group if he/she cannot respond to a call prior to expiration of the call hang time. Because of this requirement, the number of members on the selectable scan list will always be less than or equal to the number of Channel Selector Knob (or Channel Rocker) positions assigned with MOTOTRBO Connect Plus Option Board CPS (up to a maximum of 16).

2.13.7 Missed Calls

The Connect Plus SU misses calls for IDs in its selectable scan list under the following conditions:

- User has disabled the scan feature via the programmable button or menu option.
- Subscriber Unit is not monitoring the control channel timeslot (already engaged in a call on a trunk-to timeslot).
- No member of the target Group is registered at the site.
- Subscriber Unit is not at their Preferred Site (multisite systems).

2.13.8 Multisite Considerations with Group Scan

When implemented in a single-site system, Selectable Group Scan is highly reliable and robust. However, when implemented in a multisite system, there are situations that cause the subscriber unit to miss calls in their scan list. The primary reason for this is that *audio is not provided to sites that do not have a Group member registered at the site*.

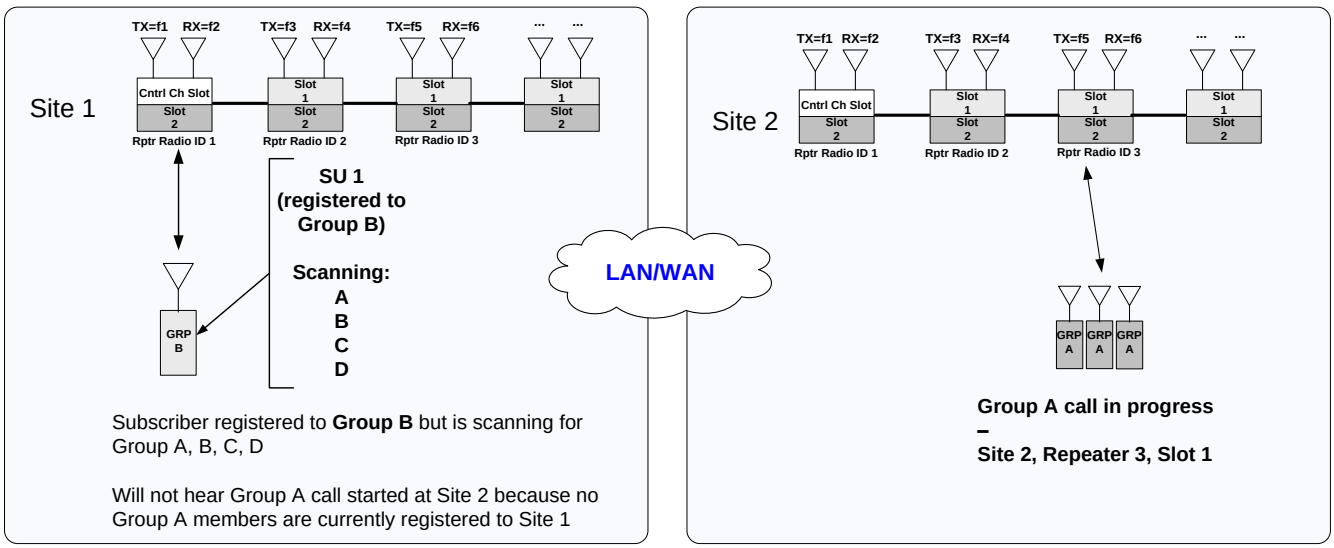


Figure 2-11 Audio Not Available at Site without Registered Group Member

2.13.8.1 Networked Audio Requires Group Member Registered at Site

In Connect Plus, a site does not provide Group audio or call assignment messages unless there is a Group member currently registered to the site. This important feature, known as “dynamic site assignment”, helps conserve RF resources as well as IP bandwidth between sites. However, it also has implications for the Selectable Group Scan feature in a multisite environment. In the figure above, a SU is registered to Group B at Site 1 (its Preferred Site), and is also scanning Groups A, C and D. Because there is no unit currently registered to Group A at Site 1, the Connect Plus network has no reason to route calls to that site. Therefore, when a call starts on Group A on Site 2, the SU registered to Group B at Site 1 will not be aware of the call.

Since the scenario shown in Figure 2-11 can never occur in true single-site, it is easy to see why Selectable Group Scan is best-suited for a single-site system. This is the only environment where the radio user has complete assurance that the site will supply audio for all of its scanned groups. That’s because there is no possibility that a transmission will occur elsewhere in the network. The key-up occurs at the present site, or it doesn’t occur at all.

2.13.8.2 System Less Aware of Target SU’s Current Availability

When a subscriber unit is participating in a call on its registered Group, the controller is aware that the SU is unavailable, and it will not attempt to contact the SU with an individual call (Private Call, text message, etc) until the call on the registered Group is over. However, when the SU has scanned into a call on a Group to which it is not currently registered, the site controller is not aware that the radio is not available to receive other calls. For calls targeted to this Connect Plus SU, it is likely that the controller will try to contact the SU, and may attempt several re-tries before determining that the SU is not currently available. In the meantime, the radio that is initiating the call to the unavailable SU will be tied up in the call attempt until the controller determines that the target SU is unavailable.

2.13.9 Differences in Scan from Other MOTOTRBO Digital Modes

The primary differences between scan in Connect Plus and other MOTOTRBO digital modes are described below:

- **Subscriber Unit Monitors Control Channel Only**
  In Connect Plus, the subscriber unit only monitors the control channel frequency and timeslot for calls involving members of its scan list.

- **Connect Plus scans only the Group Scan list for the selected Connect Plus zone**
  The Channel Scan feature provided by some non-Connect Plus modes allows the radio to scan between channels in different zones and even between channels operating in different modes (analog and digital, for example). Connect Plus scans only Groups configured into the currently selected Connect Plus zone. Connect Plus does not support scanning between different zones and/or modes.

- **Interactions between Scanning & Roaming**
  In non-Connect Plus digital modes, a single channel can be enabled for a Scan list or a Roam list, but not both. Configuring a scan list for a Connect Plus zone does not affect the SU's ability to automatically roam to other Connect Plus sites. However, as discussed in a previous section, only "Automatic Scan" is available network-wide. "Selectable Group Scan" is available only at the "Preferred Site" for the currently Selected Connect Plus zone.

- **No Priority Scan:**
  Scan list members all have the same Priority.

- **Scanning Suspended While Monitoring a Call**
  While the Connect Plus subscriber unit is monitoring a scanned call, it is not monitoring the control channel timeslot. No scanning can take place without monitoring the control channel timeslot. Once the Connect Plus SU returns to the control channel, scanning resumes.

- **Other Calls are not Heard While Scanned into a Call**
  The Connect Plus SU cannot respond to any type of call request while scanned into a call (Group calls, text messages, private calls, etc). This is identical to the previous point. Since the subscriber unit is not monitoring the control channel, it cannot participate in any other calls.

- **Connect Plus Scan does not Require a "Preamble"**
  In other MOTOTRBO digital modes, a number of preamble messages are typically sent prior to data calls in order to increase the likelihood that a scanning radio will hear the call. The "TX Preamble Duration" is a configurable parameter on the MOTOTRBO CPS General Settings screen. Because a Connect Plus radio does not hop frequencies while scanning, it does not require a Preamble. If the radio is used only for Connect Plus, the "TX Preamble Duration" should be set to zero (0). If the radio is also used for non-Connect Plus modes that require a Preamble, then the Preamble be set as short as is acceptable for the non-Connect Plus mode. Otherwise, Connect Plus operation may be adversely affected.

- **User Cannot Add or Delete Scan List Members**
  Connect Plus scan lists are configured solely using MOTOTRBO Connect Plus Option Board CPS. Users cannot add or delete members from the scan list via the menu. They

can, however, enable/disable scan for individual list members as described in section "Configuring Selectable Group Scan".

2.13.10 Interactions of Scan and Emergency

This section provides a brief discussion of the interactions of the Scan and Emergency Features in Connect Plus.

Scanning the Default Emergency Revert Group ID:

If a Connect Plus radio is configured for a Default Emergency Revert Group ID, it always scans for Emergency Calls on that ID no matter where it goes in the network. However, the Connect Plus radio does not scan for non-Emergency Calls on this ID unless it happens to also be (a) its currently Registered Talk Group ID, (b) its Multigroup ID, or (c) a currently enabled member of the scan list (if the radio is currently registered to its Preferred Site and scan is turned on).

Responding to Emergency Calls:

The Connect Plus SU will respond to an Emergency Call for any of the following IDs: (a) its Emergency Revert Group ID (if configured with one), (b) its Multigroup ID (if configured with one), (c) its currently Registered Talk Group ID, (d) any currently enabled member of the scan list (if the radio is currently registered to its Preferred Site and scan is turned on).

When the Emergency Call ends:

If the Connect Plus SU scans into an Emergency Call, and then the Emergency Call ends, the SU returns the Control Channel timeslot and scans for IDs of interest as described in previous sections. If the radio user presses PTT to start a call, the SU will request a non-emergency voice call on the Contact Name that has been programmed for currently selected Channel Selector Knob (portable radio) or Channel Rocker (mobile radio) position. This is the same way the Connect Plus SU operates at the conclusion of any call – not just Emergency Calls.

2.14 Network ID

A Connect Plus radio must be programmed with the Network ID that is transmitted by the site controllers in its Connect Plus Network. The radio's Network ID is entered on the "General Settings" screen in Connect Plus CPS. Defining the Network ID is also part of creating a Network Frequency File.

When a Connect Plus SU searches for service, it will not attempt to register with a site until it verifies that the Network ID being transmitted on the Control Channel downlink agrees with the Network ID that was configured into the radio with Connect Plus CPS. This check prevents the SU from accidentally attempting to register with Connect Plus sites that are under different ownership, but located in the same geographical area and using some of the same frequencies and color codes as Control Channels within its own network.

The Network ID transmitted on the Control Channel downlink is set by the factory, and is based on information received at time of sale. All Connect Plus controllers under the same ownership are given the same Network ID, unless requested otherwise. Connect Plus controllers under different ownership are typically issued different Network ID. If there are unusual circumstances where controllers under different ownership will be part of the same Connect Plus Network, this

information should be communicated to the sales representative at time of purchase since the controllers will need to be issued the same Network ID. If it becomes necessary to change a controller's Network ID after the controller has been deployed to the field, this can be accomplished remotely provided that the required connections are in place.

Relationship of Network ID to Site Number

Each site controller that will be connected together for the purposes of Wide Area Networking must have the same Network ID, but a unique Site Number. The Connect Plus Site Number is programmable in the controller by using the MOTOTRBO Connect Plus Network Manager software. Site Numbers are also important when programming the Connect Plus SU with Connect Plus CPS. Each Connect Plus Zone must be programmed with a "Preferred Site" number. The Site ID is also part of Network Frequency File configuration.

2.15 Programmable Range for Connect Plus IDs

The programmable ID range is Connect Plus is slightly less than Digital MOTOTRBO Conventional (which supports entries up to 16776415). In Connect Plus, the highest configurable ID is 16776351.

The Connect Plus software will use the same Radio ID that is programmed with MOTOTRBO CPS. Although MOTOTRBO CPS allows the entry of Radio IDs 16776352 through 16776415, these numbers must not be used for Connect Plus radios. If any of these numbers is used as the Radio ID, the SU will not function correctly in the Connect Plus personality until the number is changed to a Radio ID that falls within the allowable Connect Plus range. Connect Plus supports the following ranges:

- The programmable range for Radio IDs (Unit IDs) is 1-16776351
- The programmable range for Group Call IDs and Multigroup Call IDs is 1-16776351. Any number from this range can be used as a regular Group Call contact type, or as a Multigroup Call contact type, but the same number cannot be used for both.
- The programmable range for Dispatch Call IDs is 1-16776351
- Site All Call (voice) uses a fixed ID of 16777215. This cannot be changed by the user.
- Site All Call (text) uses a fixed ID of 16776415. This cannot be changed by the user.

2.16 Connect Plus Voice and Data Privacy

Voice and Data Privacy is not available in the initial Connect Plus release. The "Privacy" checkbox in MOTOTRBO CPS must not be enabled for any digital channel that is enabled for Option Board Trunking.

2.17 Connect Plus RDAC Interface

Repeater Diagnostics and Control (RDAC) software can be used in the Connect Plus system to monitor and control repeaters on a Connect Plus site. The RDAC configuration and capabilities for Connect Plus are similar to IP Site Connect mode.

There are several important points to note regarding RDAC operation in a Connect Plus system:

- When using RDAC with Connect Plus, the RDAC application must be configured for "IP Site Connect Mode". For Connect Plus, each "IP Site Connect System" equates to one Connect Plus site. Earlier versions of RDAC supported just one IP Site Connect System (i.e. one Connect Plus site) per instance of the RDAC application. Newer versions of RDAC can communicate with more than one IP Site Connect Master. This means that newer versions of RDAC can be configured to monitor multiple IP Site Connect Systems (i.e. multiple Connect Plus sites) from a single instance of the RDAC application. However, any Connect Plus site managed by the RDAC application (whether a single Connect Plus site or multiple Connect Plus sites) must reside in the same LAN or VPN as the PC running the RDAC application.

- When configuring the RDAC application, the controller's IP address and port is set as "Master". RDAC communicates with the controller in order to obtain IP addresses for the site's repeaters. Once RDAC has a repeater IP address, it can communicate with that repeater directly.

- The PC hosting the RDAC application must be on the same Local Area Network (LAN) or Virtual Private Network (VPN) as the controller and the site's repeaters. The reason is as follows: RDAC communicates with the XRC 9000 and with the site's repeaters via the IP Site Connect Protocol. The Controller is the IP Site Connect Master and the repeaters and RDAC are IP Site Connect Peers. If IP Site Connect Peers are ever located in different networks, then all peers must address the IP Site Connect Master via its publicly addressable IP, not its local IP address. This even applies to the peers that are in the same LAN as the Master. This requires a router capable of a special feature called "hair-pinning", which turns the messages around to send them back to the IP Site Connect Master (in this case, the XRC 9000 controller). Due to the time sensitive nature of the messaging between the XRC 9000 controller and its peer repeaters, the latency added by this additional routing and the hair-pin address conversion will be detrimental to system performance. For this reason Connect Plus requires all IP Site Connect Peers, including RDAC, to be located in the same Local Area Network (LAN) or Virtual Private Network (VPN) as the XRC 9000 controller acting as IP Site Connect Master.

- When configuring the RDAC application, set the RDAC ID for a value higher than 15. This assures that there will be no conflict with a Radio ID that might be already programmed into one of the site's repeaters. (In Connect Plus, each site repeater is programmed for a unique Radio ID between 1 and 15.)

- The XRC 9000 has a configurable parameter called "RDAC UDP Listen Port". This field, which appears on the MOTOTRBO Connect Plus Network Manager Site Configuration screen, determines which port the controller listens to for incoming messages from the RDAC application.

- When RDAC sets a repeater for "Disable", the XRC 9000 controller will not use the repeater for Control Channel signaling or call assignment.

2.18 Connect Plus and Application Developer Program (ADP)

Motorola offers an Application Developer Program (ADP), which allows accredited third party developers to create customized applications used with specific MOTOTRBO interfaces such as Location Services, Text Messaging, etc.

In regards to Connect Plus, these MOTOTRBO ADP interfaces fall into three categories:

1. MOTOTRBO interfaces that are supported with some modifications needed for Connect Plus. (Location Service, Text Messaging Service, Presence Notification Service)

2. MOTOTRBO interfaces unique to Connect Plus. At present, only the 3rd party interface to the XRT 9000 Gateway falls into this category. For more information, see the "XRT 9000 Gateway" section.

3. MOTOTRBO interfaces not currently supported in Connect Plus.

Where an interface is supported in Connect Plus, the third party developer will need to make some modifications for Connect Plus operation (as compared to how the product works in other MOTOTRBO digital modes.) These modifications are necessary due to the Connect Plus system architecture, which is quite different from other MOTOTRBO modes. In other MOTOTRBO modes, a third party application typically resides on a PC that connects to a MOTOTRBO radio via USB. In Connect Plus, third party applications do not speak directly to the Connect Plus SU. Instead, they communicate with the SU via the XRC 9000 controller. The connection between the third party application and the XRC 9000 is via IP.

For accredited ADP developers, Motorola provides Application Developer Kit (ADK) documents to describe the protocols used to interface with the MOTOTRBO product. In addition to the applicable MOTOTRBO ADK document(s), a third party developer wishing to develop a product for a supported Connect Plus interface will require an additional document explaining the ADK modifications required for Connect Plus. These modifications are most typically related to message addressing.

The following table shows whether specific MOTOTRBO interfaces are currently supported in Connect Plus.

Interfaces supported in Connect Plus with some modifications	**Interfaces not currently supported in Connect Plus**
Text Messaging	Telemetry
Location Services	IP capable Peripheral
Presence Notifier to Watcher (PN2W)[16]	Non-IP capable peripheral Raw IP Data pass through

The XNL/XCMP interface is a special case. The XRC 9000 uses this interface to communicate with the MOTOTRBO Repeater, and the Connect Plus Option Board uses this interface to communicate with the MOTOTRBO radio, however Connect Plus does not currently support this interface for third party applications.

[16] In Connect Plus Presence Notification services are provided by the XRC 9000 controller. The Motorola Presence Notifier application is not used or supported.

Because the only Option Board slot is already occupied by the Connect Plus Option Board, the MOTOTRBO Option Board interface is not available to 3rd party developers in Connect Plus mode.

3 Connect Plus System Components and Topologies

3.1 Connect Plus System Components

The System Components of a Connect Plus System are similar to those of other digital modes, such as IP Site Connect or Capacity Plus. The reader can refer to the section on *System Components* of [1] for detailed information on the MOTOTRBO equipment and specifications. The primary differences for Connect Plus System Components are listed immediately below. These differences will be discussed in greater detail in the sections that follow:

System Components of Connect Plus that are not used in other MOTOTRBO digital modes:

- XRC 9000 controller

System Components used in other digital modes that are not used in Connect Plus:

- Radio Control Station as the LRRP and Text Message application interface
- Text Message terminal connected directly to SU via USB
- Multi-Channel Device Driver (MCDD)

3.1.1 Fixed End Components

3.1.1.1 XRC 9000 Controller

Each Connect Plus site requires at least one XRC 9000 Controller. If desired, the customer may purchase a second XRC 9000 Controller per site to serve as backup to the primary XRC 9000. The secondary XRC 9000 can be configured to assume site control if the primary XRC 9000 fails, provided that the secondary controller has IP connectivity with its local repeaters. The secondary controller provides backup capability, but it does not increase the number of repeaters and calls that can be managed per site.

The XRC 9000 controls up to 15 MOTOTRBO repeaters per trunked site. Because this is an IP interface, the XRC 9000 and its connected repeaters could theoretically be in different locations. However, due to the time sensitive nature of the messaging between the controller and the repeaters, the XRC 9000 and its trunked repeaters must be at the same physical location and connected to the same Ethernet switch. Other configurations are neither recommended nor supported.

Because the repeaters operate in digital mode, the XRC 9000 can control up to 30 digital channels (timeslots) per Connect Plus site. One of these timeslots must be dedicated for Control Channel

signaling. All other timeslots are used by the controller for call assignment. Any timeslot that is not the Control Channel timeslot is a “trunk-to” timeslot. This term is used because the SU moves or “trunks” to the slot after receiving a call assignment message on the Control Channel downlink.

The XRC 9000 communicates with its trunked repeaters via the IP Site Connect Protocol. The XRC 9000 is configured as the IP Site Connect Master and requires a static IP address. Its repeaters are configured as IP Site Connect Peers. Repeater IP addresses may be static or assigned via DHCP.

XRC 9000 Functions for its Local Site

The XRC 9000 acts as the site controller for its co-located repeaters. It communicates with the repeaters via IP in order to:

- Act as IP Site Connect Master
- Encode & Decode Control Channel messaging
- Process registrations and Call Requests
- Track which RF resources are (and are not) currently available
- Assign RF resources
- Maintain a Busy Queue when no RF resources are available
- Repeat transmitted audio packets on the repeater downlink
- Receive text messages created by SU’s that are registered to the site.
- Deliver text messages addressed to SU’s that are registered to the site.
- Receive Location Requests sent by the Location Server or forwarded from other sites.
- Deliver Location Requests addressed to SU’s that are registered to the site.
- Receive Location Reports from SU’s that are registered to the site, and forward the reports to the Location server.
- Assist repeater with FCC compliance (CWID, Level I and II Monitoring)
- Track airtime usage other site statistics

XRC 9000 Multisite Functions

The ability to operate in a multisite network is a purchasable option for the XRC 9000 controller. If multisite networking is desired, each Connect Plus site requires an XRC 9000 controller, and each XRC 9000 must be enabled for multisite operation.

Each XRC 9000 only has direct control over the MOTOTRBO repeaters at its own site location. In multisite operation, the XRC 9000 controllers communicate with one another via IP to facilitate

multi-site call set-up and audio routing. TCP/IP is used for call set-up messages. Audio packets are transported via UDP/IP.

In a multisite network, the controller has all of the same responsibilities that it has in single site mode, along with several additional functions as listed below:

- Track registrations and de-registrations throughout the Connect Plus network
- Based on its list of registered SU's and Groups, efficiently assign local RF resources for inbound network calls.
- Facilitate network call set-up
- Duplicate and forward voice packets to any site where the Target ID is registered
- Provide voice arbitration in the event of simultaneous or near-simultaneous voice transmissions at multiple Connect Plus sites. When the XRC 9000 receives voice packets from multiple sources for the same call, the controller uses time stamps to decide which voice stream will be transmitted on the repeater downlink under its control.
- When receiving a Text Message or Location Request for a registered SU from another site, or from a third party application, the XRC 9000 transmits the message or request to the registered SU.
- When receiving a Text Message or Location Request for an SU that is registered to a different network site, the XRC 9000 routes the message to the site where the Target ID is registered.
- Send a periodic "Neighbor Site" message to tell SU's which network site(s) is/are RF-adjacent to this one.
- Provide NTP service to the other site controllers if configured through the Network Manager. For more information on the NTP settings the reader can refer to [4].

XRC 9000 Configuration & Programming

The XRC 9000 controller must be configured for proper operation. This configuration can be accomplished either locally or remotely by using the MOTOTRBO Connect Plus Network Manager software. The Network Manager is used to:

- Validate and configure privileges for Connect Plus subscribers
- Configure site and network parameters
- Monitor site RF activity in real time
- Monitor airtime usage and diagnostic information
- Perform XRC 9000 controller storage maintenance, namely clearing old airtime logs

For more information on the MOTOTRBO Connect Plus Network Manager, see the section "Other IP Components of the Connect Plus Multisite Network".

3.1.1.2 Repeater Operation in Connect Plus

The MOTOTRBO repeater interfaces with the XRC 9000 Controller to provide the RF interface for the Connect Plus site. Each XRC 9000 can control up to 15 MOTOTRBO repeaters, for a total of 30 digital channels (timeslots).

The repeater must be enabled for digital operation and configured as an IP Site Connect Peer. The XRC 9000 serves as the IP Site Connect Master. For a more thorough discussion on MOTOTRBO CPS programming requirements for the MOTOTRBO repeater, see "Connect Plus System Design Considerations".

Even though the repeater is configured for IP Site Connect, it knows that it is actually part of a Connect Plus Site and not a conventional IP Site Connect System. The repeater knows this via IP messages from the XRC 9000 controller. As a Connect Plus repeater, its operation differs from other digital modes in several ways:

- In Connect Plus operation, the repeater doesn't automatically repeat everything it receives on its uplink. Instead, it forwards received transmissions to the XRC 9000 controller. The controller decides whether to route the transmission back to the repeater downlink.

- The Connect Plus controller only routes "authorized transmissions" back to the repeater downlink. An authorized transmission is one that has been initiated and validated via Connect Plus messaging on the Control Channel timeslot. Because of this, a conventional (non-Connect Plus) SU cannot utilize the repeater as long as the downlink is under Connect Plus control. If a conventional SU (operating in digital mode) attempts to access a Connect Plus repeater, its transmission will be received by the repeater and forwarded to the controller, but the controller will not repeat the transmission on the downlink. This feature prevents unauthorized "pirating" of Connect Plus channels. However, if IP communications between the XRC 9000 controller and the repeater are disrupted for an extended period of time (at least a minute or longer), the repeater will enter "Conventional Fallback Mode", in which it operates as a digital conventional repeater. In Conventional Fallback Mode, the repeater will automatically repeat the transmissions of a correctly programmed conventional SU. For a more thorough discussion on Connect Plus operation in the presence of failures, see the "Connect Plus System Design Considerations" section.

- In conventional IP Site Connect, a radio transmission received by one IP Site Connect repeater is not only repeated on its own downlink, it also transmitted by all other IP Site Connect repeaters – regardless of whether any SU is currently present to receive the call. In Connect Plus, each downlink timeslot is controlled independently, thereby allowing for efficient utilization of network RF resources. A Group voice call, for example, will only be heard at sites where a Group member is currently registered. If a Group member is not currently registered, the site is not brought into the call.

- In conventional IP Site Connect, IP Site Connect functionality can be enabled or disabled per repeater timeslot. The available options are "None", "Slot 1", "Slot 1 & 2", or "Slot 2". When using the repeater for Connect Plus, the XRC 9000 Controller will assume it has access to both repeater timeslots. Therefore, the Connect Plus repeater must be configured for IP Site Connect on "Slot 1 & 2" with MOTOTRBO CPS. This rule is not enforced by MOTOTRBO CPS, but it is required for proper operation.

- In other digital modes, the repeater is programmed with a Radio ID in the range of 1 to 16776415. In Connect Plus, each repeater in the Connect Plus site must be programmed with a unique Radio ID in the range of 1 to 15. Repeaters in other Connect Plus sites will

use this same range (1-15). This rule is not enforced by MOTOTRBO CPS, but it is required for proper operation.

- In other digital modes, Base Station Identification (also called CWID) is handled entirely by the repeater. In Connect Plus mode, CWID is handled jointly by the repeater and the XRC 9000 controller. The CWID itself (usually the FCC license call sign) is programmed into the repeater with MOTOTRBO CPS, but the CWID TX Interval is programmed into the controller. When the repeater registers with an IP Site Connect Master identifying itself as the XRC 9000 controller, the repeater knows to ignore the CWID TX Interval programmed with MOTOTRBO CPS. The Controller will tell the repeater when to send CWID. For a more thorough discussion on CWID, see the "Connect Plus System Design Considerations" section.

- In other digital modes, FCC Type I compliance is handled entirely by the repeater itself, and FCC Type II compliance is handled by the repeater after being initiated by an external input. In Connect Plus mode, the repeater operates in much the same way, but it also takes the additional step of informing the XRC 9000 controller when it has taken itself off-line. This is necessary so that the controller will not try to assign calls to the repeater until the repeater reports itself back on-line.

- In other digital modes, the repeater downlink uses embedded signaling to indicate the status of the repeater timeslots. This embedded signaling rides in more than one part of the transmitted signal. In Connect Plus, some of this embedded signaling is used just as in other digital modes, while other parts of the embedded signaling convey information that is unique to Connect Plus.

- In Connect Plus mode, the repeater acts as a "conduit" for Connect Plus control messages, but it does not process the messages. The messages are processed by the XRC 9000 controller and the Connect Plus SU.

- In Connect Plus mode, the XRC 9000 controller provides voice arbitration in the event of simultaneous or near-simultaneous voice transmissions at multiple Connect Plus sites. This differs from conventional IP Site Connect operation, where voice arbitration is done by the repeater itself.

- Prior to Connect Plus Release 1.1, Call Hang Times were configured in the repeater using MOTOTRBO CPS. Beginning with Connect Plus Release 1.1, the Call Hang Time values programmed with MOTOTRBO CPS will be overwritten by the XRC 9000 when it establishes its link with the repeater. In doing so, the XRC 9000 uses the Call Hang Time values that have been programmed with the MOTOTRBO Connect Plus Network Manager. The repeater will use the Network Manager-configured values as long as it maintains its connection to the XRC 9000. Regardless of which method is used to set the Call Hang Times, Connect Plus requires the following:

    - In conventional operation, the repeater can be configured with a "zero" Call Hang Time to create a "transmission trunking" environment where each PTT is treated as a brand new call. This configuration is not supported in Connect Plus because the time required for Control Channel call processing, validation, channel assignment, and synchronization with the assigned timeslot would have to be repeated for each PTT. Connect Plus recommends that Call Hang Time values be set to 3 seconds (or longer) for each call type.

    - The Hang Time value selected for each call type must be programmed the same in all Connect Plus repeaters, at all sites, network-wide.

For more information on repeater configuration and operation for Connect Plus, see the "Multiple Digital Repeaters in Connect Plus Mode" section in "Connect Plus System Design Considerations".

3.1.1.3 Radio Control Station in Connect Plus

The Control Station Radio, an important system component in other digital modes, is not necessary in Connect Plus.

In other digital modes, a Text Message application or Location application resides on a PC that has a USB connection to a mobile radio, serving as Control Station. The Control Station radio acts as peer to other subscriber units in the field via the Common Air Interface. Connect Plus does not use this architecture. In Connect Plus, the Text Message or Location application resides on a PC that is connected via IP to a XRC 9000 Controller. This can be any Connect Plus controller on the radio network. The controller is the application's gateway to the Common Air Interface. This architecture provides significant advantages because the XRC 9000 Controller is the system component with the required knowledge to locate the destination SU, identify an available RF resource, and deliver the message to its intended target.

Other digital modes utilize Control Stations as the application gateway for GPS Revert or Data Revert Channels. The SU picks which "revert channel" to use based on MOTOTRBO CPS programming. This strategy is not used in Connect Plus. Instead, the XRC 9000 Controller assigns timeslots for all data calls. In doing so, the controller may use any available timeslot.

3.1.1.4 MC1000, MC2000, MC2500 Console in Connect Plus

The MOTOTRBO Connect Plus mobile supports the MC Deskset Series of consoles. The MC Deskset Series provides a complete portfolio of products for a small control room. The portfolio ranges from a simple talk and listen unit to a miniature multi-channel console.

The MC1000, connected through its Tone Remote Adapter (TRA), can control a single control station, and provides a selection of up to four Connect Plus Channel Rocker positions. Each of these Channel Rocker positions can be used to start a Group or Private Call, depending on how the radio is programmed with MOTOTRBO Connect Plus CPS. This unit requires no software for programming.

The MC2000, connected through its TRA, can also control a single control station, but provides a selection of up to 16 Connect Plus Channel Rocker positions. Each of these Channel Rocker positions can be used to start a Group or Private Call, depending on how the radio is programmed with MOTOTRBO Connect Plus CPS. This unit is programmed by using configuration software installed on a PC.

The MC2500 controls up to 4 control stations (one TRA per Control Station). Each control station provides a selection of up to 16 Connect Plus Channel Rocker positions. Each of these Channel Rocker positions can be used to start a Group or Private Call, depending on how the radio is programmed with MOTOTRBO Connect Plus CPS. This unit is programmed by using configuration software installed on a PC.

The TRA interfaces to the control station using the 26-pin MAP connector. The console interface to the control station consists of TX_Audio, RX_Audio, and External PTT. Additionally, Talk Group steering is provided by the control station and Connect Plus Option Board through the GPIO pins, which are configurable using both MOTOTRBO CPS and MOTOTRBO Connect Plus CPS.

The Connect Plus interface does not require pins to be assigned to the Monitor or Channel Activity functions. This is because the control station always monitors a "busy" channel (the Control Channel) while idle. This will not prevent the console operator from the making a call request. Supervisory tones such as the Talk Permit Tone and the Busy Tone are provided to the console operator by the Connect Plus radio. These tones tell the console operator how the Connect Plus System is handling the radio's call request.

3.1.1.5 XRT 9000 Gateway

The XRT 9000 Gateway is an optional component of the MOTOTRBO Connect Plus digital trunking system. XRT 9000 is designed to perform protocol translation for equipment and applications wishing to interact with the Connect Plus system. The XRT 9000 is an Internet Protocol (IP) based device that allows connectivity from authorized clients that are part of the Motorola Solutions Application Development Partner (ADP) Program. The XRT 9000 Gateway Protocol Specification defines the messages that provide access to the following features:

- Group Call
- Multigroup Call
- Private Call
- Emergency Call
- Call Alert
- Radio Monitor
- Airtime Billing
- Radio Check
- Radio Enable
- Radio Disable

When the client application establishes communication with the XRT 9000, messages are exchanged to identify the client, to check authorization, and to enforce client privileges as configured into the XRT 9000. Client privileges include access to airtime logging data from the Connect Plus network and the ability to register Talk Paths with the XRT 9000. Group Talk Paths support group communications with Connect Plus radios. Private Talk paths support individual communications, such as Private Calls, Radio Check, etc. The total number of Talk Paths registered by all clients cannot exceed the number of Talk Paths licensed for the XRT 9000, which is a maximum of 100. The number of licensed Talk Paths determines how many Group and Private IDs can be registered by all clients, but not the maximum number of simultaneous calls. The maximum number of simultaneous calls on a single XRT 9000 is 30.

Third party client applications are available to perform the following functions through their interface to Connect Plus via the XRT 9000 Gateway:

- Connect a digital, wireline console to the Connect Plus network
- Automatically retrieve and process airtime data from the XRC 9000 controllers
- Provide Connect Plus connectivity for certain 2-wire and/or 4-wire analog devices
    - Converting analog audio to AMBE+2™ digital audio
    - Converting AMBE+2™ digital audio to analog audio

In the future, the number of client applications that can access the Connect Plus system via the XRT 9000, and the number of features provided by those applications, is expected to grow.

To the Connect Plus system, each XRT 9000 looks very much like another Connect Plus site. In fact, the XRT 9000 is assigned a special site number, and must be listed in the Multisite Configuration of the XRC 9000 controller(s). A single site system (i.e. a XRC 9000 controller that is not enabled for the multisite feature) supports a maximum of one RF site and one XRT 9000 Gateway. Because the XRT Gateway is configured as Site 255, the term “single site system” is somewhat of a misnomer. A Connect Plus multisite system supports a maximum of five XRT 9000 Gateways (site numbers 251-255).

The MOTOTRBO Connect Plus XRT 9000 Configuration Tool is the software application used to configure the XRT 9000 Gateway. This application can connect to the XRT 9000 via IP, or by using a serial connection.

3.1.2 Mobile Components

3.1.2.1 MOTOTRBO Portable Radio

The Connect Plus MOTOTRBO portable is available in two tiers:

- A keypad radio with display, and
- A non-keypad radio with no display

Connect Plus mode portable radio has slightly different battery life characteristics compared to the radios configured to operate in other MOTOTRBO digital modes due to the presence of the Option Board, which consumes additional power. The following table lists the average battery life at 5/5/90 duty cycle with battery saver disabled; GPS options disabled, no attached accessories, automatic roaming disabled and transmitting at high power. Actual performance may vary by band and usage characteristics. Low capacity batteries (e.g. NiMH 1300 mAh) are not recommended for use with MOTOTRBO Connect Plus portables unless required, as noted in the table.

Battery Type	Battery Life
IMPRES Li-ion 2150 mAh Battery	13.0 Hours
IMPRES Li-Ion 1750 mAh Battery[17]	7.0 Hours

Table 3-1 Expected Battery Life

For more details on the MOTOTRBO Portable Radio the reader can refer to the *MOTOTRBO Portable* section in [1].

3.1.2.2 Portable Radio Accessories & Peripherals Interface

The configurable pin options provided by MOTOTRBO CPS for the portable radio are not presently supported in Connect Plus. They currently apply to non-Connect Plus modes only.

[17] For use with portables certified as *intrinsically safe* by CSA (Canadian Standards Association).

3.1.2.3 MOTOTRBO Mobile Radio

The Connect Plus MOTOTRBO mobile is available in two tiers:

- A radio with full display, and
- A radio with numeric display

For more details on the MOTOTRBO Mobile Radio the reader can refer to the *MOTOTRBO Mobile* section in [1].

3.1.2.4 Mobile Radio Front Panel Accessory Interface

For description on the radio front panel accessories, the reader can refer to the *Front Panel Accessory Interface* section for the MOTOTRBO Mobile in [1].

3.1.2.5 Mobile Radio Rear Accessory and Peripherals Interface

Utilizing configurable GPIO pins for specific features requires programming with both MOTOTRBO CPS and MOTOTRBO Connect Plus CPS. First, MOTOTRBO CPS is used to assign the pin as a Generic Input or Generic Output. Then, MOTOTRBO Connect Plus Option Board CPS is used to configure the Generic Input or Generic Output for a specific feature. It is important to note that Connect Plus CPS does not know which physical pin number is used for the feature, and MOTOTRBO CPS does not know which Connect Plus feature is assigned to its physical pins. This means that the individual configuring the mobile and the Option Board must understand the big picture in order to configure both software programs correctly.

Connect Plus supports the following MOTOTRBO CPS configurable options:

Pin 17: Connect Plus supports “Generic Input 1” through “Generic Input 6”

Pin 19: Connect Plus supports “Generic Input 1” through “Generic Input 6” and “Generic Output 1” through “Generic Output 6”

Pin 20: Connect Plus supports “Generic Input 1” through “Generic Input 6” and “Generic Output 1” through “Generic Output 6”

Pin 21: Connect Plus supports “Generic Input 1” through “Generic Input 6” and “Generic Output 1” through “Generic Output 6”

Pin 22: Connect Plus supports “Generic Input 1” through “Generic Input 6” and “Generic Output 1” through “Generic Output 6”

Pin 24: Connect Plus supports “Generic Input 1” through “Generic Input 6” and “Generic Output 1” through “Generic Output 6”

Pin 26: Connect Plus supports “Generic Output 1” through “Generic Output 6”

Note the following:

- A single pin cannot be configured for both a Generic Input and a Generic Output.
- Once a pin is assigned as a Generic Input or Generic Output with MOTOTRBO CPS, a specific feature should be assigned to the Generic Input or Output using MOTOTRBO Connect Plus CPS.
- Connect Plus Supports the following features for Generic Inputs 1-6. Once a feature is mapped to a Generic Input, it cannot be used again:
    - External Mic PTT
    - Channel Select 1
    - Channel Select 2
    - Channel Select 3
    - Channel Select 4
    - Channel Select 5
- Connect Plus Supports the following feature for Generic Output 1-6. Once a feature is mapped to a Generic Output, it cannot be used again:
    - Horn and Lights (note: only Pin 26 supports 12v output for Horn and Lights)

3.1.2.6 Connect Plus Radio Configuration Requirements

Connect Plus uses the same MOTOTRBO portable and mobile radios as other digital modes. However, for Connect Plus operation these devices must meet several additional requirements, which are outlined as follows:

- The Connect Plus radio requires radio software version R01.06.30 or later.
- A Motorola Option Board must be installed in the SU. Prior to the installation of Connect Plus software, the radio's Option Board is referred to as a Generic Option Board (GOB). Following installation of Connect Plus software, the Option Board is referred to as Connect Plus Option Board.
- In order for the Connect Plus Option Board to enable its OTA interface and "talk" to the XRC 9000 controller, it must first verify that the Connect Plus feature has been enabled in the MOTOTRBO subscriber unit.

To program a radio for Connect Plus operation, two different versions of CPS programming software are needed:

- MOTOTRBO CPS is used to create zones and channels for Connect Plus use. See "Connect Plus System Design Considerations", for a more detailed discussion of MOTOTRBO CPS programming guidelines.

- Connect Plus CPS is used for advanced configuration of Connect Plus parameters, including all of the following operations:
    - Creating Connect Plus Contacts
    - Assigning Channel Selector Knob positions (portable radio) or Channel Rocker positions (mobile radio)
    - Entering Network, Site, & Frequency information
    - Configuring Connect Plus feature options
    - Configuring Connect Plus Menu Operation

3.1.3 User Interface & Ergonomics in Connect Plus

3.1.3.1 User Interface Dependencies

Because Connect Plus uses the same radio hardware as other digital modes, the physical buttons used by Connect Plus operation are the same as other digital modes. In some cases, however, these buttons operate differently for Connect Plus. All Connect Plus users should be aware of the following principles:

It is quite possible (in fact, it's likely) that the same programmable button will be used to activate different features, depending on whether the radio is selected to a Connect Plus channel or a non-Connect Plus channel.

- When selected to a non-Connect Plus channel, a programmable button operates as configured with MOTOTRBO CPS.
- When selected to a Connect Plus channel, programmable buttons operate as configured with Connect Plus CPS.

It is also important to note that Connect Plus is not aware of how a button has been programmed with MOTOTRBO CPS, and may not be aware of its current MOTOTRBO state (activated or de-activated). This can impact Connect Plus operation. For more information, see the following topics under "Connect Plus System Design Considerations":

- How MOTOTRBO CPS Button Settings Affect Connect Plus Operation
- How MOTOTRBO CPS Menu Settings Affect Connect Plus Operation

3.1.3.2 Connect Plus Buttons & Indicators

Push-to-Talk Button (PTT): In Connect Plus, if the radio is idle and monitoring the Control Channel timeslot when the user presses PTT, the SU will attempt to start a voice call using the Contact Name that has been programmed for the selected Channel Selector Knob position (portable radio) or Channel Rocker position (mobile radio). The contact name can either be a Group type (Group ID, Multigroup ID, Site All Call Group) or Private Call type. If it is a Group type,

the radio attempts to start a Group Call to the programmed ID. If it is a Private Call ID, the radio attempts to start a Private Call to the destination Private ID. The SU sends a Call Request message on the Control Channel uplink. After transmitting the call request, the radio automatically de-keys in order to listen for the controller response. The radio user is usually unaware that the radio has keyed and de-keyed because he/she continues to press PTT while awaiting the talk permit tone. When the user hears the talk permit tone, this indicates that a channel has been granted and the user may begin to speak. If PTT is pressed during a call in progress (during the Call Hang Time), the radio begins transmitting audio to the assigned channel or slot. The call request and set-up procedure does not apply in this case because the trunk-to slot has already been assigned.

Note: The Talk Permit tone is a programmable feature. When enabled via Connect Plus CPS (it is enabled by default), it can also be toggled on and off via the radio menu. Because Connect Plus is a trunking system, it is highly recommended to keep the Talk Permit tone enabled at all times. Otherwise, the radio user will not know when (and if) the controller has assigned a timeslot for the radio's transmission. When the Talk Permit tone is enabled, Connect Plus CPS also provides the ability to enable a "Pre-Tone". The purpose of the pre-tone (which is disabled by default) is to tell the radio user that the SU is in the process of call request. The Pre-Tone will be followed by a Talk Permit tone (if the channel is granted), a busy tone (if the call is placed in the Busy Queue) or a denial tone (if the request is denied for any reason).

Channel Selector Knob (portable) or Channel Rocker (mobile): In Connect Plus, each Channel Selector Knob position (for the portable radio) and the first 16 Channel Rocker positions (for the mobile radio) can be mapped to a specific Contact Name & Registration Group via CPS programming. The Contact Name determines what type of voice call is started when PTT is pressed. The Registration Group determines which Group ID the SU registers with when the knob or channel rocker is selected to that position. It is not allowable to assign some Channel Selector Knob (or Channel Rocker) positions to Connect Plus calls, and other positions to non-Connect Plus channels, within the same zone. To make a non-Connect Plus call, the user must change out of the Connect Plus zone, and then select the appropriate non-Connect Plus zone and channel. If the radio user selects an unprogrammed position for the Channel Selector Knob (mobile) or Channel Rocker (portable), the radio sounds a continuous tone and displays, "unprogrammed". The knob or channel rocker must be moved to a programmed position before the radio will be usable.

Programmable Buttons: Connect Plus CPS is used to configure how the radio's programmable buttons will operate when the radio is selected to a Connect Plus channel. The number of programmable buttons varies according to radio model. For each available button, the short press and long press can be programmed to operate differently. The orange button located on the top of the portable radio is commonly used to initiate and/or cancel an Emergency Call, although it can be configured to function differently. If the radio is used for both Connect Plus and non-Connect Plus channels, then it is important to understand the interactions discussed in "User Interface Dependencies".

Status Indicators: Wherever possible, status indicators (LEDs, display, icons, tones, etc.) work in a similar fashion for both Connect Plus and non-Connect Plus channels. Some differences in operation are inevitable due to the nature of the radio-Option Board interface.

Menu System: When the radio is selected to a non-Connect Plus channel, the menu system is under the control of the radio's main board, and the programmable menu options are configured via MOTOTRBO CPS programming. When the radio is selected to a Connect Plus zone, the menu system is under the control of the Connect Plus Option Board, and the programmable menu options are configured via Connect Plus CPS programming. Wherever possible, Connect Plus attempts to duplicate the Menu structure and available options used on non-Connect Plus channels. Some minor differences are inevitable due to differences in Connect Plus operation and the nature of the radio-Option Board interface. The top-level Menu headings for Connect Plus are:

Contacts, Scan, Zones, Messages, Call Logs, and Utilities. For details on these menus, see references [2] and [3].

Full keypad: The MOTOTRBO keypad portable with display offers a full numeric keypad for users to manually enter target addresses for system features. This keypad is also used as an alphanumeric keyboard for text messaging. The non-display portable does not come with a keypad. A mobile radio equipped with the standard microphone does not provide a means to compose text messages or manually enter target addresses for call features. As an option, the MOTOTRBO mobile offers an Enhanced Keypad Microphone so that users can compose text messages and manually enter target addresses for call features.

3.1.3.3 Connect Plus Voice Feature Support

The following chart illustrates voice feature support for various MOTOTRBO models while selected to a Connect Plus channel.

Radio Model	**Group Call**	**Multigroup Call**	**Site All Call**	**Private Call**	**Emergency Call**
Display Portable	Yes	Yes	Yes	Yes	Yes
Non-Display Portable	Yes	Yes	Yes	Yes[18]	Yes[19]
Mobile with full display	Yes	Yes	Yes	Yes	Yes
Mobile with numeric display	Yes	Yes	Yes	Yes[18]	Yes[15]

To initiate a Multigroup Call, Site All Call, or Private Call the SU must be enabled for the call privilege in the controller's user database.

3.1.3.4 Connect Plus Command & Control Feature Support

The following chart illustrates which MOTOTRBO radio models can initiate various "Command & Control" call features.

Radio Model	**Radio Check**	**Call Alert**	**Remote Monitor**	**Radio Enable**	**Radio Disable**
Display Portable	Yes	Yes	Yes	Yes	Yes
Non-Display Portable	No	Yes[20]	No	No	No
Mobile with full	Yes	Yes	Yes	Yes	Yes

[18] For these models Private Call can be initiated by (a) assigning a One-Touch-Call to the Private Call ID or (b) assigning a Channel Selector Knob position (portable radio) or Channel Rocker position (mobile radio) for the destination Private Call ID. Private Call initiation via the Radio Menu is not available.
[19] These models have the ability to initiate an Emergency Call, but they do not have the ability to provide special ergo when receiving an Emergency Call. The *receive* ergo for these models will be the same as for Group calls.
[20] Indicates the call type can only be initiated via a programmable "One Touch Call". Initiation via the menu is not available.

display					
Mobile with numeric display	No	Yes[20]	No	No	No

To initiate any of these call types, the SU must be enabled for the associated privilege in the controller's user database.

3.1.3.5 Analog Capability Not Available in Connect Plus

Connect Plus is a digital mode. Analog operation is not available while operating on a Connect Plus Channel. To activate analog capability, it is necessary to program the radio with a non-Connect Plus, analog capable, channel. This channel cannot be placed in any Connect Plus zone. It must be placed in a non-Connect Plus zone.

3.1.3.6 Connect Plus GPS Capability

Many radio models come equipped with an integrated, internal GPS receiver. Connect Plus supports Location Requests and Reports for radios that are so-equipped. For more information, see Connect Plus Location Services in the System Features section.

3.1.3.7 Connect Plus Text Messaging Compatibility

The following chart illustrates Text Message capability for various MOTOTRBO models while selected to a Connect Plus channel.

Radio Model	Receive Text Message?	Send Quick Text (programmed) Text Message	Create and send a limited free-form text message	Use a connected PC to create & send a text message
Display Portable	Yes	Yes	Yes	No
Non-Display Portable	No	Yes (if programmed for a One Touch Call)	No	No
Mobile with full display	Yes	Yes	Only if equipped with an optional Enhanced Keypad Microphone	No
Mobile with numeric display	No	Yes (if programmed for a One Touch Call)	No	No

If the radio is enabled for the "Route to PC" option with MOTOTRBO CPS, this will affect operation in non-Connect Plus channels only. Connect Plus Text Messages will not be routed to the PC.

3.1.3.8 Connect Plus Over-The-Air (OTA) File Transfer Capability

The following chart illustrates Connect Plus OTA File transfer capability for various models. OTA File Transfer is a Connect Plus feature not available in other digital modes.

Radio Model	Receive File via OTA File Transfer (for a supported file type)	Radio user can cancel transfer & start call	Utilities Menu displays "Current" & "Pending" Files[21]
Display Portable	Yes	Yes	Yes
Non-Display Portable	Yes	Yes	No
Mobile with full display	Yes	Yes	Yes
Mobile with numeric display	Yes	Yes	No

3.1.4 Connect Plus Data Applications

3.1.4.1 Application Server in Connect Plus

In other digital modes, a Data Application (such as a Text Message application or a Location application) resides on a PC that has a USB connection to a mobile radio, serving as Control Station. The Control Station radio acts as peer to other subscriber units in the field via the Common Air Interface. Connect Plus does not use this architecture. In Connect Plus, the Text Message or Location application resides on a PC that is connected via IP to a XRC 9000 Controller. This can be any Connect Plus controller on the radio network. The controller is the application's gateway to the Common Air Interface. This architecture provides significant advantages because the XRC 9000 Controller is the system component with the required knowledge to locate the destination SU, identify an available RF resource, and deliver the message to its intended target.

3.1.4.2 Connect Plus Presence Notifier

Data applications work best when they know whether the Destination Connect Plus SU is currently registered (or not registered) to the Connect Plus network. This knowledge allows the application to operate efficiently and to conserve IP bandwidth.

In other MOTOTRBO digital modes, subscriber radios report their presence in the network by using the Automatic Registration Service (ARS) protocol to communicate with the MOTOTRBO Presence Notifier or a third Party ARS application. The Connect Plus SU does not use ARS to report its

[21] Option Board Codeplug File displays "current" file only.

presence in the network. Instead, Connect Plus uses short messages that are sent on the Control Channel as part of the normal procedure for registering or de-registering with the XRC 9000 Controller.

In other MOTOTRBO digital modes, a data application may obtain presence information by subscribing to the MOTOTRBO Presence Notifier or a 3rd Party ARS application. In Connect Plus, a data application may obtain presence information by subscribing to the Connect Plus controller, acting as Presence Notifier. In doing so, the data application utilizes Motorola's Presence Notifier-to-Watcher Interface Specification, with some modifications as specified for Connect Plus. This allows the data application (the "Watcher") to request presence information for specific SU's. The XRC 9000 notifies the Watcher when the specified SU registers or de-registers from the Connect Plus network.

3.1.4.3 Multi-Channel Device Driver (MCDD) in Connect Plus

The Multi-Channel Device Driver (MCDD) is not used in Connect Plus. In Connect Plus, a data application can send its message to any XRC 9000 controller in the network. The application does not need to be concerned about what site or channel the destination SU is currently using. Tracking the SU between sites is the responsibility of the XRC 9000 controller. If the SU is not registered to the controller that received the message, the controller forwards the message to the controller of the SU's registered site.

3.1.4.4 Text Message Application, Server & Client in Connect Plus

While Connect Plus supports third party text message applications (including server & client operations), the Motorola MOTOTRBO Text Messaging application is not currently supported. To determine whether a specific third party application supports Connect Plus operation, contact the vendor. The vendor can also supply specifications for the computer platform necessary to run the application. For general information about how third party text applications work in Connect Plus, see "Connect Plus Text Messaging" in the System Feature section.

3.1.4.5 Location Tracking Application, Server & Client in Connect Plus

While Connect Plus supports third party text Location tracking applications (including server & client operations), the Motorola MotoLocator tracking application is not currently supported. To determine whether a specific third party application supports Connect Plus operation, contact the vendor. The vendor can also supply specifications for the computer platform necessary to run the application. For general information about how third party Location applications work in Connect Plus, see "Connect Plus Location Services" in the System Feature section.

3.2 Connect Plus System Topologies

3.2.1 Direct Mode

Direct Mode, where one SU communicates directly to another SU without using a MOTOTRBO repeater, is not available in Connect Plus. A Connect Plus SU can only communicate with other

SU's via MOTOTRBO Repeaters and the XRC 9000 controller. To set-up Direct Mode, it will be necessary to program the SU with at least one non-Connect Plus zone and channel. While the radio is selected to the Direct Mode channel, the SU will not hear any Connect Plus calls. When programming the Direct Mode frequency, do not program any Connect Plus repeater frequency. Otherwise, the Direct Mode transmission may interfere with Connect Plus operation.

3.2.2 Repeater Mode

The MOTOTRBO repeater is a required component of the Connect Plus trunking system, as it provides the RF path between the Connect Plus Controller and the Connect Plus SU. Furthermore, Connect Plus SU's never speak to each other in Direct Mode (while selected to a Connect Plus personality). Connect Plus transmissions pass through one or more MOTOTRBO repeaters and one or more XRC 9000 controllers (depending on whether the SU's are located at the same site or at different sites).

In Connect Plus, the repeater operates in digital mode, thereby providing all of the advantages of digital signaling (two timeslots, error correction, etc.). In addition, Connect Plus offers the additional benefits of trunked operation. In conventional operation, each position on the SU's Channel Selector Knob (portable radio) or Channel Rocker (mobile radio) is assigned a specific repeater and timeslot via CPS programming. If the repeater timeslot is busy with another call, the radio user is blocked from communicating until the timeslot becomes available. In Connect Plus, the SU makes the Call Request on the Control Channel timeslot, and the controller can assign the call to any available repeater and timeslot in the site. While this requires a dedicated timeslot for Control Channel signaling, it also greatly reduces call blocking. Calls are not blocked until all of the site's repeaters and timeslots are busy. Even then, the Controller will continue to receive Call Requests and place them in the Busy Queue. When a timeslot becomes available, the controller assigns the highest priority call from the Busy Queue. When priorities are equal, calls are assigned on a first-in, first-out basis.

Just as in other MOTOTRBO digital modes, all MOTOTRBO repeaters that have overlapping coverage must be programmed with different frequency pairs so as not to interfere with one another. Frequencies may be re-used when coverage does not overlap. If coverage does not typically overlap, but may in certain conditions (such as when the SU is in a very high place), the re-used frequencies must have different Color Codes. This will not eliminate interference between the two repeaters, but it will help SU's distinguish between the different repeaters – especially while Roaming.

In other digital modes, the MOTOTRBO repeater processes calls without the involvement of any additional device, such as a controller. In Connect Plus, both the MOTOTRBO repeater and the XRC 9000 controller are involved in every Connect Plus call. For more information about how the Connect Plus system uses the MOTOTRBO Repeater and how calls are processed, see the following sections:

- Connect Plus System Feature Overview: Connect Plus Features (and its sub-sections)
- Connect Plus System Components and Topologies: Repeater Operation in Connect Plus
- Connect Plus System Design Considerations: Multiple Digital Repeaters in Connect Plus Mode

3.2.3 Topologies of a Connect Plus System

Connect Plus system topologies fall into two major categories:

- Connect Plus Single Site System
- Connect Plus Multisite Network

3.2.3.1 Connect Plus Single Site System

A Connect Plus Single Site System provides multi-channel trunking capability to a single geographical area. The size of the geographical is determined by factors such as:

- Propagation characteristics of RF band utilized
- Height of site antenna(s) and repeater power output
- RF output & antenna efficiency of mobile and/or portable radio devices
- Type of terrain and other obstructions (buildings, etc)

The essential components of a Connect Plus Single Site System are:

- XRC 9000 Trunking Controller
- 1-15 MOTOTRBO Repeaters. All repeaters under the control of the same XRC 9000 controller must reside in the same RF frequency band and must all have an identical coverage footprint (both “talk in” and “talk out”).
- Ethernet Switch to connect XRC 9000 Controller with repeaters
- Other Site Equipment to include
    - RF Equipment such as combiners, RF cables, antenna(s), etc.
    - Power backup for the XRC 9000 controller
    - Power backup for MOTOTRBO Repeaters
- MOTOTRBO portable and/or mobile radios (including antennas, microphones, etc). These MOTOTRBO SU’s may be located anywhere within the RF coverage of the Connect Plus site.

The optional components of a single-site Connect Plus Single Site System are:

- A second XRC 9000 Controller to serve as redundant backup to the primary Controller
- PC with Location Tracking application
- PC with Text Messaging application

- PC with RDAC application for repeater monitoring and alarm reporting

- In Connect Plus, the above applications communicate with the Connect Plus System via IP connection to the XRC 9000 controller. The computer hosting the application can be co-located with the controller, or it can be in a different location. If the computer is in a different location, a Backend IP network is needed to connect the XRC 9000 with the PC hosting the application. A Backend network is also needed if the System Administrator wishes to remotely access the Controller via IP using a PC running the MOTOTRBO Connect Plus Network Manager software.

- XRT 9000 Gateway, a device that allows certain 3rd party client applications to interface with the Connect Plus System. For more information, see the "XRT 9000 Gateway" section.

3.2.3.2 Connect Plus Multisite Network

Connect Plus Multisite Networking is a purchasable option. Multisite Networking refers to the ability to interconnect multiple Connect Plus single-site systems. In the initial release, up to six single-sites can be joined together to form a Connect Plus network.

The most common reason for connecting multiple sites is to enlarge the RF coverage available to the Connect Plus SU. Because of this, each Connect Plus site is typically placed in a different geographical area and provides the RF coverage for that area. As the radio user moves from one coverage area to another, the SU is able to automatically "Roam" from one site to another. Whenever the SU registers with a different site, the controller forwards information on the SU's whereabouts to all other controllers. This allows all network controllers to "track" the SU as it moves it around the network. The registration process not only tells the controller which SU is registering with the site, it also tells the controller which Talk Group the user has selected for communications. When the radio user wishes to communicate with other SU's, the XRC 9000 controllers will transmit the call at any network site where the Destination ID is currently registered. It should be noted that even in a multisite network, each site is still controlled by its local XRC 9000 Controller. A controller can assign a call to any repeater within its own site, but it cannot assign a call to another site's repeater without the permission and involvement of that site's controller. A controller can "trunk" SU's to any repeater in its own site, but it cannot "trunk" an SU to a repeater in a different site. The SU must "roam" to the new site after it loses signal from the current site.

A less common reason for linking multiple Connect Plus sites is to provide communications between MOTOTRBO radios that use different frequency bands. In this case, each frequency band requires its own Connect Plus site. The Connect Plus sites in different frequency bands can be geographically separated or they can be co-located.

Because a Connect Plus network is essentially a collection of interconnected single-sites, the list of single-site essential components (from the previous section) also applies to each site in the multisite configuration. In addition to these, multisite operation requires several other "essential" elements. They are listed as follows:

- Each site requires its own XRC 9000 controller, and each XRC 9000 must be enabled for the purchasable multisite permission.

- Each controller must be configured with several additional parameters that are not used in the single-site, stand-alone configuration. These parameters tell the controller how to communicate with the other networked controllers, what timer value to use for call

arbitration, and they also tell the controller what "Neighbor Site" information should be transmitted over-the-air to the listening SU's.

- Because the XRC 9000 controllers communicate via TCP/IP and UDP/IP, there must be a Backend IP Network to connect the different sites. Network IP configurations and bandwidth requirements are discussed in other sections of this System Planner.

The optional components of a Connect Plus Multisite Network are very similar to the optional components of a stand-alone single-site:

- A second XRC 9000 Controller to serve as redundant backup to the primary Controller.

- PC with Location Tracking application. It can be connected via IP to any XRC 9000 controller in the network. The connected controller will inspect the incoming messages, and forward them to other site controllers, if necessary. While it's not required to have multiple Location Tracking applications connected to different sites, there are scenarios where the customer's requirements may warrant such a configuration.

- PC with Text Messaging application. It can be connected via IP to any XRC 9000 controller in the network. The connected controller will inspect the incoming messages, and forward them to other site controllers, if necessary. While it's not required to have multiple Text Messaging applications connected to different sites, there are scenarios where the customer's requirements may warrant such a configuration.

- PC with RDAC application for repeater monitoring and alarm reporting. Earlier versions of RDAC supported just one IP Site Connect System (i.e. one Connect Plus site) per instance of the RDAC application. Newer versions of RDAC can communicate with more than one IP Site Connect Master. This means that newer versions of RDAC can be configured to monitor multiple IP Site Connect Systems (i.e. multiple Connect Plus sites) from a single instance of the RDAC application. However, any Connect Plus site managed by the RDAC application (whether a single Connect Plus site or multiple Connect Plus sites) must reside in the same LAN or VPN as the PC running the RDAC application.

- Up to five XRT 9000 Gateways. The XRT 9000 Gateway is a device that allows certain 3rd party client applications to interface with the Connect Plus System. For more information, see the "XRT 9000 Gateway" section.

3.2.4 Network IP Topologies for Connect Plus System

The devices in a Connect Plus network (with the exception of the subscriber radios) communicate with one another via IP messages received on their Ethernet port(s). It follows that these devices will each have an IP address and will be need to be connected via some type of IP network. This section will discuss various IP topologies of the Connect Plus System.

The IP network topologies can be divided into two primary configurations:

- Local Area Network
- Wide Area Network

Some customers will have network topologies that are combinations of these configurations.

3.2.4.1 Local Area Network (LAN) Configuration

Customers that have high capacity network connectivity throughout their organization will most likely have a desire to utilize their existing infrastructure for wide area connectivity. Connect Plus supports the following technologies:

- Private LANs
- Corporate LANs
- Private Wireless LANs (e.g. Motorola's Canopy[22] or Point-to-Point (PTP)[23], 802.11/Wi-Fi network)

Exact configurations of Local Area Networks can vary greatly. As long as the devices are on the same network, or have access to other networks through an internal router or NAT configurations, the Connect Plus system will operate correctly. It is also assumed that in these local configurations that bandwidth is not an issue. The diagram below shows a simple diagram of Connect Plus sites connected through a local area network.

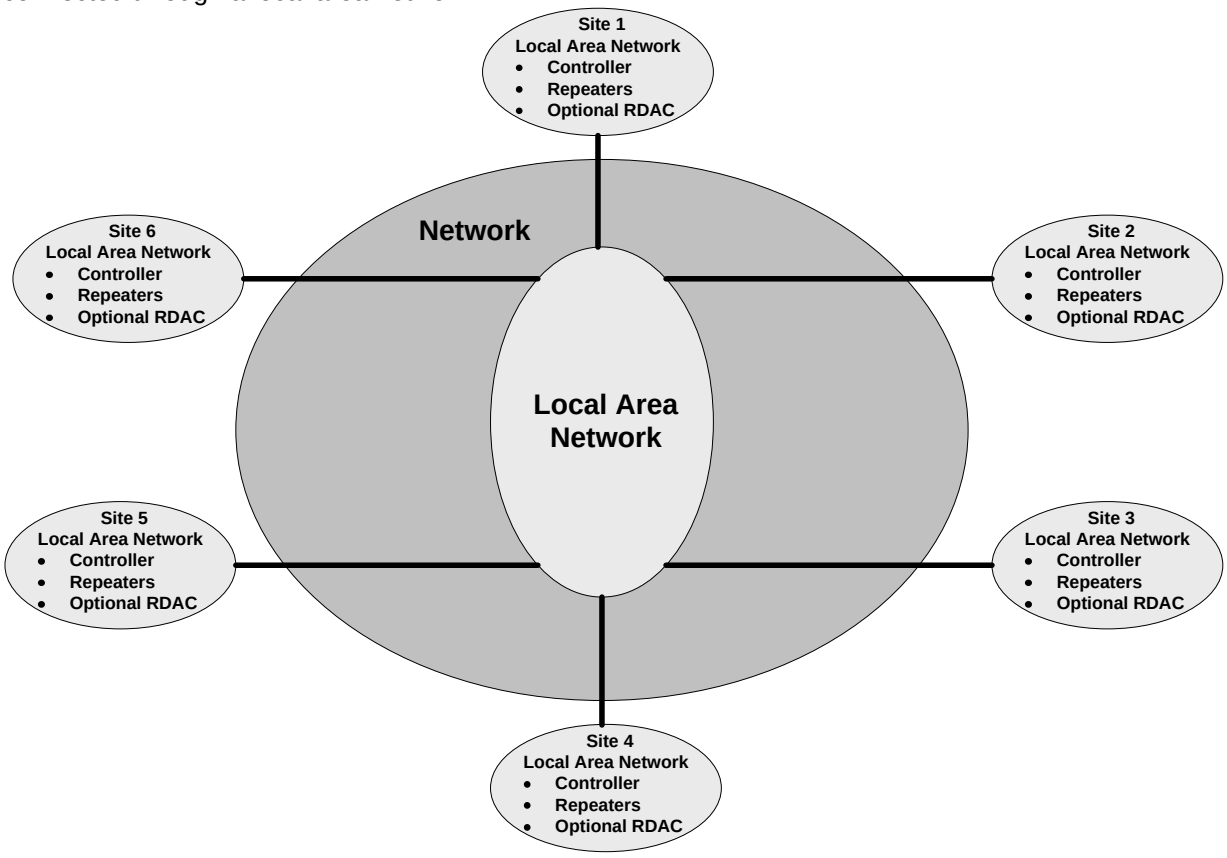


Figure 3-1 Connect Plus Sites Connected through LAN

3.2.4.2 Wide Area Network (WAN) Configuration

One of the values of Connect Plus is the ability to connect sites over public Internet Service Provider (ISP) links as well as private broadband connections. ISPs provide a range of

[22] For more information about Canopy, see Motorola Business Products & Services Point-to-Multipoint site.
[23] For more information about PTP, see Motorola Business Products & Services Point-to-Point site.

technologies with varying bandwidth. Connect Plus supports the following technologies (as long as the requirements listed in the backend Network Considerations section are met):

- Private T1
- DSL/ADSL
- Cable Modem
- Broadband Wireless Access
- ISDN
- Frame Relay

For all the types of network links listed above it is **strongly** recommended to establish a commercial grade of service with the ISP in order to ensure reliability required for real-time packet based communication systems such as Connect Plus. For discussion on backend network characteristics the reader is encouraged to review section Considerations for the Connect Plus Backend Network.

Connect Plus does not support dial-up connections (due to small bandwidth) or Satellite Internet access (due to large delay). When utilizing public internet connections, it is important that the system installer understand the bandwidth and delay that each Connect Plus device requires in order to operate optimally. They must also understand the details (bandwidth and delay) of the network link at each site and between sites. For example, if connecting sites have long distances between them, the delay of the entire link needs to be considered.

A Connect Plus site can be (and is suggested to be) behind a router and/or a NAT and/or a firewall. Although not required, it is highly suggested in order to protect against the undesired solicitations common over the public internet. Although Connect Plus should work through most off-the-shelf devices, the following router/NAT/firewalls have been validated with Connect Plus:

- HP ProCurve 7102dl Secure Router[24]
- HP A-MSR20-20 Router (JF283A)

For the first release Connect Plus provides TCP authentication, but no IP encryption features. For customers that are concerned with such privacy matters, and want to protect the system traffic over the IP networks it is recommended to employ a Secure VPN layer. Secure VPN is not a function of the Connect Plus device but rather of the router. It is important to note that VPN does add the need for additional bandwidth and may introduce additional delay. This should be taken into consideration in bandwidth planning. The following Secure VPN router has been used with other MOTOTRBO system installations, but has not been officially validated on Connect Plus:

- Linksys 4 Port Gigabit Security Router with VPN: Model RVS4000

Each XRC 9000 controller requires a static IPv4 address from the Internet Service Provider. The other Connect Plus controllers utilize this static IPv4 address to establish their link with the wide area system.

The diagram below shows a simple diagram of Connect Plus sites connected through a wide area network.

[24] The **ProCurve 7102dl** router has been scheduled for "End of Sale" by HP and may not be available for purchase at the time of this publication.

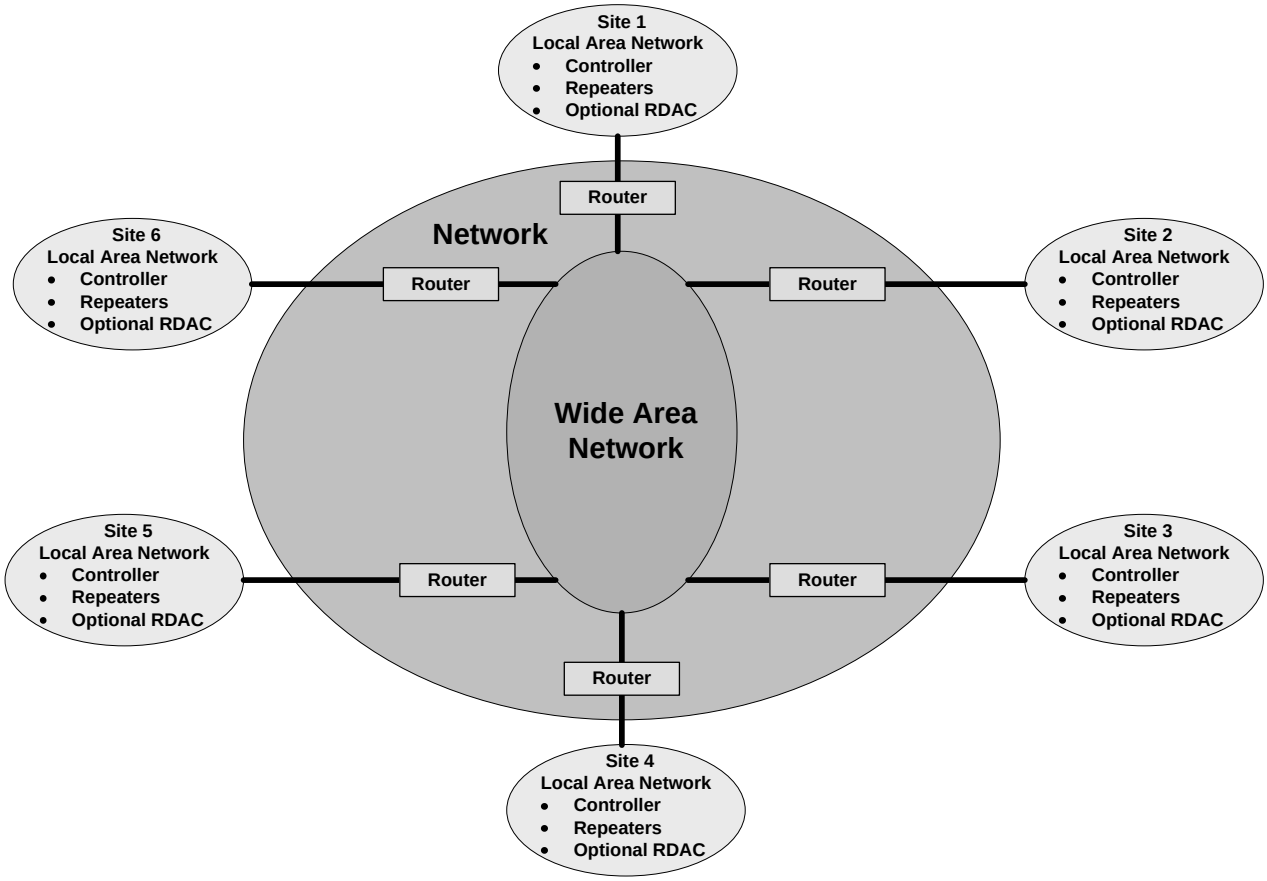


Figure 3-2 Connect Plus Sites Connected through WAN

3.2.4.3 IP Topologies of a Single Site System

An example of a Connect Plus Single Site system configuration is illustrated in .

XRC 9000 Controller and MOTOTRBO Repeaters: Because the XRC 9000 controller and the MOTOTRBO repeaters under its control must be in the same physical location and connected to the Ethernet switch[25], these devices will be on the same Local Area Network (LAN).

RDAC Application: If RDAC capability is desired for error reporting, the PC hosting the RDAC application must be in the same LAN (or VPN) as any Connect Plus site being managed by RDAC. The reason is as follows: RDAC communicates with the XRC 9000 and with the site's repeaters via the IP Site Connect Protocol. The Controller is the IP Site Connect Master. The MOTOTRBO repeaters and the RDAC application are IP Site Connect Peers. If IP Site Connect Peers are ever located in different networks, then all peers must address the IP Site Connect Master via its publicly addressable IP, not its local IP address. This even applies to the peers that are in the same LAN as the Master. This requires a router capable of a special feature called "hair-pinning", which turns the messages around to send them back to the IP Site Connect Master (in this case, the XRC 9000 controller). Due to the time sensitive nature of the messaging between the XRC 9000 controller and its peer repeaters, the latency added by this additional routing and the hair-pin

[25] Connect Plus has been tested and validated with the **HP ProCurve 2510-24** Ethernet switch.

address conversion will be detrimental to system performance. For this reason Connect Plus requires all IP Site Connect Peers, including RDAC, to be located in the same Local Area Network (LAN) or Virtual Private Network (VPN) as the XRC 9000 controller acting as IP Site Connect Master.

Location Tracking Application: If a Location Tracking Application is desired, the PC hosting the application can be located in the same LAN as the XRC 9000 controller, or in a different LAN.

Text Messaging Application: If a Text Messaging Application is desired, the PC hosting the application can be located in the same LAN as the XRC 9000 controller, or in a different LAN.

MOTOTRBO Connect Plus Network Manager Software: A PC hosting the MOTOTRBO Connect Plus Network Manager software can connect to XRC 9000 either locally or remotely. For remote connections, the PC hosting the MOTOTRBO Connect Plus Network Manager program can be located in the same LAN as the XRC 9000 controller, or in a different LAN.

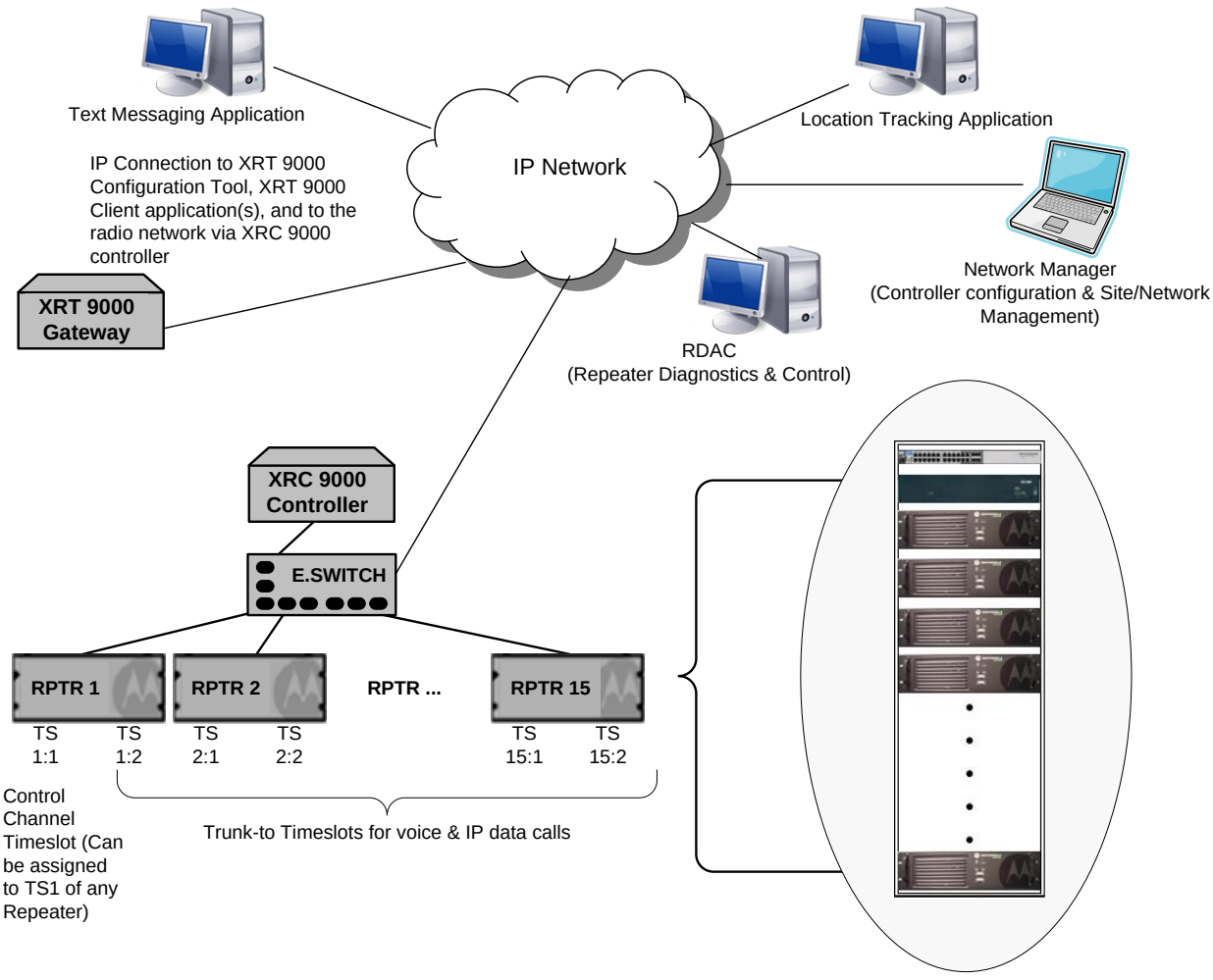


Figure 3-3 Connect Plus Single Site Configuration

XRT 9000 Gateway: Allows certain 3rd party client applications to interface with the Connect Plus System. The XRT 9000 Gateway can be located in the same LAN as the XRC 9000 controller, or in a different LAN.

3.2.4.4 IP Topologies of a Multisite Connect Plus Network

A multisite Connect Plus Network consists or multiple Connect Plus single-sites that are networked together via an IP backbone. The sites communicate with one another via TCP/IP and UDP/IP. An example of a Connect Plus Multisite system configuration is illustrated in Figure 3-4.

XRC 9000 Controller and MOTOTRBO Repeaters: As stated in the previous section, the XRC 9000 controller and its connected site repeaters are always in the same LAN.

XRC 9000 Controllers located at different sites: In a multisite network, the repeaters communicate only with their local XRC 9000 controller. They do not exchange messages with controllers or repeaters at other Connect Plus sites. Instead, all network communications are handled by the XRC 9000 controllers. These controllers can all be in the same network, in different networks, or a combination of both.

The recommended multisite topology, wherever possible, is that the all XRC 9000 controllers should reside in the same private network or virtual private network (VPN). There are some important reasons for this recommendation:

- Regardless of what network configuration is utilized, the network links must meet the bandwidth, latency, and jitter requirements discussed in Connect Plus System Design Considerations. In a Private IP Network the amount of IP traffic, network capacity, and message routing is under the control the network owner. Because of this, the private network can be designed to ensure adequate Connect Plus bandwidth and performance. In public networks, capacity, loading and routing tend to be more unpredictable. This makes it more difficult to assure that Connect Plus requirements can be consistently met.

- In Private or Virtual Private Networks, each XRC 9000 controller can communicate with one another directly, using IP addresses that are known and consistent network wide. This greatly simplifies the required IP set-up, both in the XRC 9000 controllers and in the network's routers. When the XRC 9000 controllers reside in multiple IP networks, the IP configuration is not as straight-forward.

- Private networks have advantages in the important area of IP security. Connect Plus supports the ability to work through a Secure VPN (Virtual Private Network). Secure VPN is not a function of the XRC 9000 controller device but rather of the router. It is important to note that VPN does add the need for additional bandwidth and may introduce additional delay. This should be taken into consideration in bandwidth planning.

While it is highly desirable to exclusively utilize private IP links, this may not be possible for all customers. Connect Plus has been designed to accommodate different types of network configurations, including the ability to connect sites over public Internet Service Provider (ISP) links.

Connect Plus is also designed to work in a mixed IP network environment. Examples of a mixed IP network environment include the following:

- Some sites reside in a private IP network, while others reside in a public IP network

- Some sites reside in public IP network "A", while others reside in public IP network "B"

Mixed IP network topologies significantly complicate IP address set-up, port configuration, router configuration, and IP security issues.

Regardless of whether Connect Plus sites are linked via private or public connections, the following requirements must be fulfilled for all Connect Plus IP links:

- Each Connect Plus Controller requires a static IP address. In a public network, the static address is provided by ISP (Internet Service Provider).

- Regardless of what network configuration is utilized, the network links must meet the bandwidth requirements discussed in Connect Plus System Design Considerations.

- Connect Plus sites communicate exclusively via TCP/IP and UPD/IP. If a linking technology converts these messages to a different format for transport, they must be converted back to TCP/IP and UDP/IP prior to being delivered to the XRC 9000 Controller at the destination site. If any conversion is done, the process must be completely transparent (invisible) to all XRC 9000 controllers. Furthermore, the conversion process must not prevent the network link(s) from meeting the bandwidth requirements discussed in Connect Plus System Design Considerations.

- Connect Plus does not support dial-up connections for inter-site messaging (due to small bandwidth) or Satellite Internet access (due to large delay).

- Network security is an important consideration. In the event that Connect Plus sites will be connected through anything other than a Private Network or Virtual Private Network, a Certified Networking Professional will need to assist the system owner in protecting the radio network from the undesired solicitations common over the public internet.

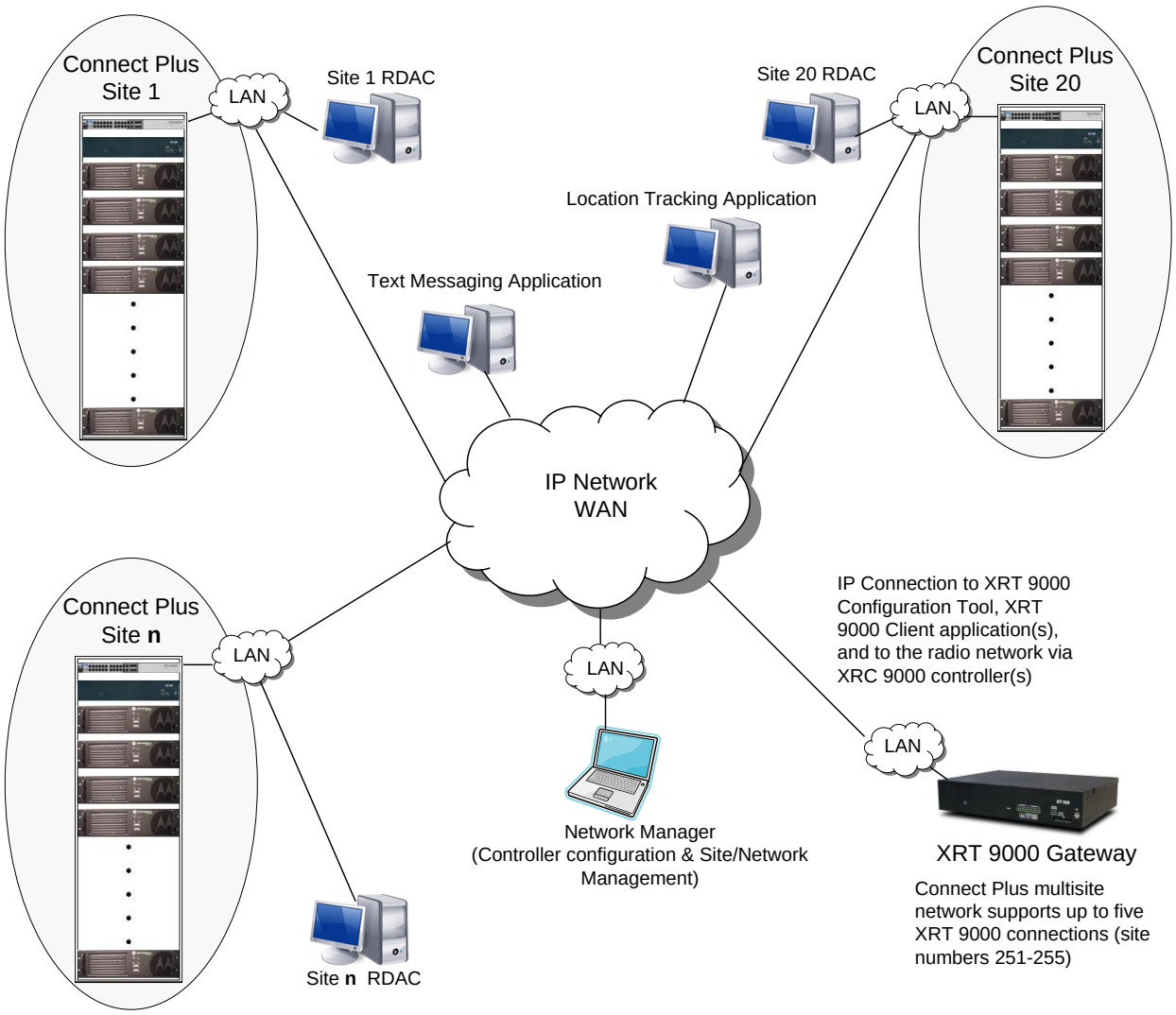


Figure 3-4 Connect Plus Multisite Configuration

3.2.4.5 Other IP Components of the Connect Plus Multisite Network

RDAC application: As discussed previously, the RDAC application must reside in the same LAN (or VPN) as its IP Site Connect Master (the XRC 9000 controller) and its IP Site Connect Peers (the MOTOTRBO repeaters under the control of the XRC 9000 Controller.) If the RDAC application is managing multiple IP Site Connect Systems (i.e. multiple Connect Plus Sites), then all sites managed by the RDAC application must be in the same LAN (or VPN) as the PC running the RDAC application. For more information on the reasons for this requirement, please see the previous section *IP Topologies of a Single Site System*.

Location Tracking Application: If a Location Tracking application (also known as the LRRP application) is utilized in the Connect Plus multisite network, it can send the Location Request to any Connect Plus site controller. The PC hosting the requesting application can be located in the same IP network as the destination site, or in a different IP network. The XRC 9000 controller that receives the message will inspect the message contents to determine the destination SU. If the SU is registered at a different network site, the XRC 9000 controller will forward the message to the registered site. The registered site, upon receiving the Location Report from the SU, sends it directly to the requesting application. It does not route the report back through the Connect Plus site that received the request.

When a Connect Plus controller sends a message to the Location application, the IP address and port used by the controller depends on how the controller is programmed. There are two configuration choices:

- **Method A**: Controller is not programmed to use a LRRP Server IP address and port that has been configured into the controller. In this case, the controller sends the Location Report to the source IP address and port extracted from the LRRP Request that prompted the report.

- **Method B**: Controller is programmed to use a LRRP Server IP address and port that has been configured into the controller In this case, the controller sends the Location Report to the address and port configured into the controller. This feature is known as LRRP IP Message Forward, also known as the “override” function.

Method A is the default Controller operation. It provides more flexibility than Method B because it supports a different Location Tracking application for each SU. However, it can only be used when all network sites have the same perspective back to the requesting application. The following example describes one scenario where all network sites would not share the same perspective. The Location application and Site 1 are both located in the same LAN. The Location application sends a message to Site 1. Site 1 inspects the message and sees that the destination SU is registered at Site 2. Site 1 forwards the message to Site 2, which is located in a different IP network. The forwarded message is wrapped inside of a Connect Plus TCP inter-site message. Site 2 sends the Request to the SU and receives a Location Report. When Site 2 sends the Location report back to the requesting application, it must not use the Source IP address and port extracted from the request because that is the application’s “private IP address” on its LAN, and it will not be correct from the perspective of Site 2. Instead, Site 2 must use the application’s “public IP address” and port. Since this cannot be known by inspecting the contents of the received message, Site 2 must be enabled for “override” and must use its configured “LRRP IP Message Forward” address and port. This is just one example where Method B must be used. Other scenarios could also necessitate this approach. Method B provides less flexibility than Method A because there is just one configurable LRRP Server IP address and port per site. This means that all SU’s must report to the same Location tracking application.

Text Message Application: If a Text Message application (also known as the TMS application) is utilized in the Connect Plus multisite network, it can send the TMS message to any Connect Plus site controller. The PC hosting the requesting application can be located in the same IP network as the destination site, or in a different IP network. The XRC 9000 controller that receives the message will inspect the message contents to determine the destination SU. If the SU is registered at a different network site, the XRC 9000 controller will forward the TMS message to the registered site. If the TMS message was a "Simple Text Message", the site forwards the message to the destination SU. If the TMS message was a "TMS Service Availability" Message, the site stores the information contained in the message on behalf of the destination SU.

When a Connect Plus SU wants to send a simple text message to a Dispatch Call ID (which represents a "client" of the TMS application), the SU sends the message to the controller of the site where the SU is registered. The message contains the destination Dispatch Call ID, but it does not contain the IP address of the Text Message application. The SU counts on the controller to forward the message to the correct IP address and port for the TMS application. When the controller forwards to the simple text message to the TMS application, the IP address and port used by the controller depends on how the controller is programmed. There are two configuration choices:

- **Method A**: The controller is not programmed to use a TMS Server IP address and port that has been configured into the controller. In this case, the controller sends the simple text message to the source IP address and port extracted from the TMS Service Availability Message, which the controller stored on behalf of the SU.

- **Method B**: Controller is programmed to use a TMS Server IP address and port that has been configured into the controller. In this case, the controller sends the simple text message to the address and port configured into the controller. This feature is known as TMS IP Message Forward, also known as the "override" function.

Method A is the default Controller operation. It provides more flexibility than Method B because it supports a different TMS application for each SU. However, it can only be used when all network sites have the same perspective back to the TMS application. The following example describes one scenario where all network sites would not share the same perspective. The TMS application and Site 1 are both located in the same LAN. The TMS application sends a TMS Service Availability Message to Site 1. Site 1 inspects the message and sees that the destination SU is registered at Site 2. Site 1 forwards the message to Site 2, which is located in a different IP network. The forwarded message is wrapped inside of a Connect Plus TCP inter-site message. Site 2 stores the information contained in the message on behalf of the destination SU. Sometime later, the SU sends the controller a simple text message which is destined for a Dispatch Call ID. When the controller forwards this simple text message to the TMS application, it must not use the Source IP address and port extracted from the TMS Service Availability Message because that is the application's "private IP address" on its LAN, and it will not be correct from the perspective of Site 2. Instead, Site 2 must use the application's "public IP address" and port. Since this cannot be known by inspecting the contents the TMS Service Availability message, Site 2 must be enabled for "override" and must use its configured "TMS IP Message Forward" address and port. This is just one example where Method B must be used. Other scenarios could also necessitate this approach. Method B provides less flexibility than Method A because there is just one configurable TMS Server IP address and port per site. This means that any text message from any SU that is addressed to any Dispatch Call ID will be forwarded to the same TMS server.

MOTOTRBO Connect Plus Network Manager Connection Tool & **MOTOTRBO Connect Plus Network Manager**: The MOTOTRBO Connect Plus Network Manager Connection Tool is used to establish connection(s) with Connect Plus Site(s), and to authenticate the entered Username and Password. The connection can be a serial connection (to one site at a time) or a TCP/IP connection (to a single site, or to multiple sites).

For TCP/IP connections, the destination XRC 9000 can be located in the same IP network as the PC hosting the Connection Tool application, or in a different IP network. In order to connect with a desired site, the Connection Tool must be configured with a destination IP address and port that is correct from the current perspective of the PC hosting the application. If the PC is a laptop, this perspective can change as the laptop is carried from one IP network to another. So, depending on its location, the laptop may not always use the same IP address and port to connect to the same site.

Once the site connection(s) is/are established, the Connection Tool launches the MOTOTRBO Connection Plus Network Manager. The Network Manager is the software application that is used to view and configure the connected XRC 9000(s). A single instance of the Network Manager can manage simultaneous TCP/IP connections to multiple sites that share the same Network ID. This is known as the Connection Groups feature. However, only one site a time can be selected for viewing and configuration. Because it is so easy to change the selected site when there are multiple sites in the Connection Group, it is important for the user to always be aware of which site is currently selected for viewing and configuration. The Site Number for the currently selected site appears at the bottom of the Network Manager screen.

XRT 9000 Gateway: The XRT 9000 Gateway is an optional component for the MOTOTRBO Connect Plus digital trunking system that allows certain 3rd party applications to interface with Connect Plus, supporting features such as a digital wireline console, automatic retrieval of airtime billing data, and providing an interface for some analog devices. If the XRT 9000 is used to initiate and receive calls, its impact on call loading and IP network bandwidth is similar to the impact of a Connect Plus site with 15 repeaters (30 timeslots). If the XRT 9000 client application is “streaming” Connect Plus airtime data, this uses additional IP bandwidth. For more information, see the sections on Connect Plus IP Network Bandwidth Considerations.

4 Connect Plus System Design Considerations

4.1 Migrating to Connect Plus from other MOTOTRBO Digital Modes

Migrating to Connect Plus from other MOTOTRBO Digital Modes involves several prerequisites and considerations:

- Radio firmware must be Release 01.06.30 or newer.
- Each MOTOTRBO subscriber radio must have a Connect Plus Option Board, or a “Generic Option Board” that can be converted to Connect Plus operation through the installation of Connect Plus firmware. This must occur before the SU can be used for Connect Plus.
- Each MOTOTRBO subscriber radio must be enabled for the Connect Plus purchasable feature.
- Each MOTOTRBO subscriber radio must be configured for Connect Plus operation, both with MOTOTRBO CPS and with Connect Plus CPS.

- Connect Plus does not use Control Station Radios as the air interface for Location Tracking Applications or Text Message Applications. If these radios are no longer needed as a Control Stations for other MOTOTRBO modes, they can be used as Connect Plus mobiles.

- If desired, the non-Connect Plus zones and channels in the SU can be preserved, but they must be shifted in order so that they do not precede any Connect Plus zone. Guidelines for this procedure are provided in this document.

- In most cases, the Radio ID used in the previous MOTOTRBO Digital Mode can also be used in Connect Plus. There are two exceptions:

    - If the same Radio ID is used in more than subscriber unit, it must be changed to a different Radio ID that is not assigned to any other SU.

    - Radio ID's 16776352 through 16776415 are not allowable for Connect Plus operation. If the radio's current Radio ID falls into this range, it must be changed to an unused Radio ID in the allowable Connect Plus range. (1 to 16776351)

- The MOTOTRBO Repeater used in the previous digital mode can be used for Connect Plus operation, provided the following conditions have been met:

    - The repeater's software version must be capable of Connect Plus operation.

    - Both repeater timeslots will be used for Connect Plus.

    - The repeater will have to be re-configured with MOTOTRBO CPS in order to set several key parameters as required by Connect Plus.

    - The repeater will have to be connected via IP to a Connect Plus XRC 9000 Controller. The repeater must be in the same physical location as the XRC 9000 controller, and must be attached to the same Ethernet switch.

- The repeater frequency used in the previous MOTOTRBO digital mode can likely be used for Connect Plus. For more information, see Connect Plus Frequency Licensing Considerations.

Once the prerequisite conditions are met, the system can be migrated to Connect Plus operation.

Because the radios can be programmed with both Connect Plus and non-Connect Plus modes, the System Administrator has a couple of migration strategies to choose from:

- Talk Groups and Repeaters can be switched over to Connect Plus in a phased approach, with some Groups and Repeaters being switched to Connect Plus prior to others.

- The entire system can be switched over to Connect Plus at a specific time and date. Prior to the switch-over, all subscriber units must be enabled and programmed for Connect Plus operation.

Regardless of which strategy is chosen, this will have to be communicated to radio users. Each user should be instructed in how to switch the radio to Connect Plus operation (by selecting the Connect Plus zone and channel). Also prior to the switch-over, each user should be trained in how the radio operates in Connect Plus mode.

4.2 Connect Plus Frequency Licensing Considerations

4.2.1 Acquiring Frequencies

Frequency Licensing considerations and procedures for Connect Plus are similar to other MOTOTRBO digital modes. The reader can refer the section on Acquiring New Frequencies of [1]. Connect Plus has one additional (and essential) licensing consideration that does not apply to other MOTOTRBO digital modes.

In Connect Plus the downlink of the Control Channel timeslot transmits continuously. This minimizes the time the SU spends searching for service, and it allows the system to quickly respond to registrations and call requests. Any interruption to this continuous messaging adversely affects system performance. Because of this requirement, Connect Plus Control Channel frequency pairs require a Protected Service Area. Non-exclusive licenses such as FB2 or FB6 are not suitable for Connect Plus Control Channel operation (for more information refer to the "Licensing of Part 90 Radio Services" section).

4.2.2 Repeater Continuous Wave Identification (CWID) for Connect Plus

The System Administrator should be familiar with the FCC station identification requirements for each licensed frequency. Station Identification is sometimes called "Base Station Identification" (BSI), and other times it is referred to as Continuous Wave Identification (CWID). The latter name is because "CW" is another name for Morse Code, which is used to send the station's call sign. In this document, BSI and CWID are used interchangeably.

Connect Plus enables the license holder to comply with ID requirements by providing a programmable CWID and CWID interval for each Connect Plus repeater. In other digital modes, CWID is handled entirely by the repeater. In Connect Plus mode, CWID is handled jointly by the repeater and the XRC 9000 controller. The CWID itself (usually the FCC license call sign) is programmed into the repeater with MOTOTRBO CPS, but the TX Interval is programmed into the XRC 9000 Controller. When the repeater registers with an IP Site Connect Master identifying itself as the XRC 9000 controller, the repeater knows to ignore the CWID TX Interval programmed with MOTOTRBO CPS. The Controller will tell the repeater when to send CWID. If the repeater "NACKs" the controller's request for CWID (also called BSI), the XRC 9000 will retry the request several times. If the retries are also denied, the controller will make no further attempts to start BSI on the repeater, and it will automatically change the BSI interval for that repeater to zero (indicating no BSI). The controller will also place a time-stamped "BSI Error" into its Event Log, which can be retrieved and viewed with the MOTOTRBO Connect Plus Network Manager. The BSI interval will remain at zero until the radio system administrator changes it to a different value with the Network Manager.

Whenever possible, CWID should be sent on trunk channel repeaters only. CWID on the Control Channel repeater interrupts Control Channel messaging, and will cause significant operational problems to radios using the site. It should be avoided if at all possible. During CWID the repeater transitions to analog mode and ceases all digital signaling. During Control Channel CWID, the SU cannot register or request calls, and the Control Channel cannot send messages for calls in-progress. Prior to starting CWID on the Control Channel repeater, the controller sends a special message on the Control Channel downlink. Any SU that decodes this message will start a configurable timer called "BSI Wait Time" (configured with MOTOTRBO Connect Plus Option Board CPS). The value programmed for this timer must allow enough time for the repeater to send the CWID and for the Control Channel messaging to resume. SUs that decode the special message will not move to other sites during CWID (provided their timer doesn't expire), but they will

display “Searching” until the CWID finishes and the Control Channel messaging returns. SUs that do not decode this special message will attempt to locate another site during CWID.

4.2.3 Licensing of Part 90 Radio Services

Based on the Federal Communications Commission (FCC) rules and regulations[26] in the United States, trunking radio service can be on shared channels or exclusive channels. To determine the type of license needed, please consider the following:

- IG = Business/Industrial, Conventional
- YG = Business/Industrial, Trunking (**Connect Plus**)
- FB2 = Repeater on shared channel, internal systems
- FB6 = Repeater on shared channel, for profit systems
- FB8 = Repeater on exclusive channel

In the **700/800/900 MHz** bands, the channels are paired and normally licensed as exclusive.

In the **UHF** band, the channels are paired and normally licensed as shared. It requires additional coordination effort to find and license exclusive channels.

In the **VHF** band, the channels are **not** paired – base/mobile simplex channels – and are normally licensed as shared. It requires additional coordination effort to find and license shared repeater channel, and then the additional coordination effort to license repeater channels as exclusive.

Trunked systems, like Connect Plus, are often high traffic systems with a dedicated, continuous Control Channel and are usually licensed on exclusive channels. Continuous Control Channel must be exclusive (FB8), but traffic channels could be either exclusive (FB8) or shared (FB2/FB6). If the traffic channels are expected to have a high activity level, they should be exclusive (FB8). Shared traffic channels (FB2/FB6) must be capable of monitoring channel before transmitting, which usually means lower channel traffic levels.

There are two levels of monitoring for shared channels:

- **Level I** – Repeater monitors base receive channel for mobile activity (normal channel monitoring). The RSSI threshold setting in MOTOTRBO repeaters is used for FCC Type 1 compliance, as it is used to measure the maximum interference signal that the MOTOTRBO repeater tolerates. The challenge with Level I monitoring is that there could be a 'hidden node' issue where distant foreign subscribers may not be heard. Same issue occurs on normal conventional repeater channels.
- **Level II** – Requires separate remotely located monitor receiver on the repeater transmit frequency to listen to co-channel repeater output channel. This eliminates the 'hidden node' issue and is recommended if there is interference between systems using Level I monitoring.

Note: The above guidelines apply to part 90 services. Auction channels are still available in Part 22 and Part 80 in the US.

4.3 Digital Repeater Loading for Connect Plus

Accounting for repeater loading is a critical step in designing a Connect Plus system. Such planning ensures that the designer is able to choose the number of channels required to support

[26] Part 90 – Private and Land Mobile Radio Services

the customer's typical communication needs at the expected level of service. The first step is to estimate how much traffic a single slot (channel) can support. An important distinction in Connect Plus is the fact that it is digital trunking system, which means that the loading estimation models will be different than the other digital modes supported by MOTOTRBO. Since the traffic, consisting of voice, text messages, location updates, and registration requests, is mostly initiated by the end user, it is challenging to predict how often it occurs. Standard usage profiles of existing customers have been created for voice and data services. These profiles act as a baseline for estimating how much traffic a user creates on a system. If the standard profiles do not match your customer's expected usage, further estimations based on the trend lines need to be considered. After the system is used, and real life usage is identified, further adjustments may be required.

4.3.1 Voice and Data Traffic Profiles

The following table outlines the typical user traffic that is based on empirical data. These usage profiles are considered standard and are utilized to estimate the number of users that can be supported per channel. These estimates are depicted on graphs in the in the sections that follow. The same user traffic assumptions have been used for other non-Connect Plus digital configurations as well. The reader can refer to Digital Repeater Loading section in [1] for more details.

Profile Name	Traffic Type	Call Description	Traffic Per User Per Hour	
High Voice	Group Voice Call	10 second call, 2 transmissions per call	3.0 Calls per User per Hour	90%
	Individual Voice Call	20 second call, 4 transmissions per call		10%
Low Voice	Group Voice Call	10 second call, 2 transmissions per call	1.0 Calls per User per Hour	90%
	Individual Voice Call	20 second call, 4 transmissions per call		10%
High GPS	Location Updates	2 seconds per transmission	60 GPS Transmissions per User per Hour i.e. 1 Minute Update Period (Cadence)	
Low GPS	Location Updates	2 seconds per transmission	6 GPS Transmissions per User per Hour i.e. 10 Minute Update Period (Cadence)	
High Text Messaging	Text Messaging	100 characters per message	2.5 Text Messages per User per Hour	
Low Text Messaging	Text Messaging	100 characters per message	0.5 Text Messages per User per Hour	

Table 4-1 Voice and Data Traffic Profiles

4.3.2 Estimating Loading For Connect Plus

The following charts in Figure 4-1 and Figure 4-3 represent loading characteristics of a Connect Plus system based on a certain user experience, for a given number of active (call participants) users, and for different combinations of Voice and Data Profiles as defined in 4.3.1.

The charts represent a radio user's experience in making a call in terms of Grade of Service (GoS). GoS is directly related to the probability of a call getting blocked i.e. probability of all the trunked channels being busy. For example, a GoS of 2% means that 2% of the calls made by the radio users will need to wait in the Busy Queue for a channel to become available.

The "channel" in the chart refers to a logical channel (i.e. a timeslot). In Connect Plus, both channels of a repeater are in trunked mode (except for the Control Channel repeater). Therefore, the charts provide the number of users only for an even number of channels.
The number of calls handled by a Connect Plus system may vary considerably based upon the number of users and volume of calls. Typical systems are heavily loaded for a few hours in a day. It is recommended that the system be designed with an adequate amount of channel resources to handle both peak and off-peak traffic. The charts in this section represent estimated number of active users that can be supported **per site**.

The first chart (Figure 4-1) is for High Voice profile (i.e. 3 Calls per User per Hour) with no GPS data, whereas Figure 4-2 illustrates the capacity for Low Voice (i.e. 1 Call per User per Hour) with no GPS traffic.

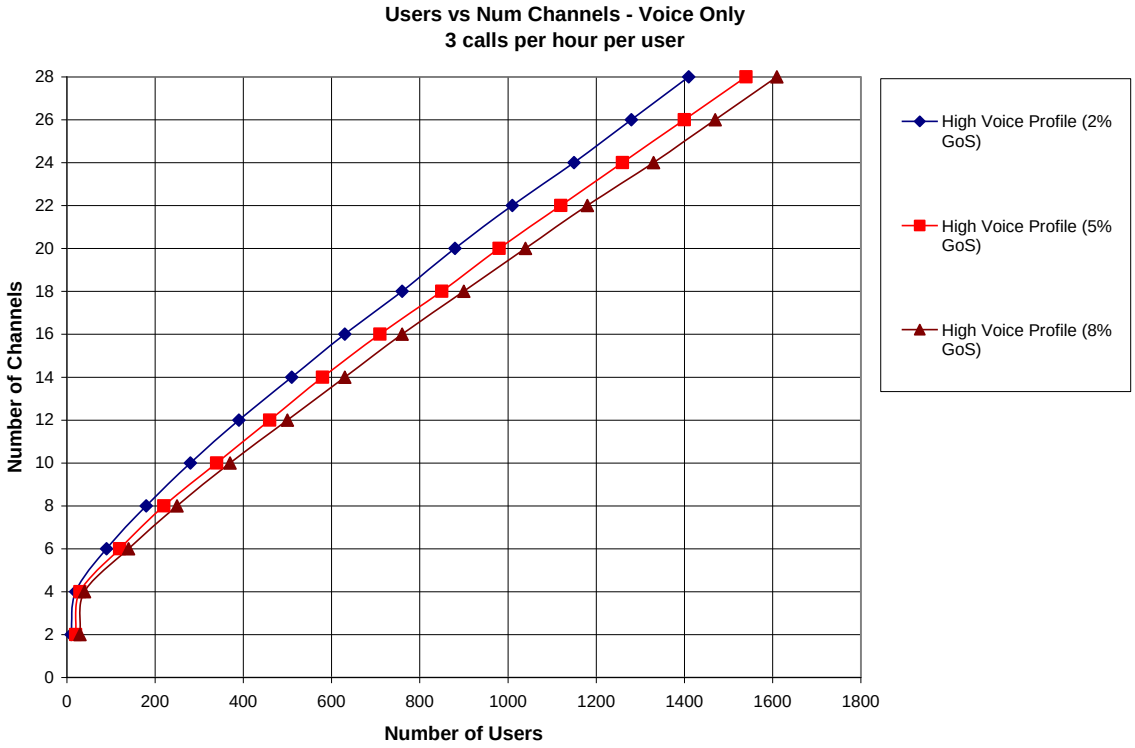


Figure 4-1 Users vs. Number of Channels for High Voice-Only Traffic

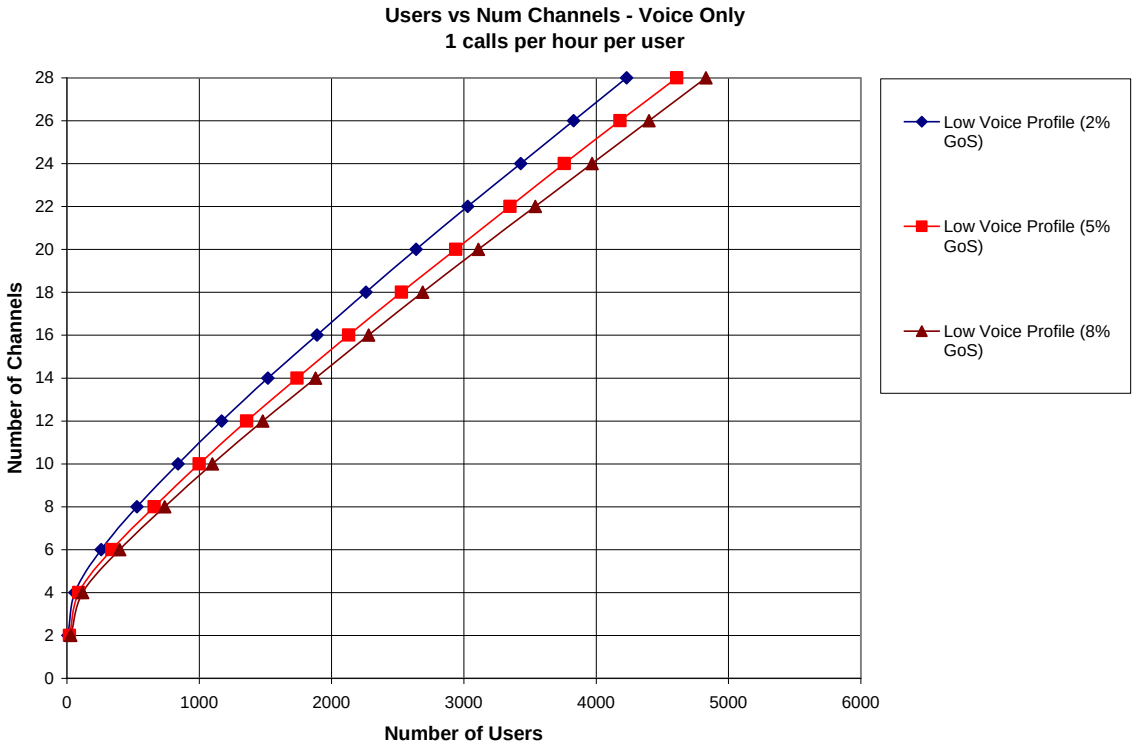


Figure 4-2 Users vs. Number of Channels for Low Voice-Only Traffic

Figure 4-3 is for mixed voice and GPS data profile. The graph shows High Voice with low GPS data traffic. Since Connect Plus is a trunking system, both voice and GPS data are using the trunked channels. The reader should note the trend indicated in the chart – the number of users does not increase proportionally with the number of channels. The rate increases as the number of channels increase. This is due to the fact that the efficiency of trunking increases with the increase in the number of channels.

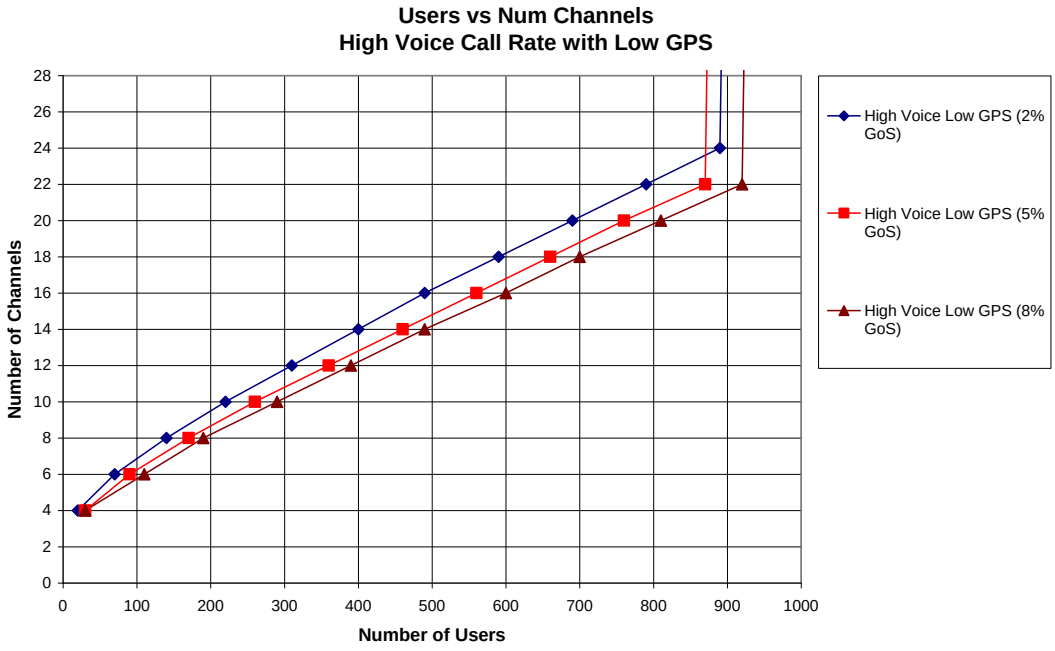


Figure 4-3 Users vs. Number of Channels for High Voice & Low GPS Traffic

Figure 4-4 depicts the loading profile for Low Voice call rate with Low GPS updates.

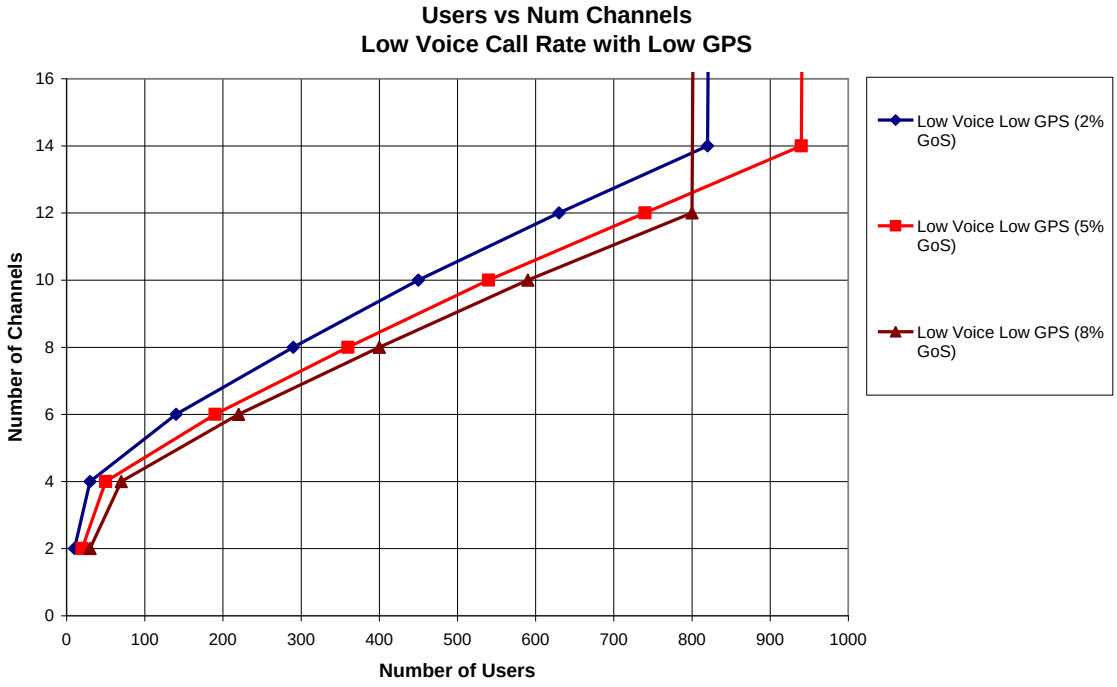


Figure 4-4 Users vs. Number of Channels for Low Voice & Low GPS Traffic

In the case of high GPS data, it is recommended that a Connect Plus system have sufficient trunked channel allocated for Location Updates. The *Number of Data Sessions Allowed* parameter in the XRC 9000 controller can be set to a higher value to accommodate this type of traffic.

4.3.3 Setting Repeater Hang Times in Connect Plus

When Connect Plus radios move to a trunk-to timeslot to participate in a voice call, the Call Hang Time allows an opportunity for talk-back using the same Call ID, without having to return to the Control Channel to request a new call. Besides providing an opportunity for talk-back on the assigned timeslot, the Call Hang Time helps provide continuity to the conversation and prevents the channel from being assigned to another call. The Call Hang Time is configurable per call type for “Group Call”, “Private Call”, and “Emergency Call”.

In other digital modes, the repeater can be configured with a “zero” Call Hang Time to create a “transmission trunking” environment where each PTT is treated as a brand new call. This configuration is not recommended or supported in Connect Plus because the time required for Control Channel call processing, validation, channel assignment, and synchronization with the assigned timeslot would have to be repeated for each PTT.

Selecting value(s) for the Call Hang Times is one of the most important decisions to be made when configuring a system. There are pluses and minuses to both “longer” and “shorter” Hang Time values. Selecting the best Call Hang Time value is somewhat of a trade-off, and will vary according to the needs of the system and its users.

Longer Hang Time values provide the greatest opportunity for the radio user to talk-back on the assigned channel without having to start a brand new call. This benefits both the user and the system. Speaking during the Hang Time of an existing call provides faster access than having to start a new call. It also assures that the speaker will have an available channel, whereas a new Call Request might be placed in the Busy Queue. Longer Hang Time values also help reduce Control Channel congestion on busy systems. On the other hand, longer Hang Time values are perceived as detrimental when the call is really over and users must wait for the channel to drop.

It should be noted that Connect Plus does not recommend or support a value of “zero” for Call Hang Times. The default Call Hang Time Values (3 seconds for Group Call and 4 seconds for Private and Emergency Calls) or longer are recommended. In many systems Private Call Hang Time is set longer than the Group Call Hang Time (due to the additional call set-up messages before a Private Call), and Emergency Call Hang Time is set longer than either Group Call or Private Call. See section “Programming the Repeater’s Emergency Call Hang Time” for important considerations for setting the Emergency Call Hang Time.

The method for setting the Call Hang Times depends on both the repeater’s and the XRC 9000’s software version. For Connect Plus releases prior to Release 1.1, the Call Hang Time settings are programmed into the repeater via MOTOTRBO CPS. After setting the Call Hang Time with MOTOTRBO CPS, the Connect Plus Network Manager is used to set the corresponding “Call Inactivity Timer” in the controller for at least one second longer than the Call Hang Time configured into the repeater.

For Connect Plus Release 1.1 and later, the Connect Plus Network Manager has configurable settings for “Group Call Hang Time”, “Private Call Hang Time” and “Emergency Call Hang Time”. The XRC 9000 uses these values to automatically configure the repeater’s Call Hang Timers during Link Establishment. The repeater uses the Network Manager values as long as it maintains connectivity to the XRC 9000, but it does not save the Network Manager-configured values to persistent memory. If MOTOTRBO CPS is used to read the repeater’s codeplug, it will display the

CPS-configured values, not those set with the Network Manager. If the repeater loses connectivity with the XRC 9000 and enters conventional fallback mode, it uses its CPS configured Hang Time values. When the XRC 9000 comes back on line, the repeater will automatically initiate Link Establishment with the controller. If Link Establishment is successful, the repeater will exit conventional fallback operation, and will once again use the Hang Time values that were configured with the Network Manager.

Beginning with Connect Plus Release 1.1, the Connect Plus Network Manager no longer provides configurable settings for the Call Inactivity Timers. These are set behind-the-scenes depending on the Call Hang Time values programmed with the Connect Plus Network Manager.

Regardless of which Connect Plus release is being used, the radio System Administrator must assure that the value chosen for each Call Hang Time setting is programmed the same into each Connect Plus repeater and site network-wide. Beginning with Connect Plus Release 1.1, the XRC 9000 helps with this requirement by automatically configuring each of the site's repeaters with the Hang Time values programmed with the Network Manager. However, the System Administrator must assure that all XRC 9000 controllers in the multisite network are configured with the same Hang Time values.

Important Note: The ability to set the Call Hang Timers value via the Network Manager requires the repeater to have MOTOTRBO Release 1.8 software (or later). For more information, see the section "Migrating to Controller-Set Call Hang Time".

4.3.4 Migrating to Controller-Set Call Hang Time

If a Connect Plus System upgrades from a prior Connect Plus release to Connect Plus Release 1.1 (or later), the System Administrator should utilize the following guidelines to assure a smooth transition from MOTOTRBO CPS-configured Call Hang Times to Network Manager-configured Call Hang Times. Because this discussion covers the migration of an existing system, it assumes that MOTOTRBO CPS was used to configure the Call Hang Times into the repeaters per the Connect Plus rules (which state that the Hang Time value selected for each call type must be programmed the same in all Connect Plus repeaters, at all sites, network-wide.)

- Prior to upgrading the XRC 9000 to Connect Plus Release 1.1, it is recommended to first upgrade the repeater firmware for all site repeaters to MOTOTRBO System Release 1.8 (or newer). This is because repeaters with older firmware will not accept the controller's request to set Call Hang Times. If the XRC 9000 attempts to set the Call Hang Time, but the repeater does not positively acknowledge the request, the XRC 9000 will generate an Event Log Entry indicating that repeater failed to adjust Hang Time. The Event Log Entry indicates that the repeater's Radio ID. If it is not possible to upgrade the repeater firmware prior to upgrading the XRC 9000 firmware, then see the important note at the end of this section. The subsequent bullets assume that all repeaters have been upgraded to MOTOTRBO System Release 1.8 or later.

- Immediately after upgrading a controller to the new Connect Plus release, use the Network Manager set the Call Hang Times to match the Hang Time values configured into the repeaters of the sites that have not yet been upgraded.

- Continue to follow the rule above until all sites have been upgraded to the new Connect Plus Release.

- When all sites have been upgraded to the new Connect Plus release, all Hang Times will be adjusted via the Connect Plus Network Manager and not via MOTOTRBO CPS. The

Network Manager can now be used to adjust a Call Hang Time to a different value, if desired. Because the Call Hang Timers are “Critical” parameters (i.e. requiring a site reset), the adjustment should be done when site activity is low.

- If the Call Hang Time is adjusted at any Connect Plus site, it should be adjusted to the same value at all other Connect Plus sites (using the Network Manager) as soon as possible. For any period of time that Hang Times are set to different values at different sites, there is a possibility of unexpected network operation (such as a call ending at one site while it is still underway at a different site).

Note: If any network repeater still has firmware prior to MOTOTRBO Release 1.8, then the Call Hang times set by the Network Manager must be configured to exactly match the Call Hang Times configured into the repeater with MOTOTRBO CPS (per call type). When all network repeaters have been upgraded to MOTOTRBO System Release 1.8 firmware, the Call Hang Time values configured with the Network Manager do not have to match the Call Hang Time values configured with MOTOTRBO CPS. The repeater will use the Network Manager-configured value when it has a link with the XRC 9000. The repeater will use the MOTOTRBO CPS-configured value when it doesn’t have a link with the XRC 9000.

4.4 Multiple Digital Repeaters in Connect Plus Mode

4.4.1 Configuring Connect Plus Repeaters with MOTOTRBO CPS

The MOTOTRBO repeater is a required component of the Connect Plus trunking system, as it provides the RF path between the Connect Plus Controller and the Connect Plus SU.
Each XRC 9000 Controller can control up to 15 MOTOTRBO repeaters. The XRC 9000 and its connected repeaters must be in the same physical location, and connected to the same Ethernet switch. The XRC 9000 acts as the IP Site Connect Master and the connected repeaters are configured as IP Site Connect Peers.

Before the MOTOTRBO Repeater can operate in a Connect Plus system, it must be configured with MOTOTRBO CPS according to the guidelines provided below. These guidelines do not address every programmable repeater parameter, just the settings that are critical to Connect Plus operation,

Prior to configuring the repeater, use MOTOTRO CPS to read the repeater’s codeplug. Then, from the MOTOTRBO CPS Main Menu select “View”, and then select “Expert” from the drop-down View Menu. This will assure that the programmer sees all of the settings discussed in the tables below.

MOTOTROBO CPS General Settings screen
Settings critical to Connect Plus Operation

Setting	**Notes and Additional Information**
Radio ID	Each Repeater must be programmed with a unique Radio ID (1-15). Once a Radio ID is used, it cannot be repeated in the same Connect Plus site. However, because Connect Plus restricts all repeater Radio ID’s to the same 15 numbers, they can be re-used at different sites. The Radio ID must match the frequency configuration for this repeater & site in the Connect Plus Network Frequency File.
SIT (Subscriber Inactivity Time)	For Connect Plus releases prior to R1.1, the repeater’s Subscriber Inactivity Time is configured with MOTOTRBO CPS, and the System Administrator

	must assure that SIT is equal to or longer than the longest Call Hang Time value. For Connect Plus Release 1.1 and later, the SIT value configured into the repeater with MOTOTRBO CPS will be overwritten by the XRC 9000 during Link Establishment with the repeater. The XRC 9000 will set the repeater's SIT based on the Call Hang Time values configured with the Connect Plus Network Manager. The repeater will use the SIT value sent by the XRC 9000 as long as it maintains its connection to the XRC 9000.
Group Call Hang Time	The Group Call Hang Time must be configured with the same value for all Connect Plus repeaters and sites in the same network. The method for setting the Group Call Hang Times depends on the XRC 9000's software version. For Connect Plus releases prior to Release 1.1, the Group Call Hang Time is programmed into the repeater with MOTOTRBO CPS. Beginning with Connect Plus Release 1.1, the Group Call Hang Time value configured with MOTOTRBO CPS will be overwritten with the Group Call Hang Time configured with the MOTOTRBO Connect Plus Network Manager. See section "Setting Repeater Hang Times in Connect Plus" for important information on selecting the Group Call Hang Time value.
Private Call Hang Time	The Private Call Hang Time must be configured with the same value for all Connect Plus repeaters and sites in the same network. The method for setting the Private Call Hang Times depends on the XRC 9000's software version. For Connect Plus releases prior to Release 1.1, the Private Call Hang Time is programmed into the repeater with MOTOTRBO CPS. Beginning with Connect Plus Release 1.1, the Private Call Hang Time value configured with MOTOTRBO CPS will be overwritten with the Private Call Hang Time configured with the MOTOTRBO Connect Plus Network Manager. See section "Setting Repeater Hang Times in Connect Plus" for important information on selecting the Private Call Hang Time value.
Emergency Call Hang Time	The Emergency Call Hang Time must be configured with the same value for all Connect Plus repeaters and sites in the same network. The method for setting the Emergency Call Hang Times depends on the XRC 9000's software version. For Connect Plus releases prior to Release 1.1, the Emergency Call Hang Time is programmed into the repeater with MOTOTRBO CPS. Beginning with Connect Plus Release 1.1, the Emergency Call Hang Time value configured with MOTOTRBO CPS will be overwritten with the Emergency Call Hang Time configured with the MOTOTRBO Connect Plus Network Manager. See section "Setting Repeater Hang Times in Connect Plus" and section "Programming the Repeater's Emergency Call Hang Time" for important information on selecting the Emergency Call Hang Time value.
CWID	If this repeater must send CWID to satisfy FCC requirements, enter the ID in this field. In Connect Plus, the repeater will ignore the TX Interval programmed with Connect Plus CPS. The TX interval for this repeater must be set in the XRC 9000 controller.
TX Power Settings	Repeater Power Settings should be set the same for all repeaters in the same site. This is because all repeaters in the same site must have the same coverage footprint.

MOTOTROBO CPS Network screen
Settings critical to Connect Plus Operation

Setting	Notes and Additional Information
CAI Network	Set to 12 (default setting)
CAI Group Network	Set to 225 (default setting)
Repeater Type	Set to “IP Site Connect Peer”
Beacon Duration	Set to “Disabled”
Master IP	Enter the IP Address of the XRC 9000 Controller
Master UDP Port	Each repeater in the site must be programmed with a unique number for “Master UDP Port”. The number must fall between “First UDP Repeater Listen Report” (a programmable controller parameter) and “First Repeater Listen Port” +14
Ethernet IP	If DHCP is not used, enter the repeater’s Ethernet IP in this field. This must be a unique IP address that is not used for any other device at this, or other sites.

MOTOTROBO Channel Screen
Settings critical to Connect Plus Operation

Setting	Notes and Additional Information
Color Code	Color Code must match the information for this Radio ID and frequency pair (for this site) in the Network Frequency File.
IP Site Connect	Must be set to “Slot 1 & Slot 2”
Messaging Delay	In conventional IP Site Connect, this sets the repeater’s arbitration timer. In Connect Plus, arbitration is done by the XRC 9000 controller, which has a programmable parameter called “Arbitration Time”. When the repeater is programmed for Connect Plus, leave the Messaging Delay at the default setting of “Normal”.
RSSI Threshold	This threshold is used to measure the maximum interference signal that the repeater will tolerate. If the repeater detects an interfering signal at or above this threshold, it takes itself offline and reports its off-line condition to the XRC 9000 Controller. If the Control Channel repeater were to take itself off-line, site operations would be severely impacted. For this reason the interference threshold for the Control Channel repeater should be set quite high (in the range of -80 to -40 dBm). Connect Plus Control Channel frequency pairs require a Protected Service Area. Non-exclusive licenses such as FB2 or FB6 are not suitable for Connect Plus Control Channel operation.
RX Frequency & TX Frequency	Repeater frequencies must be different for each repeater in the site. The frequency information must match the information for this Radio ID and frequency pair (for this site) in the Network Frequency File.
Power Level	Should be set the same for all repeaters in the same site. This is because all repeaters in the same site must have the same coverage footprint.
TOT (Time out Timer)	Must not be set any shorter than the longest TOT in any Connect Plus SU.

4.4.2 Coverage Area of Connect Plus Repeaters in Single site Configuration

Trunking is based on the assumption that the SU can communicate with every site repeater just as well as it communicates with the Control Channel repeater. For this reason, all repeaters under the control of the same XRC 9000 controller must reside in the same RF frequency band and must all have an identical coverage footprint (both “talk in” and “talk out”).

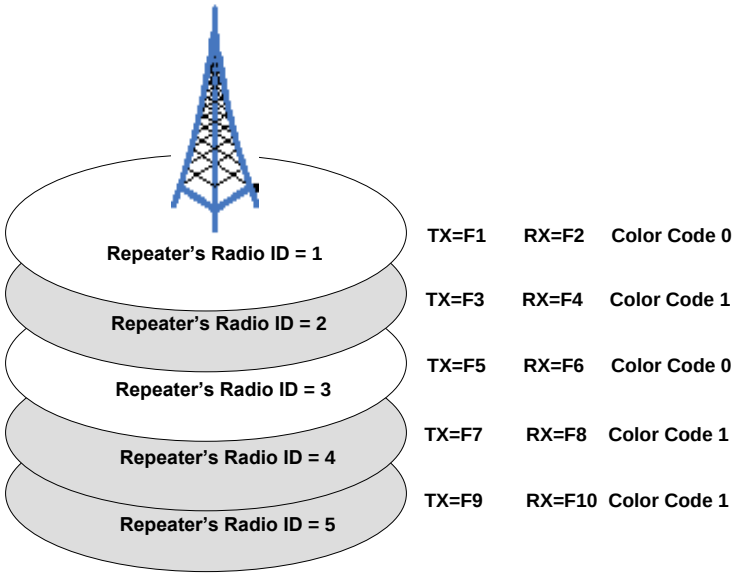
4.4.3 Frequencies and Color Codes in a Connect Plus Single Site System

Because all of the MOTOTRBO repeaters in the same Connect Plus site have the same coverage footprint, they must be programmed with different frequencies, so as not to interfere with one another. Figure 4-5 shows an example of a Connect Plus Single Site system. All of these frequencies must be in the same RF frequency band. For example, if any site repeater is in the

VHF band, then all site repeaters must be VHF also. The Color Codes can be the same, or they can be different.

All Repeaters in the same Connect Plus Site

- **Must have different frequencies (but in the same frequency band)**
- **Must have same coverage footprint**
- **Color Codes can be the same or different**
- **Must be programmed with a Radio ID (1-15) that is unique to this Connect Plus site.**



Circles represent areas of single repeater RF coverage.

Figure 4-5 Multiple Digital Repeaters in Connect Plus Single Site

The following information for each repeater in the Connect Plus network must be programmed into the SU's Network Frequency File:

- Which site the repeater is located at.
- The repeater's Radio ID (1-15). In the Connect Plus system, this equates to the channel (repeater) number.
- SU TX (Repeater RX) Frequency
- SU RX (Repeater TX) Frequency
- The repeater's Color Code
- A checkbox to indicate if the repeater is the Control Channel Frequency. Although the software allows the box to be checked for more than repeater per site, in the initial release the Connect Plus Option Board will only search one Control Channel repeater per site. The repeater searched will be the first repeater on the site list that has the "Control Channel" box checked.

For proper operation, the Network Frequency File must match the actual network configuration at all times. If changes are made to any of the information listed above, it will be necessary to provide the SU with an updated version of the Network Frequency File. For more information on the Network Frequency File, and the options for providing the SU with an updated file, see "Network Frequency File" in the System Feature Overview Section.

4.4.4 Coverage Area of Connect Plus Repeaters in Multisite Configuration

The most common reason for connecting multiple sites is to enlarge the RF coverage available to the Connect Plus SU. Because of this, each Connect Plus site is typically placed in a different geographical area and provides the RF coverage for that area. As the radio user moves from one coverage area to another, the SU is able to automatically "Roam" from one site to another.

When there are multiple Connect Plus sites, the ideal topology is for the RF coverage of each Connect Plus site to over-lap slightly with its geographically adjacent neighbor sites. This emulates the "cellular" network design where each site is a "cell" in a network of slightly overlapping cells. This design will provide the most satisfactory operation for automatic Roaming by the Connect Plus SU.

It's possible that circumstances beyond the control of the network designer will necessitate a departure from the ideal topology of slightly overlapping coverage cells. Examples include the following:

- Rather than providing "slightly overlapping coverage" in all cases, some sites have no overlapping coverage at all. They are separated from other sites by "dead areas", where there is no coverage at all.
- Rather than providing "slightly overlapping coverage" in all cases, the coverage areas of some sites may overlap significantly.
- Some networks may have combinations of different coverage characteristics; slightly overlapping for some sites, no overlap for some sites, significantly overlapping for some sites.

Topologies such as these provide greater challenges when configuring the Roam parameters of the Connect Plus SU. For mixed topologies, the Roam settings will be a compromise that provides acceptable (though probably not optimal) Roam operation by the Connect Plus SU. For a detailed discussion on Connect Plus Roaming (also called "Site Search), see the System Feature Overview Section.

4.4.5 Frequencies and Color Codes in a Connect Plus Multisite System

Because the most common reason for connecting multiple sites is to enlarge the RF coverage available to the Connect Plus SU, all of the frequencies in a multisite network are typically in the same RF frequency band. Because a single SU operates in just one frequency band, this makes the entire network coverage area accessible to the SU.

A less common reason for linking multiple Connect Plus sites is to provide communications between MOTOTRBO radios that use different frequency bands. In this case, each frequency band requires its own Connect Plus site(s), and each SU will only be able to access the site(s) within its own frequency band.

While the repeaters in any single Connect Plus site must all use different frequency pairs, frequencies may be re-used at different sites when coverage does not overlap. If coverage does not typically overlap, but may in certain conditions (such as when the SU is in a very high place),

the re-used frequencies must have different Color Codes. This will not eliminate interference between the two repeaters, but it will help SU's distinguish between the different repeaters – especially while Roaming.

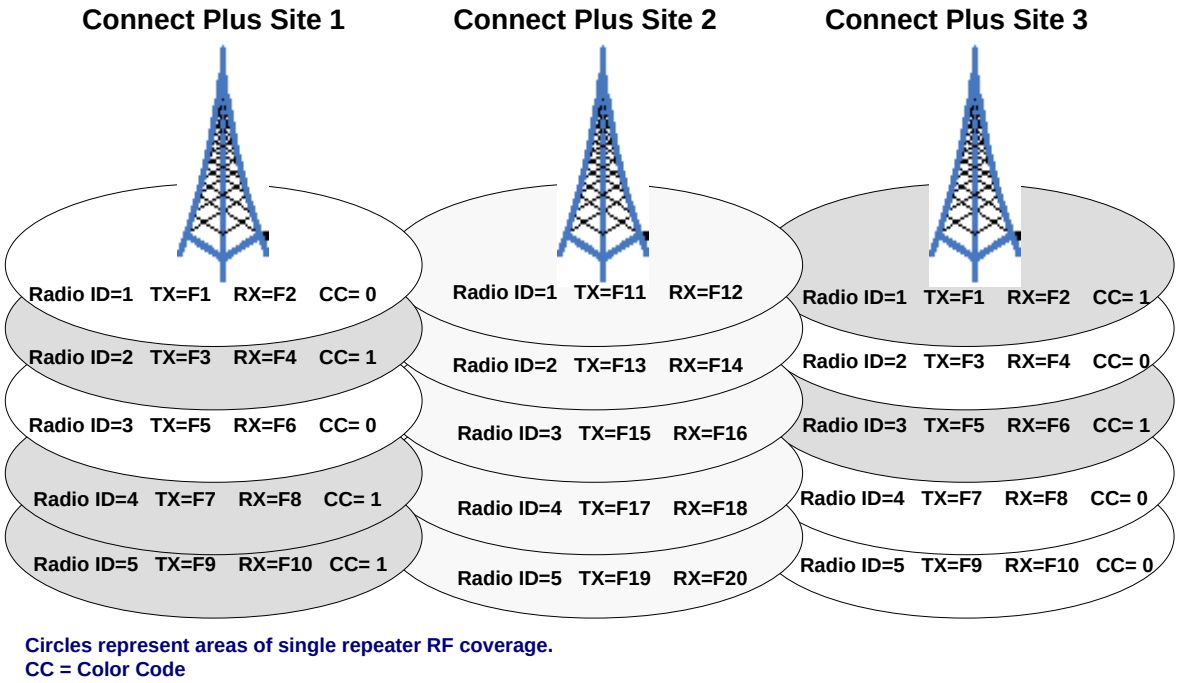


Figure 4-6 Multiple Digital Repeaters in a Connect Plus Multisite System

As stated previously, the Network Frequency File must match the actual network configuration at all times. If changes are made to any of the information listed above, it will be necessary to provide the SU with an updated version of the Network Frequency File. For more information on the Network Frequency File, and the options for providing the SU with an updated file, see "Network Frequency File" in the "Connect Plus System Feature Overview" section.

4.4.6 Considerations for the Connect Plus Backend Network

The reader is strongly encouraged to review the section on *Consideration for the Backend Network* related to IP Site Connect digital mode outlined in [1].

The first characteristic of a backend network required for adequate Connect Plus operations is broadband connectivity with relatively low delay; Connect Plus cannot operate over a dial-up connection or satellite link (due to high delay).

The XRC 9000 controller is the master device at the site and it communicates with the collocated repeaters over UDP/IPv4. The XRC 9000 communicates with other site controllers over both UDP/IPv4 and TCP/IPv4 depending on the traffic type. The controller requires a static IP address whereas the repeaters may utilize a DHCP server to acquire an IP address on power up. The dynamic address of a repeater is selected by selecting the DHCP option in the repeater CPS. It is recommended that the lease time of the IPv4 address from the DHCP should be kept as long as possible to minimize the frequency of possible short service disruptions upon IPv4 address renewal. A Connect Plus repeater registers its IPv4 address with the controller during power-on

and upon a change in its IPv4 address. The controller maintains a table of IPv4 addresses and port numbers of its collocated repeaters.
Furthermore, in a multisite Connect Plus configuration, the controller keeps a table of IPv4 addresses assigned to the controllers located at the other sites to be able to facilitate registration requests, facilitate inter-site call setup, and forward user voice and data traffic to targets registered in different sites.

The Connect Plus devices may be installed behind a network firewall. In such case, for successful communication between controllers at different sites, the firewall (router) has to be programmed to forward the Connect Plus inter-site traffic to a pre-defined set of TCP and UDP ports. The reader can refer to [4] to learn the step for configuring the XRC 9000 Controller for multisite operations.

4.4.6.1 Characteristics of Backend Network

Besides the requirement for broadband network rates, there are other IP network characteristics that are necessary to meet the customer expectations for clear voice communications, low delay and reliable data calls. These are briefly described below:

1. **Delay (Latency)** – Network delay for a two-way radio system is defined as time for voice to leave the source repeater and reach the destination repeater. Furthermore, the overall delay is comprised of the following components:
    a. **Propagation delay** – caused by the distance an electrical signal must travel on the physical medium of the backend network, such as copper wire, fiber link or backhaul microwave connection.
    b. **Serialization delay** – represents the amount of time necessary for the source repeater to actually place a packet byte by byte on its network interface.
    c. **Handling delay** – defines the aggregate delay incurred by the intermediary devices that forward a packet through the backend network. Examples of such devices are the XRC 9000 Controller, switches and routers which introduce queuing delays when more packets are transmitted to a network device than the device can handle.

    The network delay should be considered when setting the programmable “Arbitration Time” setting in the XRC 9000 controller. Upon receiving IP voice packets, the controller waits the arbitration time prior to forwarding the voice packets to the repeater for transmission. In the event of near-simultaneous key-ups at different sites during the same call, arbitration increases the chances that the same audio will be heard at all sites involved in the call. It is strongly recommended that the Connect Plus system **not** be installed on an IP network inducing a delay higher than 250 ms, although for optimal performance the delay should not exceed 60 ms (see also “Packet Loss” description below).

2. **Jitter** – Jitter is defined as variation of network delay. The source device is expected to transmit packets at regular interval, which accounts for a network delay as explained above. However, due to inconsistent queuing delays these packets may not arrive at the same interval. Such variation constitutes Jitter. Connect Plus implements a jitter buffer of 60 milliseconds to handle such effects. Any jitter above such levels significantly affects the audio quality.

3. **Packet Loss** – Packet loss in IP-based networks is both common and expected. To transport voice bursts in timely manner, Connect Plus utilizes UDP/IPv4, which is not a reliable transport mechanism (e.g. confirmed delivery). Therefore, while designing and selecting the backend network it is necessary to keep packet loss to a minimum. The Connect Plus system responds to periodic packet loss by replaying either a special packet (in the case of voice) or the last received packet (in the case of data). In the case of voice,

the ongoing call ends if six consecutive packets do not arrive within 60 ms of their expected arrival time. In the case of data, the repeater waits for the expected number of packets (as per the data header) before ending the call.

4.4.6.2 Connect Plus IP Network Bandwidth Considerations

Bandwidth is the rate of data transferred to and from a network device, often referred to as the bit rate. Bandwidth is measured in bits per second (*bps*) or kilobits per second (*kbps*). When designing a Connect Plus system, it is important to understand the needs of each Connect Plus device, so that the appropriately rated network connection for each site can be chosen.

If a customer has high speed network connections between sites, these calculations may not be as important, but if they are working on lower speed public Internet Service Providers (ISPs) it is good practice to understand these values and plan accordingly. If the minimum amount of bandwidth is not available, the end user may experience audio holes or even dropped calls. Data messaging or RDAC commands may not be successful on the first attempt, or may be dropped all together. In general, the quality of service may suffer if substantial bandwidth is not available.

Note that for most Internet Service Providers, offer asymmetric broadband channel, such that the uplink bandwidth is lower than the downlink. The downlink bandwidth is usually multiple factors above the uplink bandwidth. Therefore, it is important to understand such differences and account for them when designing a backend network. Some ISPs may advertise a particular bandwidth, but it is important to verify the promised bandwidth is available once the system is installed and during operation.

It is also important to note that if the wide area network connection is shared with other services (file transfer, multimedia, web browsing, etc.), then the Connect Plus devices may not have the appropriate bandwidth when required and quality of service may suffer. It is recommended to remove or limit these types of activities. In addition, excessive usage of the RDAC application or the Network Manager's real-time monitoring features may cause increased strain on the network during times of High Voice activity.

4.4.6.3 Required Bandwidth Calculations (no VPN)

Meeting the bandwidth requirements for a single site Connect Plus may not be a challenging task, because the XRC 9000 Controller, the local repeaters and the computers hosting the applications will, most likely, be connected through a modem Ethernet switch, which can manage traffic that is far greater than even a fully loaded system can generate.

On the other hand, when designing a multisite system the administrator/dealer should carefully consider the amount of IP data traffic that will flow between the sites based on the number of repeaters, the network location of the machines hosting the user applications (text messaging, location) and those running the diagnostic and fault management tools (RDAC, Network Manager).

The following equation should be used to calculate the bandwidth requirements for a Connect Plus site and then added together for sites, which reside behind one wide area connection.

BW_{VC} = 15 kbps = Bandwidth required to support Multisite Voice or Data (1 slot)
BW_{MC} = 100 kbps = Bandwidth required to support Multisite control messaging

BW_{RD} = 55 kbps = Bandwidth required to support RDAC commands[27]
BW_{NM} = 55 kbps = Bandwidth required to support Network Manager real-time monitoring
BW_{XRT} = 55 kbps = Bandwidth required to support XRT 9000 airtime data streaming mode

[Number of Multisite sites where call on slot **1** is repeated] - 1	**X**	BW_{VC}	kbps =		kbps
[Number of Multisite sites where call on slot **2** is repeated] - 1	**X**	BW_{VC}	kbps =		kbps
…	**X**	BW_{VC}	kbps =		kbps
[Number of Multisite sites where call on slot **N** is repeated] - 1	**X**	BW_{VC}	kbps =		kbps
[Multisite control messaging for total number of sites] - 1	**X**	BW_{MC}	kbps =		kbps
Network Manager Traffic		BW_{NM}	kbps =		kbps
XRT 9000 Streaming Airtime Data Traffic		BW_{XRT}	kbps =		kbps
RDAC Traffic[28]		BW_{RD}	kbps =		kbps
			+		
Required Uplink/Downlink Bandwidth					kbps

Table 4-2 Bandwidth Calculation Matrix

To illustrate the use of the above equation on a more complicated Connect Plus system configuration, see the following example system shown in the diagram below. This Multisite system has 3 repeaters per site with 6 sites total; one site has an RDAC and a Network Manager. The routers are not utilizing VPN. We assume all trunk-to timeslots are occupied with multisite calls. Although this is an extreme example (because in Connect Plus all calls do not typically involve every site) usually it provides the system administrator with basic guidelines on bandwidth allocation needs.
Note that user data application such as text messaging and location services are excluded from this sample system. If these services are activated then more bandwidth may be warranted.
Using the formula shown in Table 4-2, the bandwidth calculations for Site 1 in Figure 4-7 are as follows:

[Number of Multisite sites where call on slot 1 is repeated] - 1	5	x	15	kbps =	***75***	kbps
[Number of Multisite sites where call on slot 2 is repeated] - 1	5	x	15	kbps =	***75***	kbps
[Number of Multisite sites where call on slot 3 is repeated] - 1	5	x	15	kbps =	***75***	kbps
[Number of Multisite sites where call on slot 4 is repeated] - 1	5	x	15	kbps =	***75***	kbps
[Number of Multisite sites where call on slot 5 is repeated] - 1	5	x	15	kbps =	***75***	kbps
[Multisite control messaging for total number of sites] - 1	5	x	100	kbps =	***500***	kbps
Network Manager Traffic[29]					***55***	kbps
XRT 9000 Streaming Airtime Data Traffic					***55***	kbps
RDAC Traffic[30]					***0***	kbps
				+		
Required Uplink/Downlink Bandwidth for Site 1					***985***	kbps

Table 4-3 Example of Bandwidth Calculations for Connect Plus Site

[27] When the RDAC instance resides behind a firewall with NAT the RDAC bandwidth requirements should be omitted from the calculation since RDAC application must be on the same Local Area Network (LAN) or Virtual Private Network (VPN) as the controller and the site's repeaters.
[28] The RDAC calculation should be omitted if the hosting PC is behind a NAT router.
[29] Data traffic generated by the Network Manager located at Site 3, as shown.
[30] No RDAC at Site 1 as shown.

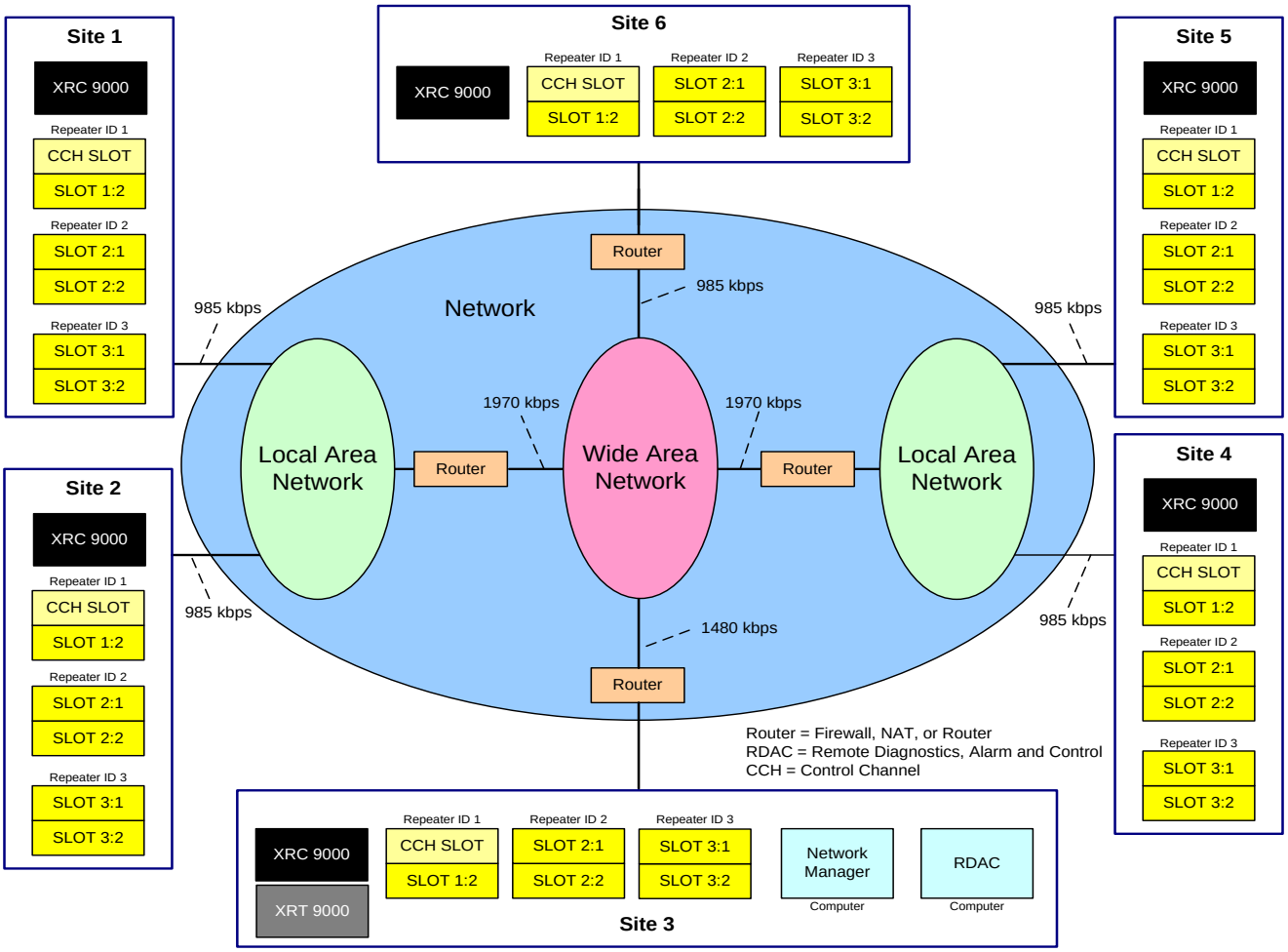
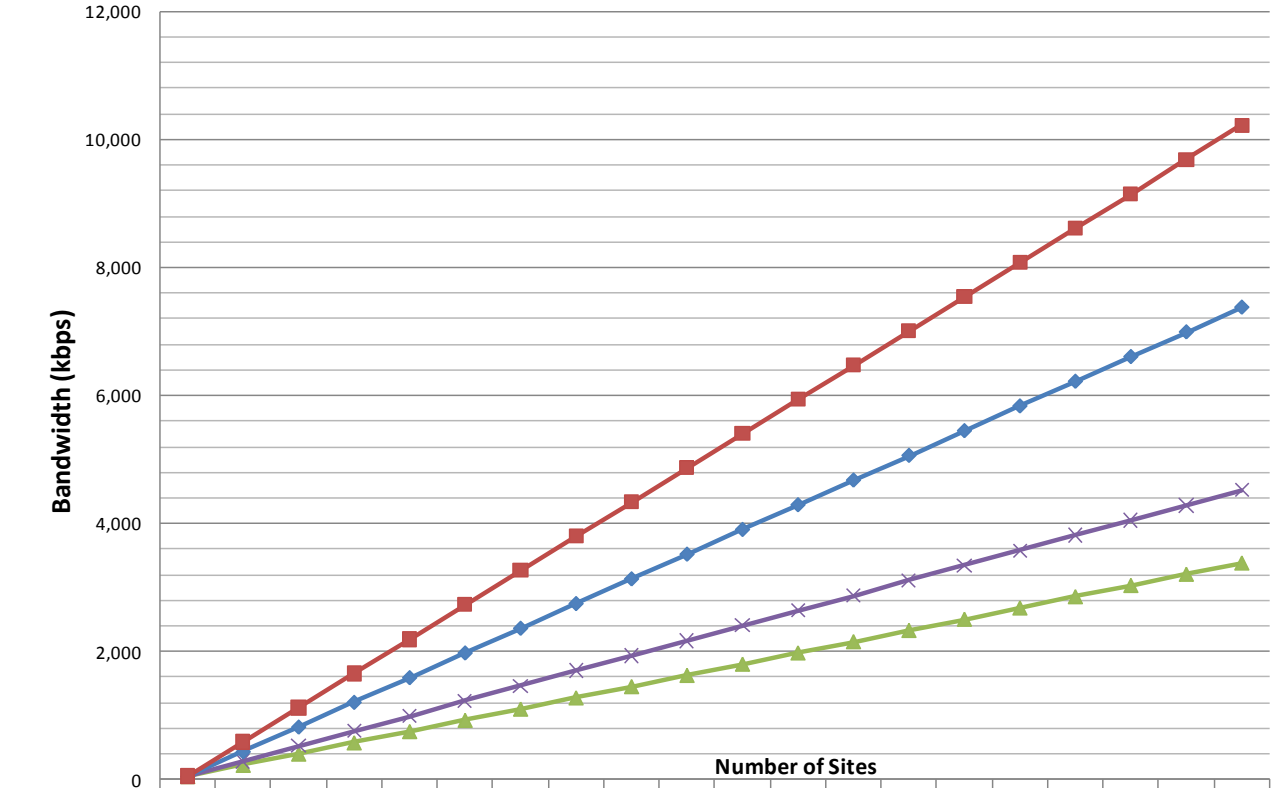


Figure 4-7 Example for Calculating Bandwidth Requirements w/o Secure VPN

The bandwidth calculations for Site 3 do not include any RDAC commands since RDAC traffic is local to the site. Another assumption is that the Network Manager at Site 3 is monitoring all 5 remote sites simultaneously; hence the additional required aggregate bandwidth is increased by 275 kbps (5 x 55 kbps) as compared to the other sites.

The chart in Figure 4-8 below shows the bandwidth requirements for Connect Plus multisite system with 3, 5, 10, and 15 repeaters **per site**.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
3 repeaters	55	230	405	580	755	930	1105	1280	1455	1630	1805	1980	2155	2330	2505	2680	2855	3030	3205	3380
5 repeaters	55	290	525	760	995	1230	1465	1700	1935	2170	2405	2640	2875	3110	3345	3580	3815	4050	4285	4520
10 repeaters	55	440	825	1210	1595	1980	2365	2750	3135	3520	3905	4290	4675	5060	5445	5830	6215	6600	6985	7370
15 repeaters	55	590	1125	1660	2195	2730	3265	3800	4335	4870	5405	5940	6475	7010	7545	8080	8615	9150	9685	10220

Figure 4-8 WAN Bandwidth Requirements for Multisite System (no VPN)

4.4.6.4 Required Bandwidth Calculations with VPN Configuration

As mentioned in previous sections, the initial release of Connect Plus provides only limited IP Security. Therefore, if a customer wants to secure the user communication traffic, Connect Plus supports the ability to work through a secure Virtual Private Network (VPN). Secure VPN is not a function of the Connect Plus system, but rather of the router. It is important to note that Secure VPN does add the need for additional bandwidth and may introduce additional delay. This should be taken into account when planning for bandwidth.

The following parameters should be used in the previous equation to calculate the bandwidth requirements of each device in the system when secure VPN in the routers is enabled and repeater authentication is disabled.

BW_{VC} = 23 kbps = Bandwidth required to support Multisite Voice or Data (1 slot)
BW_{MC} = 120 kbps = Bandwidth required to support Multisite control messaging
BW_{RD} = 64 kbps = Bandwidth required to support RDAC commands
BW_{NM} = 64 kbps = Bandwidth required to support Network Manager real-time monitoring
BW_{XRT} = 64 kbps = Bandwidth required to support XRT 9000 airtime data streaming mode

NOTE: The preceding data was compiled using the Linksys EtherFast Cable/DSL VPN Router with four-port switch. Model: BEFVP41. Other routers using different algorithms may yield different results.

4.4.7 Connect Plus IP Network Security Considerations

Network security is an important consideration. In the event that Connect Plus sites will be connected through anything other than a Private Network or Virtual Private Network, a Certified Networking Professional will need to assist the system owner in protecting the radio network from the undesired solicitations common over the public internet.

It is strongly recommended to employ the secure VPN configuration to provide high level of protection, which includes authentication and encryption. There are a slew of commercially available secure VPN routers that can be utilized to meet the network security needs of most customers. Secure VPN routers can optionally provide confidentiality of all the messages including system messages, control messages (i.e. CSBK), and voice or data headers. A disadvantage of using Secure VPN Routers is that the Connect Plus sites require more inbound and outbound bandwidth from the ISP.

4.5 Fault Management and Redundancy

4.5.1 Connect Plus Behaviors in Presence of Failures

How the Connect Plus System operates in the presence of failures depends on what type of failure is experienced. Several categories of failure will be briefly discussed:

Failure of IP connectivity between Connect Plus Sites: Connect Plus utilizes TCP/IP to send call set-up messages and other control messages between network sites. Connect Plus utilizes UDP/IP for audio routing. The XRC 9000 sends periodic messages (pings) to assess the status of TCP/IP links with other sites. These messages allow a site to know when TCP/IP communications have been lost with another site, and when TCP/IP communications have been restored. The Network Manager Site Status screen can be used to assess the status of the TCP/IP link with other network sites. For each site listed in the Multisite Details Panel, “True” indicates that there is currently a TCP/IP connection between the site to which Network Manager is currently connected and the listed site. “False” indicates that there is not currently a TCP/IP connection between the site to which Network Manager is currently connected and the listed site. It should be noted that this indicates the status of the TCP/IP connection only. When TCP/IP connectivity is normal, the XRC 9000 Controllers exchange messages with one another that are designed to “synchronize” SU and Group records, so that each site will have an identical copy of the user database. Because of this, each site can continue to validate registrations and calls, even when cut off from part (or all) of the network due to failure of network links. During this time, audio will be heard locally, and packets can still be forwarded to linked sites. Of course, sites that do not have a current link cannot transmit the same audio, and it is possible that the same Group ID will have different conversations at different sites if there is no link to join the sites together. This will be resolved when connectivity is restored.

Failure of the XRC 9000 Controller: If an XRC 9000 failure should cause the Control Channel repeater to stop sending Control Channel messages, the site becomes “invisible” to the radios until the backup XRC 9000 takes over (if the site has one), or until the primary XRC 9000 is restored to service. SU’s that were registered to the site will enter Search mode. In a multisite network with overlapping site coverage, it is possible that these radios will detect and register with another Connect Plus site. If the failed site is equipped with a backup XRC 9000, SU’s that were not able to locate a different network site will return to the original site once the backup XRC 9000 has taken over and activated the Control Channel repeater. In many cases the SU will continue using the original site without a new registration. The exception is when the SU’s Reacquire Timer expires, or if the SU attempts to register with a different network site in the interim. In those cases the SU will send a new registration to the site.

Failure of the Control Channel Repeater: If a Control Channel repeater failure should cause the Control Channel timeslot to stop sending control messages, the site becomes “invisible” to the radios until the XRC 9000 becomes aware of the failure and switches the Control Channel messages to a different Control Channel repeater. See the section on “Control Channel Roll-over” for more information. The SU will temporarily lose signal from the “old” Control Channel repeater before it will search for a new one. When this occurs, the Connect Plus radio looks at all the possible Control Channel frequencies for the last-registered site before it searches any other sites. If it locates an alternate Control Channel for the same site, and if the SU’s Reacquire Timer has not expired, the radio will continue using the site without a new registration. If the XRC 9000 is not aware of the Control Channel repeater failure, or if the XRC 9000 cannot start up messaging on the new Control Channel repeater before the SU begins searching other sites, it is possible that the SU will register with a different site (especially if the SU is in a location with strong overlapping site coverage). If the XRC 9000 is not aware of the repeater failure, or if there is no alternative Control Channel repeater available, the SU will continue searching until it locates a different site or service is restored. For situations such as these, it may be desirable to configure the SU with a Conventional Fallback Channel. For more information, see the section on Connect Plus Failure Preparedness.

Failure of a trunk-to channel repeater: If a Trunk Channel Repeater fails, the observable effect to Connect Plus operation depends on whether the XRC 9000 is aware of the failure. The XRC 9000 can become aware of the failure if the repeater reports a significant alarm, or if the failure causes the repeater to stop sending “keep-alive” messages to the XRC 9000. If the controller does not receive any repeater message prior to expiration of a timeout timer, the controller will consider the repeater to be absent, and it will no longer assign calls to the failed repeater. If the XRC 9000 is not aware of the failure, the controller will continue to assign calls to the repeater, but the calls will likely fail.

4.5.2 Connect Plus Failure Preparedness

The most important Connect Plus Failure Preparedness strategy is to provide for redundant operations by key system components.

To provide for XRC 9000 redundancy: Purchase and configure a secondary XRC 9000 controller for each Connect Plus site wherever possible. For more information, see section “XRC 9000 Redundant Controller”.

To provide for Control Channel redundancy: Configure multiple Control Channel repeaters per site (up to 4). Only one a time will be active. This strategy requires the system owner to have more than one suitable Control Channel frequency pair, and all alternative Control Channels must be configured into both the Connect Plus SU (Connect Plus CPS Network Frequency File) and the

XRC 9000 (using the Connect Plus Network Manager). For more information, see the section on "Control Channel Roll-Over".

Because the preceding strategies cannot account for every conceivable failure scenario, the following text discusses a failure preparedness strategy of last resort known as Conventional Fallback Mode*. This strategy, which allows the SU and repeater to work in conventional mode until Connect Plus operation can be restored, requires that one or more conventional fallback channels be programmed into the SU ahead of time with MOTOTRBO CPS:

- When configuring the digital channels that will be used for conventional fallback with MOTOTRBO CPS, do not check the box labeled "Option Board" or the "Option Board Trunking" box.

- The conventional fallback channel(s) cannot be placed in any Connect Plus zone. They must be placed in a non-Connect Plus zone.

Since there are numerous fallback configurations, the following questions should be considered when deciding which fallback configuration is most appropriate for the customer's application:

- What circumstances should prompt the user to select the conventional fallback channel? (Such as the radio "searching" for a long period of time in area that normally provides good coverage)

- How should the user select the conventional fallback channel?

- If the radio has multiple conventional fallback channels, what is the protocol for selecting and trying channels?

- What circumstances should prompt the user to select the Connect Plus zone and channel again? (Such as hearing an announcement on the conventional fallback channel.)

In programming the radio with a conventional fallback channel, there are several frequency and/or repeater options to choose from:

- Program direct communication on a "talkaround" frequency. This allows communication to continue even if every repeater fails. However, the SU's must be in close proximity.

- Program a conventional repeater:

    - This can be a special conventional repeater that is always available for this purpose. If the "special" repeater is at the same location as the failed site, it is possible that the failure condition may have impacted this repeater also.

    - This can be one of the repeaters normally used for Connect Plus operations. This strategy will only work if (a) there is no problem with this repeater to begin with and (b) the repeater has entered "Conventional Fallback Mode" due to a disruption of IP messaging with the XRC 9000 Controller.*

***Conventional Fall Back Mode:** If IP communications between the XRC 9000 controller and the repeater are disrupted for an extended period of time (at least a minute or longer), the repeater will enter "Conventional Fallback Mode", in which it operates as a digital conventional repeater. In Conventional Fallback Mode, the repeater will automatically repeat the transmissions of a correctly programmed conventional SU. Prior to entering Conventional Fallback Mode, a MOTOTRBO repeater that is peer to an XRC 9000 Controller will not automatically repeat transmissions received on its uplink.

4.5.3 XRC 9000 Redundant Controller

Each Connect Plus site requires at least one XRC 9000 Controller. Beginning with Connect Plus Release 1.1, the customer can purchase a second XRC 9000 Controller per site to serve as backup to the primary XRC 9000. The secondary controller provides backup capability, but it does not increase the number of repeaters and calls that can be managed per site.

There are some pre-requisites for utilizing the Redundant Controller feature:

1. The customer must purchase a second XRC 9000 controller. If the Multisite feature is purchased for the Primary XRC 9000, it must be purchased for Secondary XRC 9000 also.

2. The Redundant Controller set-up requires a total of three Ethernet cables to plug into Ethernet ports on the XRC 9000s. Standard Ethernet cables are used to connect the port labeled LAN1 on each controller to the site's Ethernet Switch. The third cable is used to directly connect the two ports labeled LAN2 on each controller. An Ethernet crossover cable is required for the direct connection.

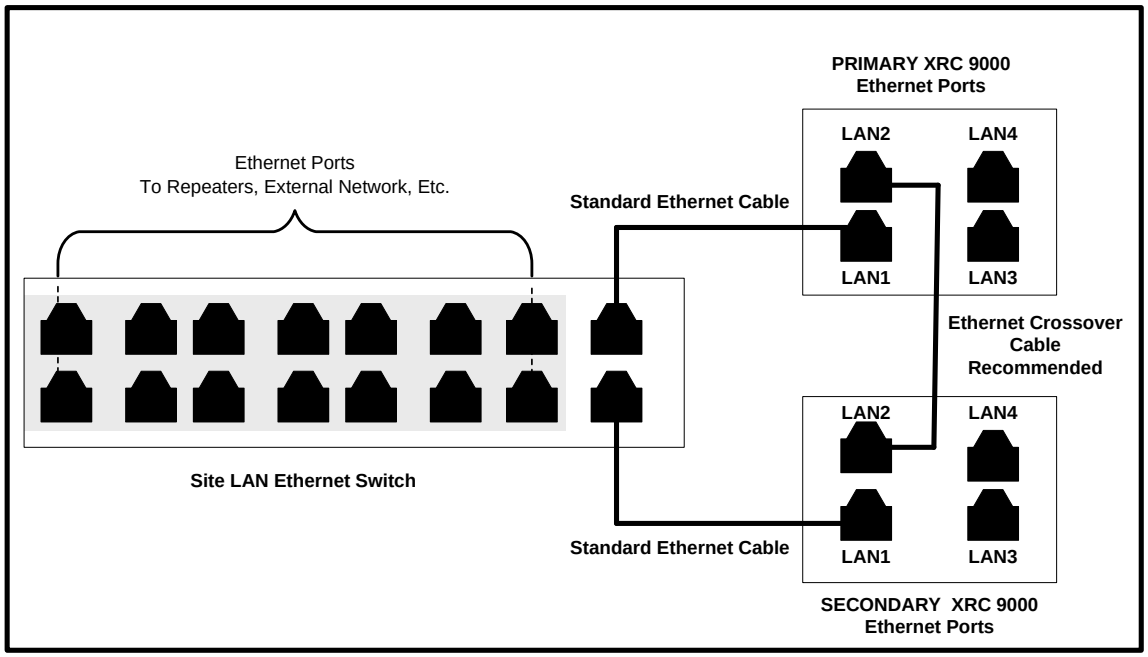


Figure 4-9 Ethernet Cable Connections

3. Except for their different roles (one configured as "Primary" and the other as "Secondary"), the two controllers require the same configuration and user information to start with. The Network Settings must be configured separately for each controller (*Network->Settings*). Other settings will be automatically shared when the Primary and Secondary XRC 9000s are connected together and automatically synchronize certain information.

4. The Network Settings screen requires a total of 4 static IP addresses (two for each controller), as depicted in Figure 4-10 and discussed in Table 4-4.

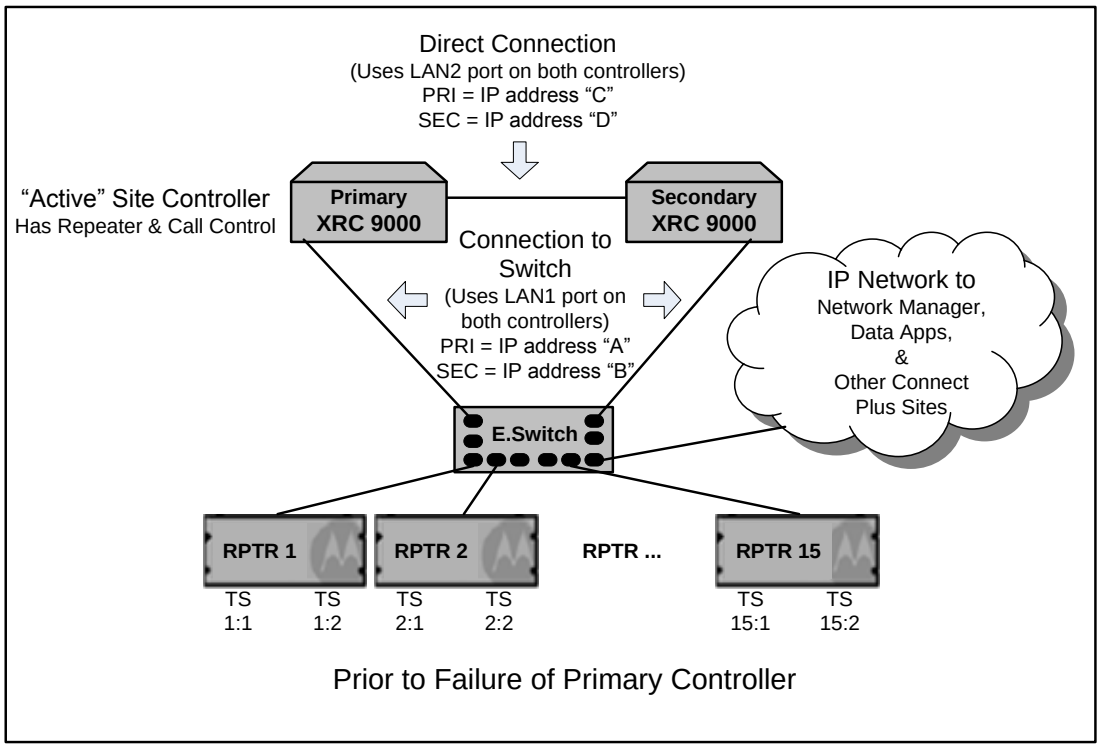


Figure 4-10 Redundant Controller Configuration with Primary XRC 9000 Active

IP Address "A" (Static IP address)	• Configured as "Primary Controller" (LAN1) IP Address • Used to address the controller that is currently "active" (has site control), regardless of whether it is the Primary or Secondary • IP address configured into the site repeaters (as IP Site Connect Master) • Multisite Tables of other Connect Plus sites point to this address • Configured "Network Properties" apply to this address
IP Address "B" (Static IP address)	• Configured as "Secondary Controller" (LAN1) IP Address • Used to address the controller that is currently "inactive" (does not have site control), regardless of whether it is the Secondary or Primary • Configured "Network Properties" apply to this address
IP Address "C" (Static IP address)	• Configured as "Primary Controller" (LAN2) IP Address • Used only for the direct connection between the two XRC 9000 controllers. Only the two controllers know about this address. • Always belongs to the Primary Controller, regardless of whether it is "active" or "inactive" • First three octets of this address must be exactly the same as first three octets of IP address "D" (Secondary Controller [LAN2] IP address). • First three octets of this address must be different than the first three octets of IP Address "A" and IP Address "B". • Configured "Network Properties" do not apply to this address
IP Address "D" (Static IP address)	• Configured as "Secondary Controller" (LAN2) IP Address • Used only for the direct connection between the two XRC 9000 controllers. Only the two controllers know about this address.

	• Always belongs to the Secondary Controller, regardless of whether it is "active" or "inactive" • First three octets of this address must be exactly the same as first three octets of IP address "C" (Primary Controller [LAN2] IP address). • First three octets of this address must be different than the first three octets of IP Address "A" and IP Address "B". • Configured "Network Properties" do not apply to this address
Notes:	• The Primary & Secondary controllers can automatically "swap" Addresses A & B in switchover scenarios, but the Network Manager configuration remains the same. • The Primary & Secondary never "swap" Addresses C & D

Table 4-4 XRC 9000 IP Addresses

Basic Concepts

Controller Roles that can be configured in the Network Manager

Beginning with Connect Plus Release 1.1, every XRC 9000 has one of three "roles" as discussed below:

- **Stand-alone**: This is the role of a controller that doesn't have any redundant backup. It is the default controller role, and will not change unless the Network Manager is used to configure a different role.

- **Primary**: This is the role assigned to the controller that should be in charge while the site is operating normally. Once assigned the Primary role via the Network Manager, it is always referred to as the Primary controller – even if the Secondary controller detects a fault and takes over.

- **Secondary**: This is the role assigned to the controller that should be in "stand by" while the site is operating normally. Once assigned the Secondary role via the Network Manager, it is always referred to as the Secondary controller – even if it takes over site control.

Non-configurable states

In conjunction with the configurable roles, there are two important non-configurable Site Control states:

- **Active Controller**: This is the controller currently in charge of site control (repeaters, calls, etc), regardless of whether it is the Primary or Secondary

- **Inactive Controller**: This is the controller currently not in charge of site control (repeaters, calls, etc), regardless of whether it is the Secondary or Primary.

    - While the Secondary Controller is inactive, it is usually (if configured & connected correctly) in "standby" mode – ready to take over site control if there is a failure of the Primary controller.

    - While the Primary Controller is inactive, it is not in "standby" mode. It will not automatically switch back to being the active controller. For switch back to occur, the "Switch to Primary Controller" command must be sent using the Network Manager software.

Creating Connections for MOTOTRBO Connect Plus Network Manager Connection Tool

1. Use the MOTOTRBO Connection Tool to create a connection pointing to the Primary Controller LAN1 IP address (IP Address "A" in the preceding table).

    a. The Network Manager uses this connection for communicating with the active Site Controller (i.e. currently in charge of repeaters and calls assignment). This could be either the Primary or Secondary controller. The site box on the Site Dashboard will show whether the Network Manager connects to the Primary or Secondary controller via this IP address.

    b. This connection can be placed in the Connection Group that contains all network sites. Using this connection, the Network Manager will automatically connect to the site's active controller.

2. Use the MOTOTRBO Connection Tool to create a connection pointing to the Secondary Controller LAN1 IP address. (IP Address "B" in the preceding table).

    a. This connection is used for communicating with the inactive Site Controller (i.e. not currently in charge of repeaters and calls assignment). This could be either the Secondary or Primary controller. The site box on the Site Dashboard will show whether the Network Manager connects to the Secondary or Primary controller via this IP address.

    b. To avoid confusion, do not place this connection in the Connection Group that contains all network sites. Use the Connection Tool's single connection feature when it is necessary to communicate with the inactive site controller. An alternative approach is to create a separate Connection Group for each site that includes both the Primary and Secondary Controller LAN1 IP connections for the site.

3. Do not create connections pointing to the LAN2 IP addresses (IP Address "C" and "D" in the preceding table). These ports are used for direct controller-to-controller communication.

Determining the Role and State of the connected XRC 9000

When connecting to a XRC 9000 with the Network Manager, it is very important to know the controller's role (Primary/Secondary) and current site control state (Active/Inactive). The Site Dashboard shows the controller's role and site control state at the bottom of the box representing the connection. Each connected XRC 9000 will have one of the following labels:

- Stand-alone (A Stand-alone is assumed to be in site control. So, no additional state is provided)

- Primary / Active
- Secondary / Inactive

- Secondary / Active
- Primary / Inactive

Important! If any changes need to be made to the XRC 9000 configuration, such changes should be configured into the active XRC 9000. The active XRC 9000 will automatically share the

changes with the inactive XRC 9000 controller. Do not individually configure any User Settings or Site Configuration parameters while connected to the inactive XRC 9000. There is too much chance that such changes will never take effect, or will be overwritten by values in the active XRC 9000, or overwritten by user configuration changes from other sites.

Maintaining the Primary and Secondary Controllers at same Firmware level

It is important to maintain the Primary and Secondary controllers at the same XRC 9000 firmware version.

- Make sure the Primary and Secondary controllers are at same firmware level prior to initial deployment of Redundant Controllers at the site.
- For field upgrades, both controllers should be upgraded when upgrading to a new XRC 9000 firmware build. (Note: This requires two separate files because each XRC 9000 must always have its own firmware file. The file name should be the same except for the serial number, which is the last part of the file name.)
- For field upgrades, the controllers can be upgraded in either order. There is some advantage to upgrading the (active) Primary controller first, and then waiting for it to come back online prior to upgrading the (inactive) Secondary. In the unlikely event that the Primary does not come back online within an expected period of time, the Secondary will try to take over site control.

Configuring the Primary and Secondary Controller

It is recommended to perform initial configuration at the shop, prior to installing the XRC 9000(s) at the site. In the case of an existing site, only the Secondary controller needs to be configured at the shop, since the Primary went through this process prior to its original deployment. Some configuration is still required for the Primary controller, but this can be accomplished at the site if necessary.

As a general rule of thumb, do not connect the XRC 9000s directly (Lan2 on Primary to Lan2 on Secondary) until both controllers have been fully configured and are ready for redundant operation. This will help prevent the Secondary controller from attempting to assume site before you are ready. The Secondary controller will not attempt to take over site control until it has synched at least one time with the Primary via the LAN2 connection.

The following outline shows the steps that must be performed before the Redundant Controller feature will be operative. Do not connect the LAN2 ports prior to the point mentioned in the outline. This outline assumes that at least one controller has been previously configured for site control. If this is not the case, follow the installation and configuration guidelines outlined in the XRC 9000 User Guide.

1. Configuring the Secondary Controller
    a. If the Secondary Controller is “fresh out of the box”, the first step is to establish communication with the controller. Because the controller comes with a default IP address, you may have to edit the IP address on your PC for the first connection. See the XRC 9000 User Guide for details. When initially configuring the IP address that will be used for this controller, enter the address into the Primary IP Address field (for LAN 1) and leave the controller role as “stand-alone”. In a later step, the controller role will be changed to “Secondary”, and its IP address will be configured into the Secondary IP address field (for LAN 1).

b. The Network Time Protocol (NTP) Configuration for the two controllers that will serve as Primary and Secondary for the same site must be configured the same. If the Primary will serve as the network's NTP Server, then the Secondary must also be configured as network's NTP Server. If the Primary is configured point to another IP address as NTP Server, then the Secondary must also point to the same NTP Server.

c. Manually set the clock on the XRC 9000 that will serve as the Secondary Controller in order to bring it as close as possible to the NTP Server time. This important step helps this XRC 9000 to synch its time with the NTP server more quickly (once a connection is established to the NTP Server). Set the date and time from the Date Time Configuration screen (*Settings->Date and Time*).

d. Configure the settings on the Controller TCP/IP screen of the Secondary Controller for field operation (*Network->Settings*).

    i. Set the Controller Role as "Secondary".

    ii. Configure Network IP Addresses, Network Properties, and Redundant Controller Feature IP Addresses to be used at the site. It is important to note that these fields must be configured with identical information in both the Primary and Secondary controller, and that the configured values do not change – even when the Secondary controller automatically assumes the Primary controller's IP address and becomes the "active" site controller.

e. After saving the Network Settings the Secondary Controller will reboot and come back with its new IP address. It will probably be necessary to make one or more changes (such as editing the PC's IP address, re-defining the connection information in the Connection Tool, taking the controller to the site, etc) prior to communicating with this XRC 9000 again.

2. Configuring the Primary Controller. (Instructions assume that this is an operating site controller that has already been configured with most settings.)

    a. Connect to the XRC 9000 that will be used as Primary Controller.

    b. Since it is important to always have a current backup file for each Connect Plus site, use the Network Manager Backup & Restore Utility to make a backup file of this controller (*Settings->Backup & Restore Utility*). Do not be concerned about performing the backup prior to configuring the Controller TCP/IP screen as described in the next step. That information is intentionally omitted from the backup file.

    c. Open the Controller TCP/IP screen (*Network->Settings*).

        i. Configure the Controller Role as "Primary"

        ii. Configure Network IP Addresses, Network Properties, and Redundant Controller Feature IP Addresses to be used at the site. It is important to note that these fields must be configured with identical information in both the Primary and Secondary controller, and that the configured values do not change – even when the Secondary controller automatically assumes the Primary controller's IP address and becomes the "active" site controller.

d. After saving the Network Settings the Primary Controller will reboot. It will be necessary to re-connect, if desired.

Making the physical connections (assumes that configuration is complete)

Follow the steps below after completing the configuration described in the previous section:

1. Bring both controllers to the site location (if not done already)

2. For an existing site, the Primary controller will already be connected to the Ethernet switch.

3. Connect the Secondary Controller to the Ethernet switch (from LAN1 port on controller).

4. Plug in the direct connection between the two ports labeled “LAN2” on the Primary and Secondary controllers.

5. Provide power to the Secondary Controller. After the Secondary Controller finishes booting up, it will communicate with the Primary Controller. The Primary and Secondary controller will then start the process of synchronizing important settings. This process can take several minutes, depending on how much information needs to be shared. See the next section for more information.

Important! Prior to leaving the site, it is strongly recommended that the technician perform a test to verify the redundant operation. The specific instructions for this test are provided in a later section.

Primary and Backup Controllers synchronize certain information

After establishing the direct connection between the Primary and Secondary controller, the two XRC 9000s will automatically synchronize the following important information:

1. If the user database is not already identical in both controllers, then the user database from the active XRC 9000 will replace the user database in the inactive XRC 9000. This process can take up to five minutes, depending on the size of the user database in the active controller. If the user database in both controllers is already identical, this step is omitted.

2. Settings contained on the active controller’s (Site) Configuration Screen will replace the Site Configuration settings for the inactive controller.

3. Settings contained on the active controller’s Multisite Configuration Screen will replace the Multisite settings for the inactive controller.

4. The list of repeaters currently checked in with the active controller.

5. The Radio ID of the repeater currently acting as Control Channel repeater.

6. The list of units and groups currently registered into the network, as well as their present site location.

7. User Roles (Login accounts) are shared from the active to inactive controller.

8. SMTP Setup and Alert Notifications that have been configured into the active controller will replace the SMTP Setup and Alert Notifications settings for the inactive controller.

9. The Primary Controller's "Site Reset" count. The "Site Reset Count" is maintained behind-the-scenes to help SUs know when they are required to re-register with a site. It is not the same thing as the "Number of site reboots", which can be viewed with the Network Manager.

10. Certain network messages that have been sent to other sites, but have not yet been acknowledged by the destination site.

In order to determine when the synch process is complete, connect to the Primary Controller with the Network Manager and view the Alert/Alarms Management Screen (*Alerts/Alarms>Alerts/Alarm Management*). The Primary Controller will show a Controller Alert that says, "Primary Controller missing connected Secondary Controller". Press the "Clear" button to clear this Alert, and then wait for five seconds and press the "Refresh" button. If the Alert does not reappear, then the synch process is complete, and the Secondary Controller is ready to assume site control when needed.

Continued Sharing of Information

Following their initial synchronization, the active controller continues to automatically update the inactive controller when certain changes occur:

Following their initial synchronization, and for as long as the active and inactive controllers have a LAN2 connection, the active controller continues to automatically update the inactive controller when changes to any of the information that was shared during the initial synchronization process described in the previous section.

The active XRC 9000 also informs the inactive controller whenever a user initiates a voluntary site reset of the active controller. The term "voluntary reset" includes the following:

1. Reboot command issued via Network Manager.

2. A "critical" setting is updated via Network Manager and saved to XRC 9000. This includes the following:
    a. Any setting in "Critical Settings" portion of Configuration screen (*Settings>Configuration*).
    b. Any setting on Controller TCP/IP screen (*Network->Settings*).
    c. Any setting on Multisite Configuration screen (*Settings->Multisite*).

3. Saved configuration file is uploaded via Network Manager.

4. Firmware Upgrade command issued via Network Manager.

Following a voluntary reset, an Inactive Secondary Controller allows the Primary Controller a period of time to reboot and resume site control. If the Primary XRC 9000 does not come back on line within the expected period of time, the Secondary Controller will attempt to take over site control.

Information not shared

It is also important to understand that there is some information that is automatically not shared between the active and inactive controllers. This includes the following:

1. Information on current calls (assigned calls and calls in the Busy Queue). These do not carry over when there is a switchover in site control from the active to the inactive controller.

2. The list of active network connections with sites listed on the Multisite Table. (When a controller takes over site control, it will attempt to set-up new connections with all sites on its Multisite Table.)

3. Schedules for Location Requests and Reports. When the 3rd party Location has gone for a period of time without any Location report from an SU of interest, it will automatically re-send the Location Request. The exact period of time in question varies by 3rd party application.

4. Airtime Logging Data. This is only saved to the currently active controller.

5. Event Log Data. This is only saved to the currently active controller.

6. Unexecuted File Transfers. These must be re-uploaded following a switch in site control.

7. Controller Alerts & Repeater Alarms on the other XRC 9000

    a. Active controller alerts will re-trigger after new controller assumes site control.

    b. Active repeater alarms will be discovered at next Link Establishment (LE) or when reported by repeater

Automatic Switch of Site Control

The active and inactive controllers exchange heartbeat messages over their LAN2 direct connection. The switchover from Primary to Secondary can be triggered by the loss of heartbeat messages between the two controllers, or by the loss of heartbeat messages between all peer repeaters and the Primary XRC 9000. Because heartbeat messages between the two XRC 9000s are sent at a much higher frequency than heartbeat messages between the Primary XRC 9000 and the peer repeaters, XRC 9000 failure can be detected in just a few seconds, whereas it takes somewhat longer to detect a failure of the IP interface between the Primary XRC 9000 and all repeaters.

In summary, automatic switchover is supported for the following scenarios:

1. Any scenario that results in the loss of heartbeat messages between an active Primary and inactive Secondary controller. Examples include (1) power failure on Primary XRC 9000 (2) Hardware failure affecting IP ports on Primary XRC 9000, (3) Connect Plus software program stops running on Primary XRC 9000. Switchover occurs following expiration of an internal timer in the Secondary XRC 9000 (approximately 3 seconds).

2. Any scenario that results in the loss of heartbeat messages between an active Primary controller all of its peer repeaters. Switchover will occur following expiration of an internal timer in the Primary XRC 9000 (approximately 16 seconds). It is important to note that depending on where the failure occurred in the IP interface, it may also be impossible for the Secondary XRC 9000 to communicate with the peer repeaters. In this event, switchover will occur, but radio communications will still be down.

Note: There are some scenarios where the Secondary XRC 9000 may attempt to take over site control, but not be able to so. An example of such a case is when the LAN2 connection between the two controllers fails, but the Primary Controller still has a good LAN1 connection to the site

repeaters. In this event, the Primary Controller will continue to control the site, and it will not relinquish its Primary Controller LAN1 IP address. If the Secondary XRC 9000 attempts to take over site control due to a Failover Trigger, but is not able to take over the Primary Controller IP address, it will create an Event Log entry and periodically retry.

Figure 4-11 illustrates Redundant Controller connections after site control switches from the Primary to Secondary controller.

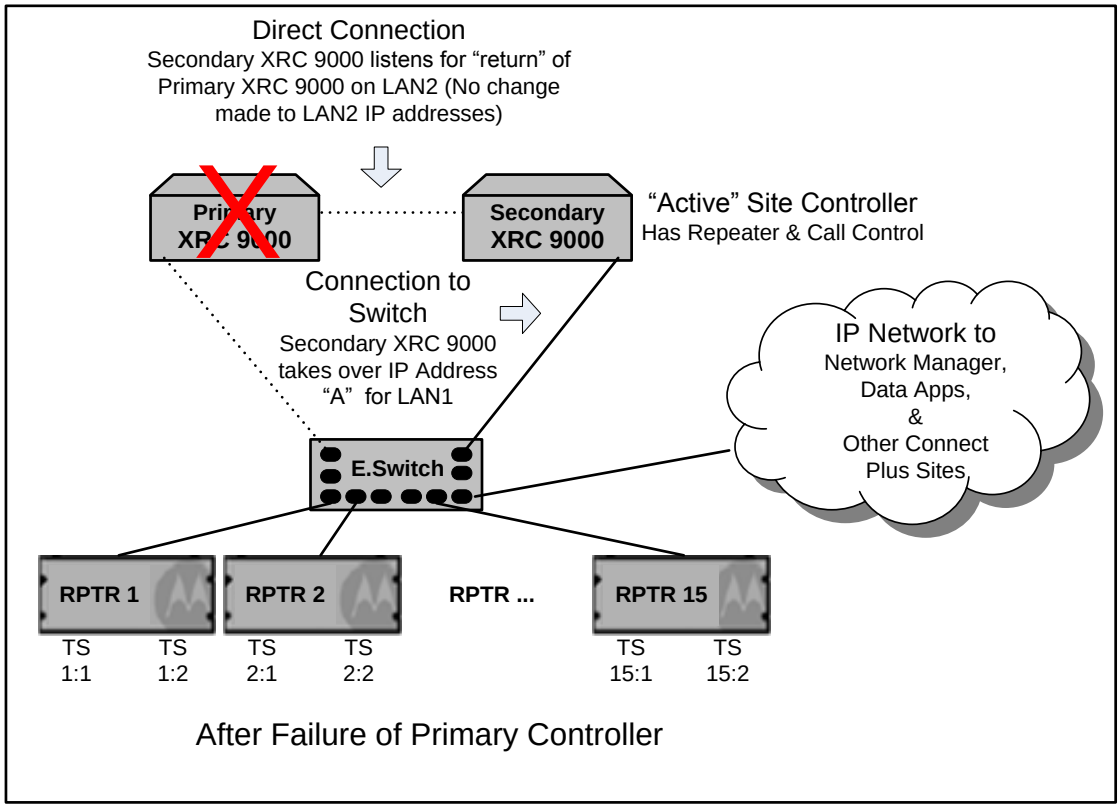


Figure 4-11 Redundant Controller Configuration with Secondary XRC 9000 Active

Swapping LAN1 IP Addresses

Whenever a controller switchover occurs, the (newly) active XRC 9000 controller will take-over the IP address that has been configured with Network Manager as the "Primary Controller IP Address" for LAN1. (IP Address "A" in the preceding table.) In other words, this is the IP address for the "active" controller, regardless of whether it is the Primary or Secondary.

If a XRC 9000 attempts to use the IP address that has been configured with Network Manager as the "Primary Controller IP Address" for LAN1, but finds out the address is already in use, it will assume the "inactive" state, and will instead use the IP address that has been configured with Network Manager as the "Secondary Controller IP Address" for LAN1. An example of such a case is when the Secondary Controller has taken over site control, and then the Primary controller subsequently comes back on line. The Primary Controller shall make one attempt to use the Primary Controller IP address. Upon finding that the "Primary" address is already in use, the controller will use (or attempt to use) the "Secondary" address for as long as it remains in the "inactive" state, even though its configured role remains that of "Primary Controller".

In order to swap IP addresses as described in this section, the site's LAN Ethernet switch must be able to accept a gratuitous ARP response, and change a previously registered IP address. If there is any question about whether the site's Ethernet switch will accept gratuitous ARP responses, check the switch configuration or consult the company IT specialist. A subsequent section describes a test that, if passed successfully, confirms that the site's LAN Ethernet switch accepts gratuitous ARP responses.

Site Control switch initiated via the Network Manager

In addition to the failure scenarios that cause automatic switchover from the Primary to Secondary controllers, switchover can also be initiated via a Network Manager Menu command. The switchover command should always be given to the active controller. It is useful for the following:

1. Technician wishes to switch site control from Primary to Secondary controller in order to perform maintenance on Primary controller.

2. Technician wishes to switchover site control from an active Secondary controller back to the Primary controller (usually after completing repair or replacement of Primary controller). Because there is no automatic switchover from Secondary to Primary, the Menu command is the only way this can be accomplished. If it is necessary to replace the former Primary Controller with another XRC 9000, use the Network Manager to perform some basic configuration on the (new) Primary Controller prior to switching site control back to the Primary. Perform the following configuration at the shop prior to bringing the (new) Primary Controller to the site:

    a. If the (new) Primary Controller is "fresh out of the box", the first step is to establish communication with the controller. Because the controller comes with a default IP address, you may have to edit the IP address on your PC for the first connection. See the XRC 9000 User Guide for details. When initially configuring the IP address that will be used for this controller, enter the address into the Primary IP Address field (for LAN 1) and leave the controller role as "stand-alone". In a later step, the controller role will be changed to "Primary", and its IP address will be configured into the Primary IP address field (for LAN 1).

    b. The Network Time Protocol (NTP) Configuration for the two controllers that will serve as Primary and Secondary for the same site must be configured the same.

    c. Manually set the clock on the (new) Primary XRC 9000 in order to bring it as close as possible to the NTP Server time. Set the date and time from the Date Time Configuration screen (*Settings->Date and Time*).

    d. Configure the Controller TCP/IP Screen of the (new) Primary Controller for field operation (*Network->Settings*).

        i. Set the Controller Role as "Primary".

        ii. Configure Network IP Addresses, Network Properties, and Redundant Controller Feature IP Addresses to be used at the site. It is important to note that these fields must be configured with identical information in both the Primary and Secondary controller.

    e. After completing the configuration above at the shop, transport the (new) Primary XRC 9000 to the site location, connect its LAN1 port to the LAN Ethernet Switch, connect its LAN2 port directly to the LAN2 port on the active Secondary XRC 9000

(using the Ethernet Crossover Cable), and apply power to the (new) Primary XRC 9000. The (new) Primary XRC 9000 will discover that the Primary Controller IP Address is already in use. It will go the "inactive" state, and it will use the Secondary Controller LAN1 IP address. When the two controllers establish communication via their LAN2 connection, the controllers will synchronize important settings as described previously. In this scenario, the settings in the active Secondary XRC 9000 take precedence and will replace the settings in the inactive Primary XRC 9000.

f. When the two controllers have finished the synch process, use the Network Manager to connect to the active Secondary XRC 9000 (using the Network Manager connection for the Primary Controller IP Address), and give the "Switch to Primary Controller" command (*Site Control->Switch to Primary Controller*).

Note: If the technician attempts to manually switch site control by using either the "Switch to Primary Controller" or "Switch to Secondary Controller" command before the two controllers have completed the synch process, the Network Manager returns a message that says, "The controller rejected the switch command". Should this occur, wait a few minutes and then attempt to give the switch command again.

Site operation during switchover

The switchover process causes an interruption to site communications. Calls in progress and calls in the Busy Queue are not maintained through a controller switchover. Following switchover, the (new) active controller will re-establish links to other network sites. SU operation is described in the next section.

SU operation during switchover

If a Connect Plus SU is transmitting voice at time of switchover, it will continue to transmit until PTT is released. Then it will enter Search mode. If a Connect Plus SU is listening to a call at switchover, the call will drop and the SU will enter Search mode. If the SU is idle when switchover occurs (not in a call), it will enter Search mode.

When switchover causes the Connect Plus SU to enter Search mode, the SU will follow its normal Search logic.

In Networks with overlapping site coverage, Connect Plus SUs may register with other network sites before the new active controller starts up Control Channel messaging. If there is no overlapping coverage (or in a single site system), the Connect Plus SU will come back to the same site and use the new active controller. Because the (formerly) active controller shared its registration list prior to the switchover, the Connect Plus SU does not need to send a registration to the new active controller. However, whether the SU sends a registration to the controller, or whether the SU starts using the site without a registration is determined through the SU's normal rules:

- If SU has not attempted to register with another site in the interim, and if the SU's configured Reacquire Timer has not expired, the SU will begin using the site without a registration.

- If SU has attempted to register with another site in the interim, or if the SU's configured Reacquire Timer has expired, the SU will send a new registration prior to using the site.

Determining XRC 9000 Status

The XRC 9000 and the Network Manager provide several indications to determine a controller's current status and whether a switchover has occurred on the site:

Network Manager Site Dashboard: As discussed previously, when the Network Manager connects to a XRC 9000, the Site Dashboard tells the "role" of each connected XRC 9000. If the "role" is "Primary" or "Secondary", the dashboard also tells the current state, "active" or "inactive".

Event Log Entries: When the Secondary controller has established connectivity to the Primary controller, and then has subsequently lost the heartbeat messages for a period of time, the Secondary controller writes a "Controller Absent" message to the Event Log. This entry is created by the Primary Controller when it loses its connection to the Secondary Controller, or when the Secondary controller fails to connect after an expected period of time following boot-up. This entry is also created by the Primary controller if it loses connectivity to all of its peer repeaters for a period of time, and cannot instruct the Secondary controller to take over site operation.

When either the Primary or Secondary controller switches states (inactive to active, or vice versa), it places a "Controller Switch State" entry in the Event Log. The message shows the controller's state, active or inactive.

The inactive controller will create a "Controller Switch State Failure" Event Log entry if it attempts to switch to the active state, but is not able to take over the Primary Controller LAN1 IP address.

Controller Alerts: Controller Alerts can be viewed on the Network Manager's Alerts/Alerts Management Screen of the active site controller. Controller Alerts do not clear automatically on the active controller. They must be cleared by the System Administrator or Technician after determining that the condition which triggered the Alert no longer exists. If the underlying trigger still exists, the Controller Alert will return.

Alerts/Alarms can be viewed and managed on the active controller only. They cannot be viewed or managed on the inactive controller. When a controller changes to the inactive state, it clears any Controller Alerts that may have been active on that XRC 9000.

There are two alerts associated with Redundant Controller operation.

> *Primary Controller missing connected Secondary Controller*: This alert indicates that the Primary Controller has not yet communicated with the Secondary Controller, or that communication has been established, but the process of synching with the Secondary Controller is not yet complete. For more information about his Alert, see the section called "Primary and Backup Controllers synchronize certain information".
>
> *Secondary Controller Active*: This alert is generated when the Secondary Controller takes over site operations.

Testing the switchover capability

After configuring and connecting the redundant controllers, the technician should test switchover functionality, using the same the same LAN Ethernet switch that is used (or will be used) at the site. The steps for the test are listed below. The test will cause an interruption to radio service at two points (switchover from Primary to Secondary, and switchback from Secondary to Primary). For this reason, it should be performed at a time when site activity is low.

1. Complete all configuration and connections as described previously.

2. Use Network Manager Connection Tool to connect to the IP address that has been configured into the controllers as the Primary Controller IP address for LAN1.

3. After making the connection, look at the box representing the connected controller in the Site Dashboard. At the bottom of this box it should say, “Primary/Active”.

4. Click on the box representing this controller in the Site Dashboard. The box turns blue and “selects” the XRC 9000 for configuration.

5. From the Main Menu, select *Site Control->Switch to Secondary Controller*

6. Acknowledge the warning message. This will reset the XRC 9000 and disconnect you from the site.

7. The switchover takes place, causing a temporary interruption to service. Calls-in-progress will drop and the subscriber units will enter Search mode. If the site has overlapping coverage with another network site, some SUs may change sites during the switchover.

8. Use Network Manager Connection Tool to connect to the IP address that has been configured into the controllers as the Primary Controller IP address for LAN1.

9. After making the connection, look at the box representing the controller in the Site Dashboard. At the bottom of this box it should say, “Secondary/Active”. Assuming that you are connected via the site’s LAN Ethernet Switch, this confirms that the switch accepted the secondary’s gratuitous ARP response.

10. Click on the box representing this controller in the Site Dashboard. The box turns blue and “selects” the XRC 9000 for configuration.

11. From the main menu, select *Alerts/Alarms->Alert Management*. This opens the Alerts/Alarms Management screen. There should be an active Controller Alert for “Secondary Controller Active”.

12. From the Main Menu, select *Site Control->Switch to Primary Controller*

13. Acknowledge the warning message. This will reset the XRC 9000 and disconnect you from the site.

14. The switchover takes place, causing a temporary interruption to service. Calls-in-progress will drop and the subscriber units will enter Search mode. If the site has overlapping coverage with another network site, some SUs may change sites during the switchover.

15. Use Network Manager Connection Tool to connect to the IP address that has been configured into the controllers as the Primary Controller IP address for LAN1.

16. After making the connection, look at the box representing the controller in the Site Dashboard. At the bottom of this box it should say, “Primary/Active”. Assuming that you are connected via the site’s LAN Ethernet Switch, this confirms that the switch accepted the primary’s gratuitous ARP response. Site Control has now been returned to the Primary.

4.5.4 Monitoring Faults in the Connect Plus System

Each XRC 9000 maintains an “Event Log”, which can be downloaded and viewed using the MOTOTRBO Connect Plus Network Manager. Not all Event Log entries are system errors.

Some (but not all) error conditions cause the XRC 9000 to raise a “Controller Alert” or “Repeater Alarm”. This is a more aggressive form of fault notification, and the user will be alerted via the Network Manager’s Site Dashboard upon establishing connection with the site.

Controller Alert: A Controller Alert is raised when certain underlying fault conditions occur. There may be several different faults that than can trigger the same category of Controller Alert. For example, any Repeater Alarm reported by the repeater to the XRC 9000 will raise the “Repeater Alarm Detected” Controller Alert. It is necessary to view the site’s Event Log to see which specific repeater alarm may have raised the Controller Alert. Because a Controller Alert “latches” until the technician clears the alert via the Network Manager, the underlying fault may or may not still be active.

Repeater Alarm: Repeater Alarms indicate some type of fault in repeater operation. In most cases, the repeater reports the alarm to the XRC 9000, which causes the controller to create an Event Log entry for the specific alarm and to raise the generic “Repeater Alarm Detected” Controller Alert (if not already active). Depending on severity, Repeater Alarms may or may not result in an interruption to service. In all cases, the underlying fault should be further investigated. Repeater Alarms differ from Controller Alerts in a couple of important ways:

1. If a Repeater Alarm is displayed, the underlying fault is likely still active. (It is possible that the fault has been addressed, but the repeater has not yet reported this to the XRC 9000.)

2. The technician cannot clear the Repeater Alarm from the Network Manager application. The Repeater Alarm must be cleared in some other fashion. The XRC 9000 will clear the alarm if the repeater reports that the alarm is no longer active, or if the repeater completes a subsequent Link Establishment and the alarm is no longer active.

The XRC 9000 can be configured to automatically send an email when a “Controller Alert” is triggered in the XRC 9000. This functionality requires some configuration in the XRC 9000, and the customer must have a SMTP server that the XRC 9000 can reach via IP.

Regardless of whether the customer becomes aware of a Controller Alert via the Network Manager Site Dashboard, or via an email, it is important to understand the following important points about Controller Alerts:

- The Alert notification contains very few details. Its purpose is to alert a significant person (such as a technician) that there is a problem that needs further investigation. The technician must use the Network Manager connect to the site so that he/she can investigate further. For many Controller Alerts, there will be an Event Log entry for the event that triggered the alert.

- Once an event occurs to trigger a Controller Alert, the Controller Alert latches “on” until manually cleared via the Network Manager (even if the underlying fault has been corrected).

- If the Controller Alert is manually cleared, but the underlying fault has not been corrected, the Controller Alert will likely be triggered again.

- As long as the Controller Alert remains latched in the “on” position, subsequent faults in the same category do not re-trigger the alert. One ramification of this operation is as follows; the XRC 9000 will not send emails for subsequent faults in the same Controller Alert category until the previous Alert has been manually cleared via the Network Manager.

- If a site has two controllers in redundant controller configuration, Alerts/Alarms can be viewed and managed on the active controller only. They cannot be viewed or managed on the inactive controller. When a controller changes to the inactive state, it clears any Controller Alerts that may have been active on that XRC 9000.

4.6 Connect Plus Data Sub-System Design Considerations

As discussed in previous sections, the Text Messaging application server is utilized with Connect Plus to allow Text Messaging client applications to exchange messages with the MOTOTRBO subscribers. Unlike the other MOTOTRBO digital modes the server connects to the XRC 9000 controller via a UDP/IPv4 connection. The same is true for the Location Tracking server. These server applications run on PC machines that require IPv4 address assignments and should be taken into considerations when designing the supporting IP network.

Moreover, all the IP-capable data devices can be dispersed across multiple networks, some of which are directly connected to the public Internet and others isolated and protected by firewalls. Connect Plus has been architected to operate over such heterogeneous networks.

4.6.1 Connect Plus Example System IP Plan

Figure 4-12 shows a hybrid network configuration with 6 sites where sites 1-4, and 5-6 respectively, are placed on private networks, but interconnected through the public Internet and protected with firewalls on each side. The diagram is provided as an example of how port forwarding can be utilized to send messages to multiple site controllers via a single IP address (the network firewall). It should be noted that another approach (which is highly recommended, but not pictured here) would be to place all 6 sites in the same Virtual Private Network (VPN) or closed private network (see “Connect Plus Simplified Example IP Plan”). The VPN approach allows each site controller to be addressed via a unique IP address, thereby eliminating the need for port forwarding.

Note that only the controllers (XRC 9000) are shown for each site and the repeaters are omitted for better clarity. For this example, the repeaters should have IP addresses in the following subnets:

- 10.0.0.X for Sites 1-4
- 192.168.0.X for Sites 5-6

These IPv4 addresses can either be statically provisioned or acquired through DHCP. The important part is that the controllers are configured with static addresses.

Each of the border routers is capable of providing Network Address Translation with port forwarding, such that the IP traffic coming from the public side can reach the target controller via the public address and a predefined port number. Here the firewalls are shown as a logical components rather than physical boxes. It is quite common that the routers themselves function as firewalls.

The public IPv4 addresses are just examples of what an ISP will provide when a customer signs up for broadband service. Connect Plus does not currently support addressing sites through DNS domain names, so it is necessary to request public IPv4 addresses from the service provider. Finally, the TMS Server and the LRRP (Location) Server are assigned private IPv4 addresses from their respective private address pools (refer to the diagram).

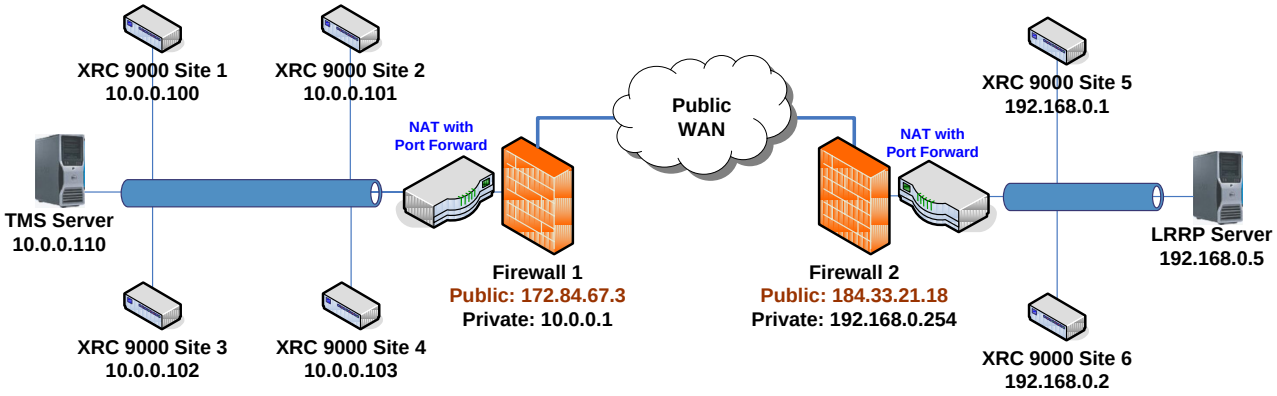


Figure 4-12 Example System IP Plan

The following table is provided for better understanding of IP data flows between the Connect Plus sites. For example, if the controller at Site 4 wants to send packets **to** the controller at Site 5, it needs to target it through the public IPv4 address 184.33.21.18.

SENDING TO	SENDING FROM XRC 9000 @					
	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Site 1	*	10.0.0.100	10.0.0.100	10.0.0.100	172.84.67.3	172.84.67.3
Site 2	10.0.0.101	*	10.0.0.101	10.0.0.101	172.84.67.3	172.84.67.3
Site 3	10.0.0.102	10.0.0.102	*	10.0.0.102	172.84.67.3	172.84.67.3
Site 4	10.0.0.103	10.0.0.103	10.0.0.103	*	172.84.67.3	172.84.67.3
Site 5	184.33.21.18	184.33.21.18	184.33.21.18	184.33.21.18	*	192.168.0.1
Site 6	184.33.21.18	184.33.21.18	184.33.21.18	184.33.21.18	192.168.0.2	*

Table 4-5 IP Address Matrix for the Example System

4.6.2 Port Assignments and Forwarding

Since the single public IPv4 address is in a way “shared” among the devices with private addresses, there has to be a mechanism to distinguish the private destination of the IP datagrams when they are received at the border router (from the public network).

A standard method to achieve this is by using a socket, which by definition is a pair of an IP address and port number. Depending on the IP payload, ports can be either TCP or UDP types. Connect Plus utilizes sockets to allow the border router to direct the public IP traffic to the correct target device, such as a controller or an application server.

For further information on how to allocate and configure ports for the Connect Plus system the reader can reference [4]. The port assignments provisioned into the XRC 9000 controllers need to be noted by the system administrator and used to configure the NAT router. Most NAT routers

allow Port Forwarding configurations for both, single (TCP or UDP) port and a range of port numbers.

The table below shows an example of Port Forwarding configuration for the system depicted in Figure 4-12. Here the assumption is that the TCP and UDP port assignments are the same for the external and internal port numbers. In other words, for **XRC 9000 Site 1** TCP packets received on socket 172.84.67.3**:**45001 will be forwarded to 10.0.0.100**:**45001.

Site	Private IP	NAT Public IP	TCP Control Port	UDP Voice Port Start	UDP Voice Port End
XRC 9000 Site 1	10.0.0.100	172.84.67.3	45001	46000	46031
XRC 9000 Site 2	10.0.0.101	172.84.67.3	45002	46032	46063
XRC 9000 Site 3	10.0.0.102	172.84.67.3	45003	46064	46095
XRC 9000 Site 4	10.0.0.103	172.84.67.3	45004	46096	46127
XRC 9000 Site 5	192.168.0.1	184.33.21.18	45005	46128	46159
XRC 9000 Site 6	192.168.0.2	184.33.21.18	45006	46160	46191

Table 4-6 Port Forwarding Example

4.6.3 Connect Plus Simplified Example IP Plan

Figure 4-13 presents multisite configuration with 3 Connect Plus sites with 3 repeaters per site, providing 5 trunked channels. The network topology is private LAN/WAN, which does not require any special port forwarding or network address translation. Each XRC 9000 controller can directly communicate with the other site controllers via their configured IP addresses. The reader can refer to Appendix B for more information and another example of private IP network topology.

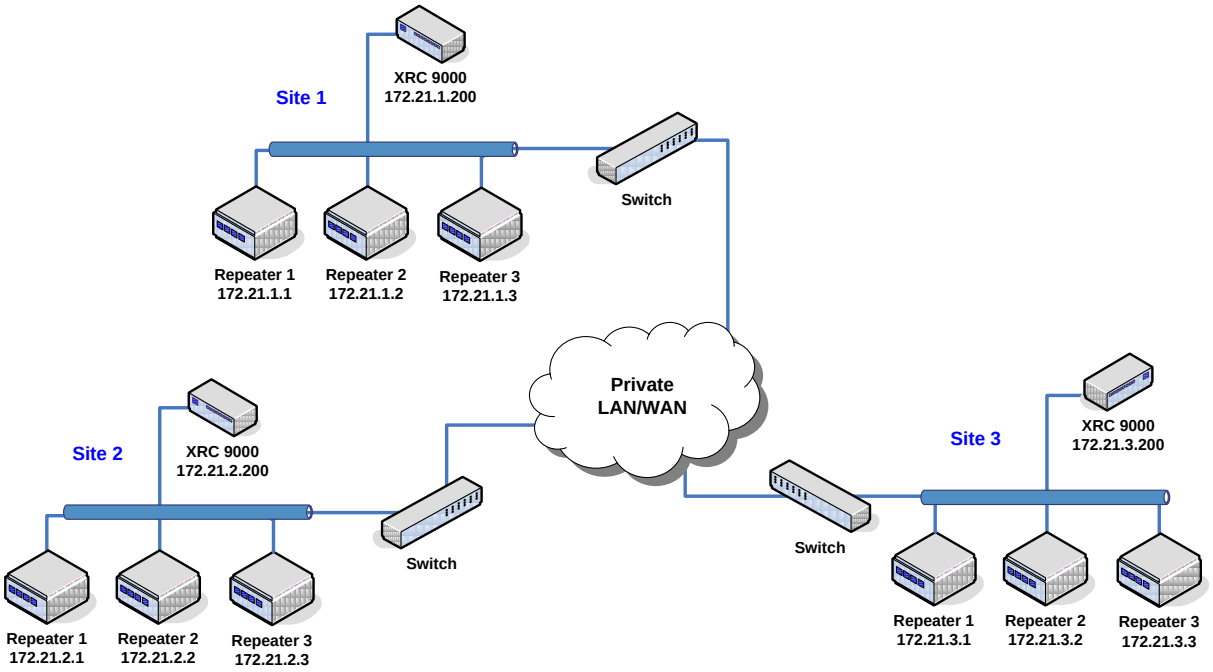


Figure 4-13 Simplified Example IP Plan

4.7 RF Resource Allocation

The following sections describe how the XRC 9000 allocates RF resources (trunk-to timeslots) at its local site. Understanding the points discussed in these sections will assist the radio system administrator in managing the site's RF resources.

4.7.1 Configurable Parameters for number of "Allowed Sessions"

For the XRC 9000, all non-emergency call sessions fall into one of the two following major categories:

- **Outbound Data Sessions**
  The call types in this category are non-emergency location request/reports, text message delivery from the XRC 9000 to a destination SU (regardless of whether the text message was initiated by another SU or by a 3rd party text message application), and Connect Plus Over-the-air (OTA) unconfirmed file transfer.

- **Voice & Inbound Data Sessions**
  The call types in this category are Group Call, Multigroup Call, Site All Call (voice), Private Call, and inbound data. At the current time there is one call session classified as inbound data – text messages from the SU to the XRC 9000.

The XRC 9000 has two programmable parameters used to determine how many calls for each category the controller will allow to be assigned at any one time.

Number of Outbound Data Sessions Allowed: This setting determines how many simultaneous sessions the XRC 9000 will allow for call types in this category. The XRC 9000 will continue to allocate timeslots (if available) for calls in this category until the site reaches the configured value. If no timeslots are available, or if the site reaches the configured value for "Number of Outbound Data Sessions Allowed", subsequent calls in this category are not placed in the Busy Queue. They are queued in the Data Scheduler until the XRC 9000 allocates a timeslot for outbound data sessions. The Data Scheduler is a software module in the XRC 9000 that is responsible for scheduling and requesting RF resources for outbound data sessions. The controller will not allocate a timeslot for outbound data sessions as long as the number of simultaneous calls for call types in this category remains at the configured value. Because sessions in this category are not placed in the Busy Queue, sites with a lot of outbound data activity (such as GPS updates) may wish to reserve one or more timeslots specifically for outbound data. This will allow outbound data sessions to continue; even when all voice/inbound data slots are busy. For more information on how to achieve this objective, please see the section titled "Timeslot Allocation Using Call Sessions Configuration Parameters".

Number of Voice/Inbound Data Sessions Allowed: This setting determines how many simultaneous sessions the XRC 9000 will allow for call types in this category. The XRC 9000 will continue to allocate timeslots (if available) for calls in this category until the site reaches the configured value. If no timeslots are available, or if the site reaches the configured value for "Number of Voice/Inbound Data Sessions Allowed", subsequent calls in this category are placed into the Busy Queue. When there are calls in the Busy Queue, and a timeslot becomes available, the XRC 9000 checks to see how many calls in this category are currently active on the site. If the number is below the configured value, the call at the top of the top of the Busy Queue is assigned to the available timeslot. If the "Number of Voice/Inbound Data Sessions Allowed" is equal to or greater than the configured value, the XRC operates as follows:

- If “Number of Outbound Data Sessions” is less than the configured value, the timeslot will be made available to the Data Scheduler for a call type in that category.

- If both the “Number of Voice/Inbound Data Sessions Allowed” and “Number of Outbound Data Sessions Allowed” are equal to or greater than the configured values, then the timeslot goes unused until at least one of the two counters drops below the configured value. In the meantime, the timeslot is available for Emergency Voice Calls and Emergency Location Updates.

It is important to note that Emergency Voice Calls and/or Emergency Location Updates are not subject to the rules discussed above. Their rules are as follows:

1. If *any* timeslot is available, it will be used for Emergency Voice Call or Emergency Location update, regardless of the two counters discussed above.

2. If no timeslot is available, the Emergency Voice Call or Emergency Location Update will be assigned to the Busy Queue and will receive priority for the next available timeslot per the rules discussed in the “Busy Queue” Section.

4.7.2 Timeslot Allocation Using Call Sessions Configuration Parameters

By understanding the operation of the two parameters discussed in the previous section, and by applying the formulas discussed below, the radio system administrator can achieve specific objectives for timeslot allocation. These objectives may vary according to priorities of the end user and the call types most commonly used. The next section provides some formulas, and the subsequent section provides some examples of how the formulas can be applied to achieve specific objectives.

4.7.2.1 Calculations to assure a minimum repeater bandwidth for specific call types

In this section, the term “bandwidth” refers to the number of repeater timeslots that the XRC 9000 makes available for calls in the “Outbound Data” and “Voice/Inbound Data” categories. The configuration strategies discussed in this section must be implemented on a per-site basis. Please note that the XRC 9000 does not provide the ability to reserve specific repeater timeslots for specific types of calls.

To assure[31] a minimum bandwidth for Voice/Inbound Data:

Total trunk-to timeslots	-	“Number of Outbound Data Sessions Allowed”	=	Minimum assured bandwidth for Voice/Inbound Data

[31] This assurance is only valid when there are no Emergency voice calls or Emergency Location Updates currently active or in the Busy Queue.

To assure[32] a minimum bandwidth for Outbound Data:

Total trunk-to timeslots	-	"Number of Voice/Inbound Data Sessions Allowed"	=	Minimum assured bandwidth for Outbound Data

To assure[33] a minimum bandwidth for Emergency Voice Call and/or Emergency Location Update:

Total trunk-to timeslots	-	("Number of Outbound Data Sessions Allowed" + "Number of Voice/Inbound Data Sessions Allowed")	=	Minimum assured bandwidth for Emergency Voice Call and/or Emergency Location Update

4.7.2.2 Examples

Example A: There are 9 trunk-to timeslots available in the site. The radio system administrator wants the XRC 9000 to assign all calls "first come-first served" as long as there are timeslots available, regardless of whether the request comes from a radio user or from the Data Scheduler. He/she is not concerned with assuring a minimum bandwidth for either category. In this case, the radio system administrator sets the "Number of Outbound Data Sessions" to 9 or higher and "Number of Voice/Inbound Data Sessions" to 9 or higher.

Example B: There are 9 trunk-to timeslots available in the site. The radio system administrator wishes to reserve at least 3 trunk-to timeslots for outbound data sessions so that GPS updates can continue, even when there are voice/inbound data sessions in the Busy Queue. However, the radio system administrator does not wish the GPS updates to totally "crowd out" the voice calls. So, he/she sets the "Number of Outbound Data Sessions Allowed" to 6 and the "Number of Voice/Inbound Data Sessions" to 6. This means there will always be at least 3 timeslots available for outbound data sessions (as long as there are not any Emergency Voice Calls or Emergency Location Updates active or in the Busy Queue), but the number can go up to 6 depending on how many voice/inbound data calls are presently active. It also means there will always be at least 3 timeslots available for voice/inbound data sessions (as long as there are not any Emergency Voice Calls or Emergency Location Updates active or in the Busy Queue), but the number can go up to 6 depending on how many outbound data calls are presently active. In this example, it is important to understand the following:

1. When there are 6 voice/inbound data sessions active, the next request in this category is placed in the Busy Queue, even if there are slots not being presently used for outbound data.

2. When there are 6 outbound data sessions active, the XRC 9000 will not make any more timeslots available for outbound data, even if there are slots not being presently used for voice/inbound data. The outbound data sessions are not placed in the Busy Queue.

[32] This assurance is only valid when there are no Emergency voice calls or Emergency Location Updates currently active or in the Busy Queue.

[33] When there are no Emergency Voice or Emergency Location Update sessions on the system, these timeslots go unused. Also, note that the radio system administrator is not required to assure a minimum bandwidth for Emergency Voice and/or Emergency Location update if he/she is willing to make these calls spend a brief period of time in the Busy Queue when all timeslots are busy with non-emergency calls.

Example C: There are 9 trunk-to timeslots available in the site. The radio system administrator does not want the site to ever become so busy with non-emergency calls that the first Emergency Call has to wait in the Busy Queue. So, he/she sets “Number of Outbound Data Sessions Allowed” to 4 and the “Number of Voice/Inbound Data Sessions” to 4. Even when both categories are at the maximum (4 + 4), there is still one unused timeslot available for Emergency. It is important to note the following:

1. When there are 4 voice/inbound data sessions active, the next request in this category is placed in the Busy Queue, even if there are slots not being presently used for outbound data.

2. When there are 4 outbound data sessions active, the XRC 9000 will not make any more timeslots available for outbound data, even if there are slots not being presently used for voice/inbound data. The outbound data sessions are not placed in the Busy Queue.

3. When there are 4 calls in each category active, there is an available slot for Emergency. However, if no Emergency Calls or Emergency Location Updates are active, then this timeslot goes unused.

4. When there are 4 calls in each category active, and when there is also an active Emergency Call or Emergency Location Update, a second Emergency Call or Emergency Location Update will go into the Busy Queue.

4.8 MOTOTRBO CPS Programming Considerations for the Connect Plus SU

Connect Plus trunking logic resides in the Connect Plus Option Board, which communicates with main board of the MOTOTRBO radio to facilitate Connect Plus operation. Because the radio and the Option Board both play a part in this process, two different software programs play a role when configuring a Connect Plus Subscriber Unit. MOTOTRBO CPS is used to configure the radio’s main board, while the Option Board is configured with Connect Plus CPS.

Although the majority of parameters associated with Connect Plus features are programmed with Connect Plus CPS, the importance of MOTORBO CPS programming cannot be over-stated. The radio must be programmed with MOTOTRBO CPS prior to using Connect Plus CPS to configure the trunking features. When configuring a Connect Plus radio with MOTOTRBO CPS, it is important to follow the guidelines provided in this document to ensure correct operation.

If the radio will contain only Connect Plus zones and channels, the MOTOTRBO CPS configuration is fairly straightforward because the programmer will not have to be concerned with screens that only affect non-Connect Plus modes. If the radio will be used for both Connect Plus and non-Connect Plus operation (such as MOTOTRBO analog & digital conventional modes or Capacity Plus), then CPS programming is more involved. The programmer will need to understand which settings affect only the non-Connect Plus modes, and which settings impact all radio modes, including Connect Plus.

The first step in configuring the SU is to use MOTOTRBO CPS to read the SU’s codeplug. Then, from the MOTOTRBO CPS Main Menu select “View”, and then select “Expert” from the drop-down View Menu. This will assure that the programmer sees all of the settings discussed in the following sections.

The following table provides a brief overview of the inter-relationship between MOTOTRBO CPS and Connect Plus. The headings in the left hand column are the major headings seen on the MOTOTRBO CPS Codeplug tree. If the table indicates that a particular screen is not used in Connect Plus, it can generally be by-passed if the radio is used for Connect Plus only. However, if the same radio is also used for non-Connect Plus modes, those screens should be configured according to the requirements of the non-Connect Plus application. This table provides an overview only. Before programming the radio, the programmer should also read the subsequent sections, which provide more detail on CPS dependencies and critical settings.

MOTOTRBO CPS Codeplug Tree	**Impact on Connect Plus Operation**
General Settings	Some settings are critical to Connect Plus operation
Accessories	When an accessory supported for Connect Plus operation is utilized, some of these settings impact Connect Plus, as well as other radio modes.
Buttons	Although Connect Plus buttons are programmed with Connect Plus CPS, some specific MOTOTRBO buttons affect Connect Plus operation if a feature is enabled while the radio is selected a non-Connect Plus zone and channel, and then the radio is changed to a Connect Plus zone and channel.
Text Messages	Not used for Connect Plus. Connect Plus Quick Text (pre-programmed) Messages are configured with Connect Plus CPS
Telemetry	Not currently supported for Connect Plus
Menu	Although Connect Plus menu operation is programmed with Connect Plus CPS, some specific MOTOTRBO menu options affect Connect Plus operation if a feature is enabled while the radio is selected a non-Connect Plus zone and channel, and then the radio is changed to a Connect Plus zone and channel.
Privacy	Not currently supported for Connect Plus. The Privacy checkbox must not be enabled for Connect Plus channels.
Network Settings	Some settings are critical to Connect Plus operation
Signaling Systems	These settings are not used for Connect Plus. In some cases, Connect Plus CPS has similar parameters.
Contacts	MOTOTRBO CPS contacts are not used for Connect Plus. Connect Plus Contacts are programmed with Connect Plus CPS.
RX Groups Lists	These lists are not used for Connect Plus
Channels	The way that Connect Plus zones and channels are organized with MOTOTRBO CPS is critical to Connect Plus operation. In regards to individual settings on the Channel screen, a few are critical to Connect Plus operation, but most are OK at default values. Many of the individual Channel settings will be overwritten with parameters

	configured with Connect Plus CPS.
Scan	These settings are not used for Connect Plus
Roam	These settings are not used for Connect Plus. Connect Plus Roam parameters are configured with Connect Plus CPS
Capacity Plus	These settings are not used for Connect Plus

When using MOTOTRBO CPS radio to configure a radio for Connect Plus, the main concerns of the radio programmer are to:

- Enable the Connect Plus purchasable feature
- Set the Radio ID
- Check settings that impact Connect Plus GPS & IP Data Operation. Many are OK are default values. Some may need to be adjusted slightly for optimal for Connect Plus operation
- Create zones and channels for Connect Plus

4.8.1 Enabling the Connect Plus Feature

Connect Plus operation is a purchasable feature for the MOTOTRBO radio. The SU can be programmed for Connect Plus prior to enabling the feature, but the Connect Plus Option Board will not enable its over-the-air signaling features until it verifies that the Connect Plus feature has been activated. Prior to feature activation, the Connect Plus SU will not search for service, attempt to register with any site, initiate calls, receive calls, etc. When an “unauthorized” radio is selected to a Connect Plus zone and channel, the LED blinks red and the radio sounds a tone. In addition, a display radio shows a message to inform the radio user that Connect Plus is not authorized.

The Connect Plus feature can be purchased through the Motorola Online (MOL) website. The process for purchasing, enabling, and viewing radio features is described in the following MOTOTRBO CPS Help screens:

- Purchasing Radio Features
- Activation
- View

MOTOTRBO CPS also provides a wizard to help walk the programmer through the process described in the Help screens listed above. The wizard is activated when choosing any item from the “Features” Menu with MOTOTRBO CPS.

After enabling the Connect Plus feature with MOTOTRBO CPS, it is necessary to recycle power on the radio. Upon power-up, the Option Board discovers that the Connect Plus feature is now enabled.

4.8.2 Setting the Connect Plus Radio ID

Each radio in the Connect Plus system must have a unique Radio ID, which is configured using MOTORBO CPS. The Radio ID field is located on the General Settings screen.

The radio uses the Radio ID as its individual ID for all digital modes. This includes not only Connect Plus, but also digital conventional and Capacity Plus.

MOTOTRBO CPS allows entries of 1 to 16776415 for the Radio ID. However, the top 64 numbers in this range (16776352 through 16776415) must not be used as the Radio ID for any Connect Plus radio. The Connect Plus system reserves these numbers for special purposes, so they must not be programmed into any radios. MOTOTRBO CPS will not block entry of these reserved values, so the programmer is responsible for entering a Radio ID that falls within the allowable Connect Plus range of 1-16776351. If the programmer enters any Radio ID higher than 16776351, the SU will not function correctly in the Connect Plus personality until the number is changed to a Radio ID that falls within the Connect Plus range.

Once a specific Radio ID is programmed into a Connect Plus SU, it cannot be used for any other Connect Plus SU network-wide. For this reason, it is very important to keep an accurate record of which radios have been assigned which Radio IDs. The programmer should maintain an accurate list that shows both the MOTOTRBO Radio Serial Number and the Radio ID it has been assigned. This information must be entered into the controller database before the radio can be used on the Connect Plus system. The MOTOTRBO Serial Number is displayed on the MOTOTRBO CPS "Device Information" Screen.

4.8.3 Other General Settings Critical to Connect Plus Operation

After entering the Radio ID, the programmer should check the status of several other configurable parameters on the General Settings screen that impact Connect Plus operation:

- **GPS**: Must be enabled for the Connect Plus SU to respond to Location Requests.
- **Private Calls**: Must be enabled if this Connect Plus SU should be able initiate Private Calls.
- **TX Preamble Duration**: In Connect Plus, the TX Preamble precedes IP data transmissions only. It does not precede Connect Plus CSBKs. If the radio is used for Connect Plus operation only, the TX Preamble should be set to zero. If the radio contains non-Connect Plus channels that require a TX preamble, it should be set as short as possible. Otherwise, it may adversely affect Connect Plus operation.
- Under "Alerts", **Disable All Tones** should not be checked, unless the programmer's desire is to disable all tones radio-wide, including Connect Plus zones and channels.

4.8.3.1 MOTORBO CPS Button Settings and Connect Plus Operation

The General Rules for programmable button operations are as follows:

- When selected to a non-Connect Plus zone and channel, a programmable button operates as configured with MOTOTRBO CPS.

- When selected to a Connect Plus zone and channel, programmable buttons operate as configured with Connect Plus CPS.

However, some MOTOTRBO CPS programmable buttons merit a special note:

If **All Alert Tones** is turned off while the radio is selected to a non-Connect Plus zone and channel, and then the radio is subsequently turned to a Connect Plus zone and channel, all tones will continue to be disabled, but the Connect Plus Option Board will not be aware of this condition. Enabling the tones while selected to a Connect Plus zone and channel will have no effect until the tones are enabled while the radio is selected to a non-Connect Plus zone and channel.

- If **Keypad Lock** is enabled while the radio is selected to a non-Connect Plus zone and channel, it will not be possible to select a Connect Plus zone and channel until Keypad Lock is disabled.

4.8.3.2 MOTORBO CPS Menu Settings and Connect Plus Operation

The General Rules for menu operations are as follows:

- When selected to a non-Connect Plus zone and channel, the Menu operates as configured with MOTOTRBO CPS.

- When selected to a Connect Plus zone and channel, the Menu operates as configured with Connect Plus CPS.

However, some MOTOTRBO CPS programmable Menu options merit a special note:

- If **Tones/Alerts** is turned off via the menu while the radio is selected to a non-Connect Plus zone and channel, and then the radio is subsequently turned to a Connect Plus zone and channel, all tones will continue to be disabled, but the Connect Plus Option Board will not be aware of this condition. Enabling the tones while selected to a Connect Plus zone and channel will have no effect until the tones are enabled while the radio is selected to a non-Connect Plus zone and channel.

- If **Keypad Tones** is turned off via the menu while the radio is selected to a non-Connect Plus zone and channel, and then the radio is subsequently turned to a Connect Plus zone and channel, Keypad tones will continue to be disabled, but the Connect Plus Option Board will not be aware of this condition. Enabling the keypad tones while selected to a Connect Plus zone and channel will have no effect until the tones are enabled while the radio is selected to a non-Connect Plus zone and channel.

- If **Keypad Lock** is enabled via the menu while the radio is selected to a non-Connect Plus zone and channel, it will not be possible to select a Connect Plus zone and channel until Keypad Lock is disabled..

- If the **LED Indicator** is turned off via the menu while the radio is selected to a non-Connect Plus zone and channel, and then the radio is subsequently turned to a Connect Plus zone and channel, then both the LED Indicator and Backlight continue to be disabled, but the Connect Plus Option Board will not be aware of this condition. Toggling the LED Indicator

"off" and then back "on" while selected to the Connect Plus channel will re-enable both the LED Indicator the Backlight for Connect Plus.

4.8.4 Network Settings Critical to Connect Plus Operation

The following table lists the MOTOTRBO Network Settings that are critical to Connect Plus operation. Network Settings not listed on this table affect Non-Connect Plus channels only.

Setting	**Connect Plus note**
Radio IP	Radio IP. This is usually left at default setting of 192.168.10.1. Connect Plus will still operate correctly if value is changed.
CAI Network	Must be left at default value of 12
CAI Group Network	Must be left at default value of 225
Maximum Transmit PDU Size	Must be set large enough to accommodate the largest text message or LRRP Report transmitted by the radio while operating in a Connect Plus zone. Recommend setting is 500 bytes or larger.

The Network Screen has several configurable port settings. As a rule, these settings affect non-Connect Plus zones and channels only, unless the programmer mistakenly selects a port number already used by the Connect Plus Option Board. To avoid conflicts with Connect Plus, the programmer must NOT use any of the following ports for these configurable settings; 4061, 4062, 4063, 4004.

4.8.5 MOTOTRBO CPS Zone & Channel Configuration for Connect Plus

One of the most important aspects of MOTOTRBO CPS configuration for Connect Plus is setting up the zone(s) and channels that will be used by the Connect Plus Option Board. Most applications will require just a single Connect Plus zone with 16 channels enabled for "Option Board" and "Option Board trunking". This is because the Connect Plus SU can Roam to any site in the Connect Plus network while operating in just one Connect Plus zone. It's usually not necessary to have more than one Connect Plus zone unless additional zones are needed for a specific reason. The following list provides some examples, but there could be other reasons that also necessitate multiple Connect Plus zones.

- Radio user needs more than 16 Talk Groups. This would require more than one zone, since each Connect Plus zone supports a maximum of 16 assignable positions on the Channel Selector Knob (portable radio) or Channel Rocker (mobile radio).

- Connect Plus organizes its Contact list on a per-zone basis, with each Connect Plus zone providing a maximum of 50 contacts. If this number is not sufficient for the radio user; one or more additional zones would be required. In this case, it's possible that the zones might be programmed identically, except for the Contact list.

- Radio user with non-display portable or numeric display mobile wishes to initiate many Private Calls. Since these models don't have a menu, the only way to initiate a Private Call is by assigning a One Touch Call button or assigning a position on the Channel Selector Knob (portable radio) or Channel Rocker (mobile radio) for each destination Private Call

ID. Since there are only 16 such assignable positions per zone, this may prompt a need for multiple Connect Plus zones.

The following rules must be followed when setting up Connect Plus channels. It is the radio programmer's responsibility to know these rules and follow them because they are not enforced by the MOTOTRBO CPS software. These rules must be followed exactly in order for Connect Plus to operate properly:

- Each Connect Plus zone must have 16 identically configured channels that are enabled for both "Option Board" and "Option Board trunking". These are the only types of channels allowed in a Connect Plus zone.

- Non-Connect Plus channels (analog conventional, digital conventional, Capacity Plus, "talkaround" channels, etc) are NOT allowed in any Connect Plus zone.

- For the Display Portable and Display Mobile, Connect Plus supports a maximum of 16 Connect Plus zones per SU. Since each Connect Plus zone must be programmed with 16 identical channels, the maximum number of Connect Plus channels per SU for these models is 16 x 16 (for a total of 256 channels). For the Non-Display Portable and Numeric Display Mobile, the radio supports a maximum of two zones per SU. If both of these zones are used for Connect Plus, the maximum number of Connect Plus channels per SU for these models is 2 x 16 (for a total of 32 channels).

- Connect Plus zones must be at the top of the Channels list. They cannot be preceded by any non-Connect Plus zones. If there are multiple Connect Plus zones, they must be contiguous – starting with the first zone on the Channels list. For example, if the radio has 5 Connect Plus zones, they must be the first 5 zones in the Channel List. Any non-Connect Plus zone must come after these zones in the list. If the radio already has non-Connect Plus zones prior to adding Connect Plus zones, the non-Connect Plus zones will have to be moved so that they follow the Connect Plus zones. This procedure is described later in this document.

- The "Channel Pool" icon must come immediately after the first zone folder. Any other position for the Channel Pool icon would be unexpected, and would likely result in undesirable operation. Because the Channel Pool icon cannot be moved by the MOTOTRBO CPS user, it is very important to follow the steps outlined in the sections called, "Creating a Connect Plus Zone and Channel" and "Connect Plus Zone Placement within the Channel List".

The steps for creating Connect Plus zones and channels are as follows. Each of these steps will be described in greater detail in subsequent paragraphs.

1. Programmer edits the first radio zone (and first digital channel in that zone) to create the first Connect Plus zone and the first Connect Plus Channel.

2. Programmer configures the Connect Plus channel settings.

3. Programmer copies & pastes the Connect Plus channel until the Connect Plus zone contains 16 identical channels.

4. If radio user needs multiple Connect Plus zones, the programmer copies and pastes the Connect Plus zone until the radio has the desired number of Connect Plus zones.

5. If the radio also has non-Connect Plus zones, then all Connect Plus zones must come before the non-Connect Plus zones. The final step is to move any non-Connect Plus zones below the Connect Plus zones so that the Connect Plus zones will be first in the list as

required. Guidelines for this operation are provided in section called, “Connect Plus Zone Placement within the Channel List”.

4.8.5.1 Creating a Connect Plus Zone and Channel

The procedure for creating Connect Plus zones and channels is as follows:

1) In the MOTOTRBO CPS codeplug tree, locate the “Channels” folder, and then locate the first zone folder underneath the “Channels” folder. Step 2 describes how to edit this zone so that it will become the first Connect Plus zone. If the zone is already in use for a non-Connect Plus mode, you can copy the zone folder and paste the copy at the end of the Channels list by following these instructions:

    a) Right click on the zone folder
    b) Select “Copy” from the right click menu
    c) Right Click on the “Channels” folder
    d) Select “Paste” from the right click menu
    e) This will place a copy of the zone folder (and all of its channels) at the end of the Channels list
    f) Now, proceed to edit the first zone folder as described in Step 2.

2) Edit the first zone folder to convert it to the first Connect Plus zone as follows:

    a) Edit the folder name, if desired, by right clicking the zone folder and selecting “Rename” from the right click menu
    b) Delete all but one digital channel from this zone folder. To delete a channel, select the channel to be deleted, press the “Delete” key, and then click “Yes” to confirm the deletion. **Note**: if the folder does not have at least one digital channel already, add one by right-clicking on the zone folder and then selecting “Add Digital Channel”.
    c) Delete all analog channels from this zone folder. To delete a channel, select the channel to be deleted, press the “Delete” key, and then click “Yes” to confirm the deletion.
    d) After completing these steps, the zone folder should now contain just one digital channel. Click on the one digital channel, and edit the channel settings according to the instructions in the next section.

4.8.5.2 Connect Plus Channel Settings

View the settings on the Channel screen in the right-hand pane. Verify that all settings are being displayed by going to Main Menu, and then selecting “View”, followed by “Expert” from the drop-down view menu.

The Channel Screen has many settings, but the programmer only needs to be concerned with a few of them. That’s because most of these settings will be overwritten by parameters entered with Connect Plus Board CPS.

Settings that must be changed from default values

There are three settings that must be changed from the MOTOTRBO default settings for proper Connect Plus Operation.

Setting	Connect Plus note
Option Board Checkbox	Programmer must select (check) this box for Connect Plus operation
Option Board Trunking	Programmer must select (check) this box for Connect Plus operation
Admit Criteria	Change this setting to “Always” for Connect Plus operation. This assures the fastest possible system access times. For Connect Plus, setting the Admit Criteria to “Always” does not mean the radio will always operate impolitely. Connect Plus will still operate “politely” during Connect Plus calls.
In Call Criteria	Set this to “Always” for Connect Plus operation. For Connect Plus, setting the In Call Criteria to “Always” does not mean the radio will always operate impolitely. Connect Plus will still operate “politely” during Connect Plus calls.

All of the other settings should be OK at the default values. Because some of these settings are important to Connect Plus operation, the programmer should check the following parameters and verify that they are set as required by Connect Plus.

Settings that should be OK at default values, but should be verified by radio programmer

Setting	Connect Plus note
Phone System	Set this to “None” for Connect Plus operation
Privacy Checkbox	This must be disabled (unchecked) for Connect Plus operation
IP Site Connect Checkbox	This must be disabled (unchecked) for Connect Plus operation
Compressed UDP Data Header	This must be disabled (unchecked) for Connect Plus operation
RX Only	This must be disabled (unchecked) for Connect Plus operation. If RX Only is desired, it must be programmed with Connect Plus CPS.
(RX) Reference Frequency	This must be selected to “Default”
(TX) Reference Frequency	This must be selected to “Default”
Contact Name	This must be selected to “None”. This will be set via Connect Plus CPS.
VOX	This must be disabled (unchecked) for Connect Plus operation
TOT (Time Out Timer)	Connect Plus CPS has a settable TOT, which defaults to 60 seconds also. This setting must not be shorter than the Connect Plus CPS value.
TOT Rekey Delay	This must be set to 0 sec
Allow interruption	This must be disabled (unchecked) for Connect Plus operation
TX Interruptible Frequencies	This must be disabled (unchecked) for Connect Plus operation

Private Call Confirmed Checkbox	This must be disabled (unchecked) for Connect Plus operation. Connect Plus provides its own confirmation for Private Calls.
Data Call Confirmed Checkbox	This box must be enabled (checked) for Connect Plus operation.

This concludes the set-up for this channel. It may seem unusual not to be concerned with settings such as “Color Code”, “Repeater Timeslot”, “RX Frequency”, and “TX Frequency”, but these settings are configured when building the Network Frequency File with Connect Plus CPS.

The next step will be to copy this channel and paste it 15 times to the Connect Plus zone, as described in the following section:

4.8.5.3 Verifying Number of Channels in Connect Plus Zone

Since Connect Plus requires 16 identically programmed channels in each Connect Plus zone, the easiest way to accomplish this is to create one Connect Plus channel, and then copy and past it 15 times into the Connect Plus zone.

- In the MOTOTRBO CPS codeplug tree view, right click on the newly created channel, and select “Copy”.
- In the MOTOTRBO CPS codeplug tree view, right click on the Connect Plus folder and select “Paste”. This will place the copied channel into the folder. The folder should now contain two identically programmed channels.
- Repeat this process 14 more times
- At the completion of this process, count the channels in the folder to verify that there are exactly 16.

4.8.5.4 Creating Additional Connect Plus Zones (if necessary)

As stated previously, most radio users will only need one Connect Plus zone. However, if more than Connect Plus zone is required, it can be accomplished via a simple “copy” and “paste” approach as described below:

- In the MOTOTRBO CPS codeplug tree view, right click on the Connect Plus zone folder and choose “copy”.
- In the MOTOTRBO CPS codeplug tree view, right click on the “Channels” folder and select “Paste”. This will place the copied zone and its 16 identical channels in the “Channels” folder. The radio now has 2 Connect Plus zones, each with 16 identically programmed channels.
- Repeat this process for each additional Connect Plus zone that is needed. The Display Portable and Display Mobile support a maximum of 16 Connect Plus zones. For the Non-Display Portable and the Numeric Display Mobile, the total number of zones is two (Connect Plus and Non-Connect Plus).

The final step will be to assure that Connect Plus zones are at the top of the Channel list as described in the next section.

4.8.5.5 Connect Plus Zone Placement within the Channel List

The last thing to be done is to assure that all Connect Plus zones are at the top of the Channel List. The reason for holding this step until last is that MOTOTRBO CPS automatically places newly created zones as the bottom of the list. For this reason, it makes sense to add all necessary Connect Plus zones prior to rearranging the Channel List.

This section provides guidelines for assuring that the Connect Plus zones are at the top of the Channels List.

For new "out of the box" radios

If a radio is a new, "out of the box" unit, it will likely have one default, non-Connect Plus zone at the top of the list. Edit this zone to make it the first Connect Plus zone by following the instructions in the section, "Creating a Connect Plus Zone and Channel".

For radios with pre-existing Non-Connect Plus zones

It is possible that the radio may have pre-existing non-Connect Plus zones which should be retained. This may be case, for example, when a conventional MOTOTRBO radio is converted to Connect Plus, and the programmer desires to retain the conventional channels.

If instructions have been followed correctly to this point, the first zone in the list will be a Connect Plus zone, but there may be other Connect Plus zones that are interspersed with non-Connect Plus zones. To re-arrange the list order so that all Connect Plus zones precede all non-Connect Plus zones follow this procedure:

1. Select all of the non-Connect Plus zones that precede the Connect Plus zones. To do this, select each non-Connect Plus zone folder by holding down the "Ctrl" key while clicking the folder. If done correctly, each selected folder title will be highlighted with a blue block.

2. Right click while these folders are selected; choose "Copy" from the right-click menu.

3. Right Click the folder labeled "Channels" at the top of the Channel List. Select "Paste" from the Right Click Menu.

4. This will paste a copy of the selected folders below the Connect Plus folders. At this point, there are two copies of these folders – the originals are still above the Connect Plus folders, and the copies are now below the Connect Plus folders. Verify this before proceeding to the next step.

5. The last step is to delete all non-Connect Plus zone folders that are above the Connect Plus zone folders. This can be done by deleting the non-Connect Plus zone folders one at a time or by dong a multiple select as previously described and then choosing "delete". In either case the software will provide a prompt to confirm the deletion(s).

After following these instructions, all Connect Plus zone folders should be at the top of the Channel List. There will likely be an icon labeled "Channel Pool" that comes immediately after the first Connect Plus zone folder. Any other position for the Channel Pool icon would be unexpected, and would likely result in undesirable operation.

When the programmer has verified that all Connect Plus zones are at the top of the Channel List, then MOTOTRBO CPS programming for Connect Plus is complete. If there is additional programming required for non-Connect Plus operation, it should be finished prior to writing the codeplug to the radio. Once the MOTOTRBO CPS programming is complete, the radio can be programmed with Connect Plus CPS.

4.9 Connect Plus Customer Fleetmap Development

Customer Fleetmap Development for Connect Plus has many similarities to Fleetmap Development for other MOTOTRBO modes, and many of the same processes and principles apply. The primary differences between Fleetmap Development for Connect Plus and other MOTOTRBO modes are as follows:

- In conventional modes, a big part of Fleetmap development is deciding which radios and groups get assigned to which repeater and timeslot. This is not a consideration in a trunking system such as Connect Plus, since the controller assigns channels and timeslots from a common pool on an "as needed" basis.

- In other digital modes, Fleetmap configuration is almost entirely in the subscriber radio (using MOTOTRBO CPS). In Connect Plus, the MOTOTRBO Connect Plus Network Manager and Connect Plus CPS both play a part in Fleetmap configuration. While this adds to the complexity of Connect Plus Fleetmap Development when compared with other modes, it also provides increased management capability and a greater degree of control. For example, in Connect Plus feature access (or feature limitations) can be addressed in two places – in the SU and the Controller. For many features, Connect Plus provides separate controls for the ability to initiate or receive a specific call type. The reader can refer to the section "Connect Plus Features" for description on the Connect Plus feature set.

- For the most part, Connect Plus features are identical or extremely similar to other digital MOTOTRBO modes. Some differences in feature availability that impact Fleetmap Development are that:

    - Connect Plus provides some features not available in other digital modes. These include Multigroup Call, the ability to send a Text Message to a Site All Call ID, and Over-the-air (OTA) File Transfer.

    - Connect Plus does not currently provide some features available in other digital modes. These include Privacy and Telemetry.

- In other MOTOTRBO Digital modes, a big part of Fleetmap Development is assigning GPS Revert Channels and/or Data Revert Channels. This is not a consideration in Connect Plus because the controller assigns channels and timeslots for data calls from the same pool of channels used for voice calls. Connect Plus does not use a Control Station radio as the interface between the Connect Plus System and a Location Tracking Application or a Text Message Application. The XRC 9000 controller fills this role.

- Scan operates differently in Connect Plus.

4.9.1 Identifying the Needs of Connect Plus Users

Just as in other digital modes, Fleetmap Development begins with identifying who the radio users are, and then identifying the needs of each radio user. Some of the questions that need to be asked include the following:

- Does the radio user have a “preferred site”? In a single site configuration, the “preferred site” is the radio user’s one and only site. In a multisite network, the “preferred site” is the site the radio user will be closest to the majority of time. The radio can automatically Roam from the “preferred site” to other network sites.

- Are there any network sites that the SU should not be allowed to use? If so, the disallowed site(s) should be unchecked in the Site Privileges list on the SU’s user record.

- Is the radio user a supervisor, or not? This impacts which features and privileges are provided to the radio user.

- How important is this radio user when compared to other users? This will determine the user’s Priority Level, as configured into the user record in the controller’s user database. Because each Talk Group record also has a configurable priority level, this question must be asked for each Talk Group.

- What department or work group does the radio user belong to? Individuals with similar responsibilities and interests are typically assigned to the same Talk Group.

- What other departments or work groups does the radio user need to talk to? This determines which other Talk Groups are programmed into the radio.

- Do a large number of individuals that span multiple departments and work groups share a common trait (such as belonging to the same company or organization)? If so, all of their radios are typically assigned the same Multigroup ID.

- Does the radio user have a need to speak with specific individuals? If so, the radio user should have the ability to initiate Private Calls, and the radio should be programmed with the Private Call destination IDs.

- Does the radio user have a GPS capable radio, and is it desirable to track its location? If so, the system must have a Location Tracking Application. The Location Tracking application must be programmed with the IP address and LRRP Port number of the XRC Controller. The application must also be configured with the user’s Radio ID and the desired location attributes and update interval.

- Does the radio user have a need to send a text message to a Dispatch PC, or receive a text message from a Dispatch PC? If so, the system must have a Text Message Application. The Text Message application must be programmed with the IP address and TMS Port number for the XRC Controller, and it must also be programmed with the Radio IDs and Group IDs of interest. Both the Text Message Application and Connect Plus SU must be programmed with one or more “Dispatch Call IDs” to represent the Dispatcher Client(s).

- Is the radio user tasked with responsibility for maintaining the radio system? If so, the radio may be programmed with multiple Connect Plus zones, so that the user can monitor and talk to many Talk Groups. Additionally, the radio user may be given the privilege and ability to make a “Site All Call”, so that information can be communicated quickly to all site users.

- Does the radio user need to have the ability to transmit an Emergency Call request? If so, the radio must be configured for an Emergency button, and the “Emergency Initiation” settings must be configured (all with MOTOTRBO Connect Plus CPS). Furthermore, the unit record for this SU must have the “Emergency Init” checkbox enabled on the user record in the XRC 9000 (using the MOTOTRBO Connect Plus Network Manager). If the

radio will use a Default Emergency Revert Group ID, then the Group number to be used must be programmed into both the SU and the SU's user record in the XRC 9000.

- Is the radio user equipped with a display radio, and does this radio need to give special ergonomic indications upon receiving an Emergency Call? If so, the "Emergency Receive" settings must be configured using MOTOTRBO Connect Plus Option Board CPS.

The process of identifying radio users and their needs should involve the radio users themselves, both at the management and non-management level. It should also be documented in a database or spreadsheet that can be used as a basis for Fleetmap Development. The database or spreadsheet should contain the following information for each radio user:

- Name
- Work area (which will be mapped to a radio talkgroup)
- Radio Model
    - Is radio GPS capable? Are location updates desired?
    - Does radio have a display? (Controller will not allow text messages to SU if no display?
- Radio Serial Number
- Radio ID
- Multigroup ID
- Default Emergency Revert Group
- Other Talk Groups the user will communicate with
- What Priority is this radio user? Each Connect Plus user record and Group record has a programmable Priority Level, 2-8. Priority 2 is the highest configurable level. Priority Level 8 is the lowest Priority Level. The Controller considers Priority Level when assigning Calls from the Busy Queue.
- Feature Privileges
    - Receive Private Calls?
    - Initiate Private Calls?
    - Initiate Multigroup Call? (voice & text)
    - Initiate Voice Call to Site All Call ID?
    - Send Text Message to Site All Call ID?
    - Initiate Remote Monitor for another SU?
    - Allow Remote Monitor by another SU?
    - Send "Disable Command" to another SU?

- Receive Disable Command sent by another SU?
- Send “Enable Command” to another SU?
- Receive Enable Command sent by another SU?
- Send Radio Check to another SU?
- Send Call Alert to another SU?
- Receive Over-the-Air File Transfer to update Connect Plus Option Board Firmware and Network Frequency File?
- Initiate Emergency Calls?
- Are there any network sites that the SU should not be allowed to use?

As the process evolves, it is not unusual to discover that individuals and needs fall into several general categories. Each of these categories may evolve into its own codeplug template.

4.9.2 Important Information about Connect Plus Call Initiation Privileges

The XRC 9000 Controller provides several programmable Call Initiation Privileges for each SU record. Once an SU is enabled with a privilege (such as the “Private Call Init” privilege) the XRC 9000 Controller does not maintain a list of which SU’s that specific radio is allowed to call. Which SU’s the radio can call is determined by the following:

- If Manual Dial is NOT enabled in the radio via Connect Plus CPS, the radio can attempt to call any Private Call ID on its Zone Contact List.
- If Manual Dial is enabled in the radio via Connect Plus CPS, the radio can attempt to Private Call any Private Call ID entered via the keypad. This essentially means that the SU can attempt to call any Private Call ID network-wide.
- When the SU attempts to initiate a Private Call, the XRC 9000 Controller will allow the radio to call any SU that has the “Private Call receive” privilege enabled on its user record in the controller database.

The same principles also apply to Remote Monitor, Radio Check, Call Alert, Radio Disable, and Radio Enable.

4.9.3 Who will the Connect Plus radio user hear?

The Connect Plus radio can receive one call at a time. While the radio is receiving one call (either voice or data), it’s possible that radio will not hear part or all of another call that it would otherwise respond to.

Assuming that the Connect Plus radio is idle and monitoring its Control Channel, the SU will respond to any of the following call assignments on a first-come first-served basis.

- The SU will respond to a call targeting its individual ID. This includes Private Calls, Call Alert, Radio Check, Remote Monitor, Radio Disable, Radio Enable, Text Message to the individual ID, Location Update Request. If it is not desirable for the radio user to receive one of these call types, then the SU record in the controller database should not be configured with the corresponding "receive" privilege.

- The SU will respond to a call targeting its Selected Group ID. The Selected Group ID is the Group ID currently selected with the Channel Selector Knob (portable radio) or Channel Rocker (mobile radio). Or, if a Private Call ID is currently selected on the Channel Selector Knob or Channel Rocker, the SU will respond to the "Registration Group ID" that has been programmed for that Knob or Channel Rocker position. Call types include voice call to the Group ID or text message to the Group ID.

- The SU will respond to a call targeting its Multigroup ID. The user's Multigroup ID is configured in two places; in the subscriber radio and in the user record in the controller database. Call types include voice call to the Multigroup ID or text message to the Multigroup ID.

- The SU will respond to a call targeting the Site All Call ID. Call types include voice call to the Site All Call Voice ID or text message to the Site All Call Text ID.

4.9.4 Who will the Connect Plus radio user talk to?

For the purposes of this discussion, the expression "talk to" will be used in a broad sense to include both voice and data features.

Who the Connect Plus radio user can "talk to" is determined by several factors:

- What privileges are configured into the controller's user database? Whenever the user record provides a programmable privilege, it always takes precedence over how the radio has been programmed with Connect Plus CPS. For example, the radio may be configured with the Menu option to initiate Remote Monitor. However, if the "Remote Monitor Init" privilege is not enabled on the user record in the controller database, the radio's request to start a Remote Monitor will be denied.

- How has the radio been programmed with Connect Plus CPS? SU programming and controller programming should be in synch in regards to the SU's privileges. It the radio user is not allowed to Remote Monitor other SU's, then the "Remote Monitor Init" privilege should not be enabled in the controller's user record and the radio should not be programmed with the Remote Monitor menu option.

- What Talk Groups have been assigned a position on the Channel Selector Knob (portable radio) or Channel Rocker (mobile radio)?

- What Multigroup ID has the radio been programmed with? Has the Multigroup ID been assigned a position on the Channel Selector Knob (portable radio) or Channel Rocker (mobile radio)? This is required for the radio to initiate a voice call to the Multigroup ID. Has the user record in the controller database been enabled for the "Multigroup Call Init" privilege?

- Has the Site All Call voice ID been assigned a position on the Channel Selector Knob (portable radio) or Channel Rocker (mobile radio)? This is required for the radio to initiate a voice call to the Site All Call ID. Has the user record in the controller database been enabled for the "Site All Call Init" privilege?

- Does the radio have a display? If not, the ability to initiate calls is restricted to calls assigned to a Channel Selector Knob (portable radio) or Channel Rocker (mobile radio) position, or programmed “One Touch Calls”. If the radio does have a display, what Menu options have been configured? This determines which calls can be initiated via the radio menu.

- Has the radio been programmed with the ability to do One Touch Calls? If so, what call types and Destination IDs have been programmed for the One Touch Call(s)? In Connect Plus, One Touch Call can be used to initiate the following Call Types:

    - Private Call (voice call) to a specific Destination ID

    - Call Alert to a specific Destination ID

    - Programmed “Quick Text” Message to a specific Destination ID. The Destination ID can be either an individual (Private Call) ID or a Group ID.

- Does the radio have a keypad (and therefore the ability to “Manually Dial” an individual ID)? If the radio doesn’t have a keypad, or if it does have a keypad but “Manual Dial” hasn’t been enabled as a Menu option, then the only individual IDs that can be targeted for calls will be those on the radio’s Contact List. Group IDs cannot be entered via Manual Dial.

4.9.5 Assigning Connect Plus Radio IDs

Each Connect Plus radio user must be assigned a unique Radio ID between 1 and 16776351. The Radio ID used for each mobile or portable SU must be unique network wide. The only exception to this rule is for repeater Radio IDs. The assignable range for repeater Radio ID’s is 1-15. Each repeater at a site must have a unique Radio ID, but the same Radio ID can (and probably will) be used again for another repeater at a different site.

Because such a wide range of assignable Radio ID’s are available for Connect Plus SU’s, the Network Administrator has many possible strategies to choose from when assigning a radio its Radio ID. The following are just some examples:

- If “Manual Dial” (direct entry from the radio keypad) will be used as a strategy for making individual calls, this would be a good reason for making Radio IDs as short as possible.

- Radio ID’s may be assigned so that each number in the Radio ID represents something. The first digit may represent the type of radio (mobile vs. portable), the second digit might represent a department, the next three digits might represent the user, and so forth.

- Radio Users in the same company or department might be assigned from the same contiguous ranges. For example, Department A radios may be assigned from the range of 100 to 199, Department B from 200 to 299, etc.

- It may be helpful to plan for a relationship between a Group ID and the Radio ID’s of the users of that Group. For example, Talk Group A may use Talk Group 1000 and their Radio ID’s may be assigned from the ranges of 101 to 199. Talk Group B may use Talk Group 2000 and their Radio ID’s may be assigned from the ranges of 201 to 299. While it’s allowable to use the same number as both a Radio ID and Talk Group ID, it isn’t necessary due to the large number of ID’s. Using different numbers for Groups and Radio ID’s can

help the radio user and System Administrator differentiate quickly between Group IDs and individual IDs.

- Some Network Administrators like to match Radio IDs with vehicle numbers. It should be noted that if a single radio user has two radios – both a portable and mobile, for example – the two radios must have different radio ID's. However, the Network Administrator can plan for a relationship between the two numbers. For example, the mobile radio in "Joe's" vehicle might be Radio ID 50, while "Joe's" portable radio is assigned Radio ID 150.

The Radio ID is programmed into the SU with MOTOTRBO CPS. See the section, "Setting the Connect Plus Radio ID" for important information on configuring the Connect Plus Radio ID with Connect Plus CPS.

Each XRC 9000 Controller in the network must have an identical user record for each Connect Plus Radio ID. Connect Plus helps the Network Administrator fulfill this rule in two ways:

- Whenever a user record is added to the user database at any Connect Plus site (or an existing record is updated with revised information), the site will automatically forward a copy of the record to other network sites. This is done on a record-by-record basis after the programmer makes the desired changes and then saves the record.

- If a new Connect Plus site is brought on-line the Network Manager software makes it easy to copy the entire user database from an existing Connect Plus site to the new site.

In case when merging of two or more Connect Plus systems is expected in the future helpful guidelines on Radio ID assignments have been provided in Appendix C.

4.9.6 Assigning Aliases for Connect Plus Radio IDs

Connect Plus CPS can be used to assign aliases for Connect Plus Radio IDs. For example, "Fred's radio" can be programmed to know that "Sue" has Radio ID 250. This is helpful in a couple of ways:

- When "Fred" wants to make a call to "Sue", he can simply choose "Sue" from the Contact List. This assumes that Fred's radio has been programmed with a Private Call Contact for ID 250, and that "Sue" has been entered as the "Contact Name" for the contact record.

- When "Fred" receives an individual call from "Sue" (or when "Sue" transmits during a Group Call), his display will show "Sue", rather than Sue's Radio ID. This assumes that Fred's radio has been programmed with a Private Call Contact for ID 250, and that "Sue" has been entered as the "Contact Name" for the contact record.

While the two features described above are a nice convenience for "Fred", a word of caution should be mentioned. If something happens to where Radio 250 no longer belongs to Sue, this is a problem because "Fred's" radio will continue to display ID 250 as "Sue". Changing the alias on the contact record requires reprogramming the radio using the "tethered" method (computer, Connect Plus CPS software, and programming cable).

For this reason, some Network Administrators avoid using a person's name as the "Contact Name" for a contact record. In place of the individual's name, they prefer to use a job title, vehicle name or number, etc.

Some Network Administrators prefer not to program Private Call contacts at all. In this case, the radio will display the Call ID in place of the alias for incoming transmissions. Also in this case,

"Manual Dial" would be the only option for initiating individual call types. The radio requires a keypad to support "Manual Dial".

If Private Call contact records and aliases are used, all radios should be programmed in a consistent manner so that the alias information in "Radio A" will be the same as the alias information in radios "B", "C" and "D".

It should also be noted that the user record in the Connect Plus controller has a field called "alias", but this alias is not transmitted over the air and it has no effect on what appears on a radio's display. The alias on a radio's display is determined via Contact List programming with Connect Plus CPS.

4.9.7 Assigning Connect Plus Group IDs

A Group Call allows multiple radios to participate in the same conversation.
Therefore, the organization of Group IDs is one of the most important decisions that will be made during the Fleet Mapping process. In most cases, a Group ID represents a department or work group. However, this merits a note of caution. While every department might desire its own ID for Group communications, this may not be advisable for several reasons:

- The more different Group IDs that have been assigned to radios, the busier the site and network is likely to be.

- The more different Group IDs that are programmed into any individual radio, the easier it is for the radio user to get "lost in the radio" and miss important communications because he/she is selected to the wrong group.

For this reason, it is advisable for multiple departments or work groups to share a common Group ID wherever possible.

The assignable range for Connect Plus Group ID's is 1 to 16776351. Once a Talk Group ID has been selected for a work group or department, the number should not be assigned to any other Group (or Multigroup) network-wide. While it's allowable to use the same number as both a Radio ID and Talk Group ID, it isn't necessary due to the large number of ID's. Using different numbers for Groups and Radio ID's can help the radio user and System Administrator differentiate quickly between Group IDs and individual IDs.

In case when merging of two or more Connect Plus systems is expected in the future helpful guidelines on Group ID assignments have been provided in Appendix C.

4.9.8 Programming Connect Plus Group IDs

A Group ID record that matches the Group number selected for the work group or department must be programmed into the XRC 9000 controller. Just as with the individual record for Radio IDs, the controller will automatically send the Group record to all of its connected sites.

Additionally, the Group ID must be programmed into the radio of each Group member using Connect Plus CPS. The following bullets describe the required steps:

- In each Connect Plus zone that requires the Group ID, use Connect Plus CPS to create a "Group Call" contact record with the "Call ID" and the "Contact Name". The "Contact Name" typically describes the work group or department (such as "shipping" or "security").

- After the Group Call Contact Record has been created, it must be assigned to a Channel Selector Knob position (portable radio) or Channel Rocker position (mobile radio), using the Connect Plus CPS Zone Channel Selections Screen. For each position (up to a maximum of 16 positions), there are three programmable fields; “Contact Name”, “Registration Group Name” and the “RX Only” checkbox. The “Contact Name” field is used to program which Group Call will be started when the radio is selected to that position and PTT is pressed. When the “Contact Name” is programmed with a Group Call, the software automatically programs the “Registration Group Name” field with the same Group Call info. The “RX Only” checkbox should be checked if the radio user is allowed to listen to the group only, but is not allowed to transmit.

4.9.9 Making a Group Call

To start a call to the Group, the radio user selects the Channel Selector Knob position (portable radio) or Channel Rocker position (mobile radio) that has been programmed for the desired Group. If the knob or channel rocker has been changed from a different position, the radio will automatically re-register with the newly selected Registration Group. Following the registration, the radio user may press PTT to start the call. When the radio sounds the “Talk Permit” tone, a timeslot has been assigned and the user may proceed to talk while pressing PTT. The transmission will be heard at any network site that has at least one radio registered to the Group and where there is an available repeater timeslot for call assignment. When the radio user releases PTT, the repeater starts the Group Call Hang Time. This allows other individuals in the Group to speak without having to initiate a brand new call.

Each transmission is identified with two numbers; the Group ID number and the Radio ID of the transmitting radio. The Group ID is what allows multiple radios to hear the same transmission. The Radio ID allows the receiving radios to know which individual within the Group is currently transmitting.

It is important to note that Group voice calls cannot be initiated via the radio menu or by pressing a “One Touch Call” button in Connect Plus. In order to start a Group voice call, the user must select the programmed position on the Channel Selector Knob (portable) or Channel Rocker (mobile).

4.9.10 Assigning Connect Plus Multigroup IDs

A Multigroup ID is a special type of Connect Plus Group feature that does not exist in other MOTOTRBO digital modes.

Each Connect Plus radio can be programmed with one Multigroup ID. The Multigroup ID is programmed into the radio using the General Settings screen of Connect Plus CPS. This same number must be programmed into the Multigroup ID field of the user record corresponding to the SU in the controller’s user database.

Multigroup operation differs from regular Connect Plus Groups in several important ways:

- The radio user doesn’t need to select the Multigroup in order to hear transmissions on the Multigroup ID. Regardless of which Group is currently selected via the Channel Selector Knob position (portable radio) or Channel Rocker (mobile radio), the radio automatically listens for Multigroup transmissions also.

- Because a radio's Multigroup ID is programmed into its unit record in the controller's database, the Connect Plus radio doesn't need to register with the Multigroup ID. The radio registers with its selected Group, and the controller automatically registers the radio to both its Selected Group and its Multigroup. This allows the radio user to hear Multigroup transmissions no matter which site he/she is registered to, and no matter which Talk Group is currently selected. If the Multigroup ID happens to also be the selected Group ID, then the radio does register with the Multigroup ID.

- A radio user requires a programmable privilege to initiate a Multigroup transmission. The "Multigroup Init" privilege is kept on the user record in the controller's user database. This permission is checked when (a) starting a voice call to the Multigroup ID, and (b) sending a text message to the Multigroup.

- A Multigroup voice call is a one-way transmission. The repeater starts the Group Hang Time after the transmission, but only the call initiator is allowed to talk during the Group Hang Time. If another radio wishes to transmit on the Multigroup, it will be processed as a new call request, and the call initiator must have the programmable permission. For this reason, the Multigroup is well suited for announcements to large numbers or radios, but it is not designed to be a conversation group.

- If the system designer/administrator does not want to include an SU in any Multigroup call, then the SU should not be assigned a Multigroup ID.

In order for a radio to hear a Multigroup transmission, all of the following requirements must be met:

- The matching Multigroup ID must be programmed into the subscriber via the Connect Plus CPS General Settings screen.

- The radio must be registered to the site and monitoring the Control Channel downlink in order to receive the call assignment. If a radio is involved in a previous call on another trunk-to timeslot, it may miss all or part of the Multigroup Call.

Deciding which SU's will share the same Multigroup ID is an important Fleet Mapping decision. Since the Multigroup works best as an announcement group, an important factor is deciding whether a large group of users shares a common interest – such as belonging to the same company or organization. If so, it makes sense to place them in the same Multigroup.

The assignable range for Connect Plus Multigroup ID's is 1 to 16776351. Note that this is the same range used for regular Talk Groups. Any number from this range can be assigned to a regular Talk Group or a Multigroup ID, but not both. Once a number has been used as either a Talk Group or Multigroup, it cannot be used again.

In case when merging of two or more Connect Plus systems is expected in the future helpful guidelines on Multigroup ID assignments have been provided in Appendix C.

4.9.11 Programming Connect Plus Multigroup IDs

4.9.11.1 Placing Multiple Radio Users in the Same Multigroup

Placing multiple radio users in the same Multigroup is simply a matter of assigning them the same Multigroup ID. To assign a Multigroup ID, use the following steps:

- Create a Multigroup record for the ID in the controller's user database. Just as with other subscriber records, the controller will automatically send the Multigroup record to all of its connected sites.
- Also in the controller user database, program the Multigroup ID into the "Multigroup ID" field on the unit record for each SU that will be a member of the Multigroup.
- When programming subscriber radios, each radio in the Multigroup should be programmed with this Multigroup ID. The set of radios that is programmed with "Multigroup ID X" should match the set of user records that have been programmed with the same Multigroup ID.
- A radio doesn't need to be programmed with a Multigroup contact record in order to receive a Multigroup call. This is because the Multigroup ID is programmed on the Connect Plus CPS General Settings screen. The contact record is required for the following:
    - To display a programmable alias for the Multigroup ID.
    - To assign a Channel Selector Knob position (portable radio) or Channel Rocker position (mobile radio) to the Multigroup ID. Assigning a Knob or Rocker position is required to initiate a Multigroup Call, but not to receive a Multigroup Call.

4.9.11.2 Programming for Multigroup Call Initiation

To allow a radio user to initiate a Multigroup Call, the following steps are required:

- In the controller database, check the "Multigroup Init" checkbox on the user record corresponding to the SU that should have the privilege.
- In each Connect Plus zone that requires call initiation on the Multigroup ID, use Connect Plus CPS to create a "Multigroup Call" contact record with the "Call ID" and the "Contact Name" for the Multigroup.
- After the Multigroup Call Contact Record has been created, it must be assigned to a Channel Selector Knob position (portable radio) or Channel Rocker position (mobile radio), using the Connect Plus CPS Zone Channel Selections Screen. The procedure for assigning a programmable Knob or Rocker position is the same as described previously for a Group Call, except that the Multigroup ID is assigned as the Contact Name.

4.9.12 Making a Multigroup Call

The procedure for starting a Multigroup Call is the same as for starting a Group Call. Prior to granting the call request the controller will check to see if the initiating radio has the "Multigroup Init" privilege on its unit record in the controller's user database.

When the radio user releases PTT after a Multigroup transmission, the repeater starts the Group Call Hang Time. Unlike other Group Calls, only the call initiator can transmit again during the Call Hang Time.

It is important to note that Multigroup calls cannot be initiated via the radio menu or by pressing a "One Touch Call" button. In order to start a Multigroup Call, the user must select the programmed position on the Channel Selector Knob (portable) or Channel Rocker (mobile), and the user record must be configured for the programmable "Multigroup Init" permission in the controller's user database.

4.9.13 Site All Call ID

The Site All Call ID in Connect Plus is very similar to the All Call ID in other MOTOTRBO digital modes. The word "Site" is added in Connect Plus to emphasize that these transmissions are heard only at the site where the call initiator is located. Unlike other Connect Plus Calls, audio is NOT networked beyond the originating site. In Connect Plus, an authorized user can also send a Site All Call Text Message. The Text Message will only be transmitted at the originating site. It will not be networked to other sites.

4.9.13.1 Site All Call Differences

Site All Call differs from other Connect Plus Groups in several important ways:

- It is not necessary to create records for the Site All Call in the controller's user database. This is because the controller is "hard coded" with information about the Site All Call IDs. These records cannot be viewed or edited.
    - Site All Call (voice) uses a fixed ID of 16777215. This cannot be changed by the user.
    - Site All Call (text) uses a fixed ID of 16776415. This cannot be changed by the user.
- The radio user doesn't need to select Site All Call in order to hear transmissions on the Site All Call ID. Regardless of which Group is currently selected via the Channel Selector Knob position (portable radio) or Channel Rocker (mobile radio), the radio automatically listens for Site All Call transmissions also.
- A radio user does not have to register with the Site All Call ID to hear Site All Call transmissions.
- A radio user requires a programmable privilege to initiate a Site All Call transmission. There are separate permissions for "Site All Call Voice Init" and "Site All Call Text Init". These permissions are kept on the user record in the controller's user database.

- A Site All Call voice call is a one-way transmission. There is no Group Hang Time after a Site All Call transmission. If another radio wishes to transmit on the Site All Call ID, it will be processed as a new call request, and the call initiator must have the programmable permission. Site All Call should only be used for important announcements of interest to all site users. It is not a conversation group.

In order for a radio to hear a Site All Call transmission, the radio must be registered to the site and monitoring the Control Channel downlink in order to receive the call assignment. If a radio is involved in a previous call on another trunk-to timeslot, it may miss all or part of the Site All Call.

Deciding which individuals can initiate a Site All Call is an important Fleet Mapping decision. In many networks this privilege is only granted to the individual responsible for maintaining the site and/or network. Once a radio user has been granted the permission, he/she should also be educated about how and when to use the Site All Call ID. Because Site All Call transmissions are heard by all idle radios registered to the site, they can be disruptive to normal communications.

4.9.13.2 Enabling Radio to Initiate a Site All Call

To allow a radio user to initiate a Site All Call, the following steps are required:

- In the controller database, check the “Site All Call Voice Init” and/or the “Site All Call Text Init” checkbox(es) on the user record corresponding to the SU that should have the privilege(s).

- In each Connect Plus zone that requires call initiation on the Site All Call ID, use Connect Plus CPS to create a “Site All Call” contact record. Note that there are separate record types for “Site All Call Voice” and “Site All Call Text”. Only “Site All Call Voice” can be assigned a position on the Channel Selector Knob (portable radio) or Channel Rocker (mobile radio).

- After the Site All Call Voice Contact Record has been created, it must be assigned to a Channel Selector Knob position (portable radio) or Channel Rocker position (mobile radio), using the Connect Plus CPS Zone Channel Selections Screen. The procedure for assigning a programmable Knob or Rocker position is the same as described previously for a Group Call, except that the Site All Call Voice Contact is assigned as the Contact Name. Also, when Site All Call Voice is assigned as the Contact Name, any type of Group Record can be assigned as the Registration Group Name. The advantage of assigning a different Group Call as the Registration Group Name is that it allows the radio to also receive calls on that ID while selected to the “Site All Call Voice” position.

4.9.14 Making a Site All Call

The procedure for starting a Site All Call is the same as for starting a Group Call. Prior to granting the call request the controller will check to see if the initiating radio has the “Site All Call Voice Init” privilege on its unit record in the controller’s user database.

When the radio user releases PTT after a Site All Call transmission, the repeater does not enter the Call Hang Time. Instead, the call ends immediately and all radios return to the Control Channel timeslot.

It is important to note that Site All Call voice calls cannot be initiated via the radio menu or by pressing a “One Touch Call” button. In order to start a voice Site All Call, the user must select the

programmed position on the Channel Selector Knob (portable) or Channel Rocker (mobile), and the user record must be configured for the programmable “Site All Call Voice Init” permission in the controller’s user database.

4.9.15 Connect Plus Private Calls

Private Call refers to the ability for one individual radio user to call another individual radio user regardless of whether the units share any common Talk Groups. The voice communication takes place using the Private ID’s (individual Radio ID’s) of the two units. So, the term “Private” means that the call involves two individual ID’s, the source and destination. It does not mean that the voice packets are encrypted in any special way.

In other digital modes, Private Calls can be configured as “confirmed” or “unconfirmed” based on MOTOTRBO CPS programming. In Connect Plus, a Private Call always requires a Control Channel acknowledgement from the destination SU before the controller will assign a trunk-to timeslot. In this sense, Connect Plus Private Calls are always confirmed. However, the “Private Call Confirmed” checkbox must not be enabled for any Connect Plus channel via MOTOTRBO CPS. This requirement prevents the participating radios from performing an additional and unnecessary CSBK exchange on the trunk-to timeslot prior to transmitting voice.

In Connect Plus, the privilege to “initiate” a Private Call and the privilege to “receive” a Private Call are separate programmable privileges on the unit record in the controller’s user database. One of the most important Fleet Mapping decisions is whether an individual should be given one or both of these privileges.

Giving many users the ability to initiate Private Calls is somewhat risky for several reasons:

- Some radio users may “hide out” in private conversations so as not to be monitored by the supervisor or Group members.
- In a related issue, a user can miss important Group communications while on a Private Call.
- If many users make Private Calls, the system will get very busy. This is because each Private Call captures at least one repeater timeslot. If the parties are located at different sites, the Private Call uses a repeater timeslot at each site.

On the other hand, if Private Calls are conducted in an educated manner, they can actually save system resources. For example, “Molly” and “Maria” are both members of the “Transportation” Talk Group, which currently has Talk Group members registered to five different sites. Molly needs to discuss some company business with Maria that is otherwise unrelated to the Transportation Talk Group. If Molly were to conduct this conversation on the Transportation Talk Group, the call would use five different repeater timeslots – one at each registered site. However, if Molly makes a Private Call to Maria, she can avoid tying up the Talk Group, and the call will only use a maximum of two repeater timeslots. If Molly and Maria are registered to the same site, the Private Call will only use one repeater timeslot.

In order for a Connect Plus Private Call to take place; all of the following must occur:

- The Source ID must be enabled for the “Private Call Initiation” privilege on its SU Record in the controller database,
- The Destination ID must be enabled for the “Private Call Receive” privilege on its SU Record in the controller database,

- The Destination SU must be registered to a network site and not currently busy in a call

- The Destination SU must acknowledge a Control Channel query before the controller will assign a trunk-to timeslot for the call. This acknowledgement is provided automatically by the destination radio. The radio user is not aware of the incoming Private Call until the trunk-to timeslot is assigned.

Private Calls are message trunking. At release of PTT the assigned trunk-to timeslot enters the Private Call Hang Time. During the Private Call Hang Time, either party may transmit on the same trunk-to timeslot. If the Hang Time expires with no further transmissions the call ends.

4.9.16 Initiating a Private Call in Connect Plus

Just like other MOTOTRBO digital modes, Connect Plus provides several different ways to initiate a Private Call. The number of ways available to any particular individual depends on his/her radio model:

- Select a Private ID from the Contact List and press PTT. This is the most common way to initiate a Private Call, but it is only available to display radios.

- Place the radio in “Manual Dial” mode, and then enter the destination Private Call ID via the keypad and press PTT to start the call. This method is only available to display radios with a keypad.

- After receiving a Call Alert, press PTT while the “ignore?” prompt still shows on the radio display. This will initiate a Private Call to the radio that sent the Call Alert.

- Initiate a Private Call via a pre-programmed One Touch Call button. This can be used to initiate a Private Call to a specific, pre-configured destination ID. This approach is available to all radios.

- Initiate a Private Call by assigning a programmable Channel Selector Knob position (portable radio) or Channel Rocker position (mobile radio) to a Private Call ID. Then select the assigned position and press PTT to start the Private Call. This approach is available for all radios, but it is more common for non-display or numeric display radios, which don’t have the option of initiating Private Calls via the Menu. The specific steps for this approach are as follows:

    - In each Connect Plus zone, use Connect Plus CPS to create a “Private Call” Contact record for each Private Call destination ID that will be assigned a Channel Selector Knob position (portable radio) or Channel Rocker position (mobile radio).

    - After a Private Call contact record has been created, it should be assigned to a Channel Selector Knob position (portable radio) or Channel Rocker position (mobile radio) using the Connect Plus CPS Zone Channel Selections Screen. The procedure for assigning a programmable Knob or Rocker position is the same as described previously for a Group Call, except that the destination Private Call ID is assigned as the Contact Name. Also, when a Private Call is assigned as the Contact Name, any type of Group Record can be assigned as the Registration Group Name. The default Registration Group Name in this case is the Site All Call

Voice ID, but it is highly recommended to change this to a different Group. In doing so, it is advisable to use a Group that is not the Site All Call Voice ID or the Multigroup ID. The radio will still receive calls on these two ID's, even they aren't programmed as the Registration Group. So, it's to the user's advantage to program a different Registration Group. If the user were to accidentally leave the Knob or Channel Rocker in this position after the Private Call ends, the user would hear communications on the programmed "Registration Group" (in addition the Multigroup ID and the Site All Call Voice ID).

4.9.17 Configuring Priority Levels in Connect Plus

Every Call Request received by the XRC 9000 controller has a Source ID and a Destination ID. The Source ID tells the controller which SU is initiating the call. The Destination ID tells the controller whether the call is targeted to another SU or to a Group ID. Both the Source ID and the Destination ID have a corresponding record in the controller's user database, and each of these records has a programmable Priority Level (2-8). Two is highest configurable Priority Level, and 8 is the lowest configurable Priority Level. These Priority Levels come into play when there is no trunk-to timeslot available, and the Controller must place the call into the Busy Queue.

When a timeslot becomes available, the Controller assigns the highest priority call from the Busy Queue. Emergency Calls have the highest priority, followed by Emergency Location Update. If there are no Emergency Calls to assign, the controller assigns non-emergency calls based on the configurable priorities of the IDs involved in the call. In doing so, it considers the Priority Level of both the Source ID and Destination ID. As a general rule, the call is assigned from the Busy Queue according to the higher of the two priorities. Site All Call requests are prioritized according to the priority of the Source ID only. When priority levels are equal, the Controller considers other factors when deciding which call to assign from the Busy Queue:

- For calls of equal priority, voice calls have priority over data calls.
- For voice calls of equal priority, calls are assigned "first in, first out".
- For data calls of equal priority, calls are assigned "first in, first out".

An important part of Fleet Map Design is determining which Priority Level will be assigned to each radio user and to each Talk Group. The Priority Level will then be configured into the corresponding record in the controller's user database. One simple approach is to leave every Talk Group record at the default Priority Level of 8 (the lowest Priority). In this approach, all Talk Groups are equal priority. Therefore, Group calls will be assigned from the Busy Queue based on the Priority Level of the Source radio only. Where priorities are equal, the calls will be assigned "first in, first out".

4.9.18 Text Messaging Considerations for Fleet Mapping Design

Connect Plus supports Simple Text Messaging as alternative to voice communications, and text messaging capability should be considered during Fleet Map design.

The system designer should be familiar with Connect Plus Text Messaging features as discussed in the System Feature Overview Section. In addition, some other Text Message considerations are as follows:

- While all Connect Plus radio models have voice capability, some Connect Plus radio models have very limited text message capability. Non-display and numeric display radios cannot receive a text message, and they can only send pre-programmed (quick text) messages that are mapped to specific Destination ID via the “One Touch Call” feature.

- The amount of information that can be carried in a single text message is limited to 138 characters.

- For text messages to an individual ID, the initiating radio sends the message to the controller, which places the message in the mailbox for the destination SU. The controller will deliver the message to the destination SU at the earliest opportunity, but this is subject to (a) SU availability and (b) timeslot availability. If the SU is not currently registered into the network, the controller will hold the message until the SU registers, or until the message times out. If the text message cannot be delivered prior to the message timeout period (fixed to 168 hours in the initial release), the message will be deleted.

- Each SU has a mailbox in the XRC 9000 controller, and each SU mailbox can hold 10 undelivered messages. If the controller cannot deliver messages due lack of SU availability (because the SU is not registered into the network, for example), and if the mailbox fills up, the controller will not accept any more messages for the SU. If a radio user tries to initiate a text message to an SU when its controller mailbox is full, the call request is denied due to “Destination Mailbox Full”. Because the controller did not accept the message for delivery, the radio user will have to try again at a later time. The mailbox remains full until messages are removed because they are delivered to the Destination SU, or because the text message times out.

- To send a Text Message to an individual ID, the radio user can select the destination Private Call ID from the Contact List, or manually dial the Private Call ID (keypad is required for Manual Dial).

- In order to send a Text Message to a Group ID, the radio must have a Group Call contact record for the destination Group. Direct Dial for Group IDs is not supported.

- There is no mailbox for text messages addressed to a Group. When the controller receives a text message addressed to a Group ID, the controller will transmit the message at each site where the Group is currently registered. Because there is no OTA acknowledgement for Group Text Messages, this is a “best effort” attempt on the part of the controller. The controller will not know for certain which SU’s did or did not receive the Group Text Message.

- When a radio receives a text message that was addressed to the Group ID, the radio user will not be aware that it was addressed to a Group and not to the radio’s individual ID. This is also true for other MOTOTRBO digital modes. If the user selects “Reply”, the reply text message will be addressed to the individual ID that was the source of the Group Text Message, it will not be addressed to the Group ID.

- If a single Group ID includes both display radios and non-display radios (or numeric display radios), voice communications is preferable to text. This is because the non-display and numeric display radios will not be able to display the text messages. If a text message is sent to a Group ID that contains non-display or numeric display radios, all Group radios will move to the trunk-to timeslot, but only the display capable radios will notify the radio user that a Text Message has been received.

- In order to send a Text Message to a Multigroup ID, the source radio must have the “Multigroup Init” privilege enabled on its user record in the controller’s user database.

- In order to send a Text Message to the Site All Call Text ID, the source radio must have the “Site All Call Text Init” privilege enabled on its user record in the controller’s user database.

Text Message Subject Line Retention in Connect Plus

A third party Text Message Application has the ability to send a Text Message containing a Subject Line to a Connect Plus SU. When the radio user reads the incoming text message, the Subject Line text appears at the beginning of the message and will likely “run-on” with the text following the subject line (in other words, the Subject Line and the following text will not be separated by a space).

If the radio user replies to the Text Message, the Subject Line is automatically included in the reply, but the radio user will not see the Subject Line text on his/her screen when composing the reply text message. The maximum length of the radio user’s reply will be 138 characters, minus the number of characters contained in the Subject Line.

4.9.19 Emergency Calls in Connect Plus

Section 2 provides an introduction to Connect Plus emergency operation in the section entitled “Connect Plus Digital Emergency”. Topics covered in that section include:

- Emergency features shared with other MOTOTRBO digital modes
- Emergency enhancements provided by Connect Plus
- Differences between Digital Emergency in Connect Plus and non-Connect Plus Modes.

This section, “Emergency Calls and Connect Plus”, expands on the information provided in Section 2 by elaborating on following topics:

- Making an Emergency Call in Connect Plus
- Emergency Calls on the SU’s Multigroup ID
- Programmable Emergency Settings in MOTOTRBO Option Board Connect Plus CPS
- Programmable Emergency Settings in MOTOTRBO Connect Plus Network Manager
- Programming the repeater’s Emergency Call Hang Time
- Emergency Handling Considerations
- Conducting Emergency Drills

4.9.19.1 Making an Emergency Call in Connect Plus

In Connect Plus, a radio user initiates an Emergency Call by pressing the “Emergency On” button configured for the unit with MOTOTRBO Connect Plus Option Board CPS.

If the button is pressed while the radio is idle and monitoring the Control Channel timeslot, the SU will immediately transmit its Emergency Call Request on the Control Channel uplink. If the SU is involved in a call in progress when the radio user presses Emergency On, the SU leaves the trunk-to timeslot and returns to the Control Channel timeslot to transmit its Emergency Call Request. If the SU is not currently registered to a site when the user presses Emergency On, the SU searches for a site. Upon detecting a qualified site, the SU transmits a Registration Request. Upon receiving its Registration Response from the XRC 9000, the SU immediately and automatically transmits its Emergency Call Request on the Control Channel uplink. Whenever the SU transmits an Emergency Call Request, the Group ID it uses is determined by its "Revert Group" setting for its current Connect Plus zone. This is described in greater detail in a later section.

The SU will persistently send its Emergency Call Request until it receives acknowledgement from the XRC 9000 controller. If multiple SUs are transmitting an Emergency Call Request, each SU expects an individual acknowledgement from the XRC 9000, and the SU will continue to transmit the Emergency Call Request until it receives one. The controller's acknowledgement message will either contain the assigned repeater and slot, or it will inform the SU that the call has been assigned to the Busy Queue. The controller's acknowledgement also tells the SU whether it needs to send an Emergency Location Update at the end of the Emergency Call. The request for the Emergency Location Update is initiated by a 3rd Party LRRP application, and the application must send the request to the controller prior to the SU's emergency.

If the call is assigned to the Busy Queue, it will be assigned the next available trunk-to timeslot. The only exception to this rule is when there are multiple Emergency Calls (for different Group IDs) in the Busy Queue. In that event, the Emergency Calls are assigned from the Busy Queue on a first-in, first-out basis. However, all Emergency Calls will be assigned prior to any non-emergency call.

The emergency ergo for an Emergency Call initiator is determined by the MOTOTRBO Connect Plus Option Board CPS "Emergency Initiation" settings. The emergency ergo for an Emergency Call receiver is determined by the MOTOTRBO CPS Connect Plus Option Board CPS "Emergency Receive" settings. These settings are explained in greater detail in a later section.

In most cases, there is just one initiator associated with an Emergency Call. However, it is possible that multiple radio users with the same Revert Group may press Emergency On during the same call (and using the same Group ID). In this case, each initiating SU will receive an individual acknowledgement from the XRC 9000, but each controller response will assign the call to the same repeater and slot. (Other sites may also be carrying the same Emergency Call, but each site assigns its repeater and slot independently of other sites in the call). Any user participating in the Emergency Call on the Revert Group can transmit on the channel either by manual key-up or Hot Mic.

The emergency initiator is usually the first radio to transmit during the Emergency Call. If enabled for "Emergency Call with Voice to Follow", the radio automatically transmits with microphone open for the duration of a programmable timer. After the initial transmission, the repeater uses the Emergency Call Hang Time. It is very important to program the same Emergency Call Hang Time in all Connect Plus repeaters and sites network-wide. During the Emergency Call Hang Time, any radio that has joined the call may transmit. During a typical emergency call there will be transmissions by one or more radio users that pressed the Emergency On button and transmissions by other radio users that did not press the Emergency On button. Receiving radios know whether or not the current voice transmission is coming from an emergency initiator. Radios that have been enabled for Emergency Call receive ergonomics will show the individual ID(s) of the emergency initiator(s) on their display, but they will not show the individual ID(s) of transmitting radios that are not "emergency initiators" (in other words, the radio user has not pressed Emergency On).

If the Emergency Call Hang Time expires with no more key-ups, the Emergency Call ends and all radios return to the Control Channel timeslot. Unlike other MOTOTRBO digital modes, this causes the initiating radio(s) to automatically exit emergency mode. If any emergency initiator feels that the call did not adequately address his/her emergency, then he/she should press Emergency On again to re-initiate the process.

4.9.19.2 Emergency Calls on the SU's Multigroup ID

Depending on how the radio is configured with MOTOTRBO Connect Plus Option Board CPS, it is possible that the SU may send the Emergency Call Request using its Multigroup ID. If so, it is important to understand two important differences between Emergency Calls on the Multigroup ID and non-emergency calls on the Multigroup:

- Each user record in the XRC 9000 provides a programmable call-initiation privilege for the Multigroup ID that can be enabled using the MOTOTRBO Connect Plus Network Manager. This programmable privilege applies to non-emergency calls only. It does not apply to Emergency Calls. When the SU sends an Emergency Call Request using its Multigroup ID, the XRC 9000 only checks whether the unit has the programmable Emergency Initiation privilege (discussed in a later section). If so, the Emergency Call is allowed, regardless of whether or not the unit has non-emergency Multigroup initiation privileges.

- During non-emergency Multigroup calls, only the initiating SU allows PTT during Group Call Hang Time. During emergency calls using the Multigroup ID, any Connect Plus SU programmed with a matching Multigroup ID is allowed to talk-back during the Emergency Call Hang Time.

4.9.19.3 Programmable Emergency Settings in Option Board CPS

MOTOTRBO Connect Plus Option Board CPS provides multiple programmable settings that affect Emergency operation in the Connect Plus SU. Some of these settings affect all Connect Plus zones. The remaining settings can be configured per Connect Plus zone.

Emergency Settings that affect all Connect Plus zones:

Connect Plus provides the same programmable options for the Emergency Button as other digital modes. On the portable radio, only the orange button can be configured for emergency. On the mobile radio, any of the configurable buttons can be set for emergency. "Emergency On" can be configured as either a short press or a long press. "Emergency Off" will automatically be the other selection for the same button. For example, if "Emergency On" is configured as a short press of the orange button, "Emergency Off" will automatically be configured as a long-press of the same button.

Connect Plus provides a configurable timer called "Emergency Short Press Duration". When "Emergency On" has been configured as a short press, this timer determines how long the button must be held before the Connect Plus SU transmits an Emergency Call Request. The purpose of this timer is to prevent short, accidental presses from starting an Emergency Call.

MOTOTRBO Connect Plus Option Board CPS provides a programmable option on the General Settings screen to define a "Default Emergency Revert Group". If used, any Group contact in any Connect Plus zone (except Site All Call) can be set as the "Default Emergency Revert Group". If

the SU is configured with a Default Emergency Revert Group, the same Group ID must be configured as the Default Emergency Revert Group on the SU's user record in the XRC 9000 (using MOTOTRBO Connect Plus Network Manager). If there is a mismatch between Default Emergency Revert Group programming in the Connect Plus SU and the XRC 9000 controller, the Emergency Call may not work as expected. This is one reason why it is critical to run an Emergency drill prior to using the feature in an actual emergency. The Emergency drill will help catch any configuration issues prior to a real emergency.

Emergency Settings per Connect Plus zone:

The configurable settings per Connect Plus zone fall into two categories; settings that affect Emergency Call initiation and settings that affect how the SU receives an Emergency Call.

Emergency Initiation Settings:

- **Emergency Type**: MOTOTRBO Connect Plus Option Board CPS provides four configurable options for Emergency Type; Disabled, Regular Emergency, Silent Emergency, and Silent Emergency with voice. These settings work very much the same as in other digital modes. The Silent Emergency options provide a means to suppress all indications of the emergency status on the initiating radio. This feature is valuable in situations where an indication of an emergency state is not desirable. Once the radio user breaks radio silence by pressing the PTT and speaking, the Silent Emergency ends, and audible and visual indications return. There are two programmable variations of Silent Emergency; "Silent" and "Silent with voice". In "Silent" (Emergency) the speaker is muted prior to pressing and releasing PTT. In "Silent with voice" the radio unmutes to qualified channel activity prior to the user pressing PTT, but the radio ergo doesn't indicate the incoming voice is associated with an Emergency Call.

- **Emergency Mode**: MOTOTRBO Connect Plus CPS provides two programmable options for Emergency Mode; Emergency Call and Emergency Call with voice to follow. As discussed previously, Connect Plus does not provide a "stand-alone" Emergency Alarm (with no Emergency Call). Even though the Connect Plus Emergency Mode options do not state the words "Emergency Alarm" as in other digital modes, Connect Plus provides essentially the same receive ergo that is associated with Emergency Alarm in other modes. In Connect Plus, this receive ergo is activated by enabling the Emergency receive setting for "Emergency Alert Tone".

  Whether the radio is configured for "Emergency Call" or "Emergency Call with voice to follow" determines how the SU makes its first transmission after synching with the trunk-to timeslot. If "Emergency Call with voice to follow" is enabled, the SU automatically transmits with microphone open for the duration of the "Hot Mic Duration" timer. When "Emergency Call" is enabled, the SU will only make a brief, automatic transmission upon synching with the voice channel. The purpose of the transmission is to start the Emergency Call on the trunk-to timeslot.

- **Revert Group**: Each Connect Plus zone provides two configurable options for Revert Group; "Selected Registration Group ID" or "Default Emergency Revert Group ID". Because this is one of the most important decisions when configuring Connect Plus emergency operation, there is an in-depth discussion on these options in the later section, "Emergency Handling Considerations".

- **Emergency Attempts**: MOTOTRBO Connect Plus Option Board CPS provides a configurable setting called "Emergency Attempts". If the Connect Plus SU sends all Emergency Attempts and gets no response from the XRC 9000 controller, it will Search for a different site. Upon locating a Connect Plus site (which might be the same site the SU

tried previously – especially in a single-site network or a multisite network without overlapping coverage), the Connect Plus SU starts over on its Emergency Attempts.

- **Hot Mic Duration**: When “Emergency Call with Voice to Follow” is selected as the Emergency Mode, this configurable timer determines how long the SU automatically transmits with microphone open after aligning with the assigned trunk-to timeslot.

Emergency Receive Settings:

For portable and mobile radios equipped with a display, MOTOTRBO Connect Plus Option Board CPS has two programmable options for Emergency Receive settings; “Emergency Alert Tone” and “Emergency Call Indication”.

- **Emergency Alert Tone**: When “Emergency Alert Tone” is enabled, the Connect Plus SU will emit a periodic and distinctive tone at the beginning of the Emergency Call. The tone will persist until the radio user acknowledges by pressing any button. Even after the radio user acknowledges the tone, emergency display ergo will continue (even after the call ends) until the radio user clears the ergo by pressing a special button sequence (short press of “Back” followed by “Emergency Off”.)

- **Emergency Call Indication**: When “Emergency Call indication” is enabled, the SU toggles the radio display to provide information about the Emergency Group ID and the SUID that started the Emergency Call (or the last SU to transmit emergency voice during the call). This display ergo automatically stops when the Emergency Call ends (unless “Emergency Alert Tone” has also been enabled). When neither option is enabled (as will always be the case for the non-display portable or numeric display mobile), the receiving SU provides the same ergo as it provides for a non-emergency Group Call.

4.9.19.4 Programmable Emergency Settings in XRC 9000 Controller

The XRC 9000 controller has three programmable settings that affect Emergency Calls. These settings are configured with the MOTOTRBO Connect Plus Network Manger.

Emergency Call Inactivity Timer: This setting, which is located on the Network Manager Site Configuration screen in Connect Plus Releases prior to Release 1.1, defines how long the controller waits during an Emergency Call to release a trunk to timeslot for other call assignments if it detects no IP activity on the timeslot and receives no repeater message indicating end of call. This must be set at least 1 second longer than the Emergency Call Hang Time set in network repeaters with MOTOTRBO CPS. The Emergency Call Inactivity Time should be set the same for all controllers in the network. Beginning with Connect Plus Release 1.1, it is no longer necessary to configure the Emergency Call Inactivity Time with the Network Manager. This setting is replaced by the Network Manager parameter for Emergency Call Hang Time.

Emergency Call Hang Time: Beginning with Connect Plus Release 1.1, the Network Manager provides a programmable setting for Emergency Call Hang Time. Prior to Release 1.1, the Emergency Call Hang Time was configured in the repeater with MOTOTRBO CPS. Beginning with Connect Plus Release 1.1, the Emergency Call Hang Time value that is programmed with MOTOTRBO CPS will be overwritten by the XRC 9000 when it establishes its link with the repeater. In doing so, the XRC 9000 uses the Emergency Call Hang Time value that has been programmed with the MOTOTRBO Connect Plus Network Manager. The programmable range provided by the Network Manager is considerably higher than the programmable range provided by MOTOTRBO CPS. The repeater will use the Network Manager-configured value as long as it

maintains its connection to the XRC 9000. See section "Programming the Repeater's Emergency Call Hang Time" for important information on configuring this timer.

Each user record in the XRC 9000 has two very important settings on the "User Details" screen.

Emergency Init (checkbox): Enable this checkbox to allow this SU to send an Emergency Call Request. Disable (uncheck) the box if the SU should not be allowed to request an Emergency Call. In this event, the Emergency Call Request will be denied. The controller provides the ability to deny emergency privileges to some SUs to prevent non-critical, low priority users from using Emergency to circumvent their low priority status.

Default Emergency Revert Group ID: This setting is used to tell the XRC 9000 whether the SU has a Default Emergency Revert Group, and – if so – which Group is used.

Enable the "None" option if the SU will not be sending Emergency Call Requests, or if the SU will only be sending Emergency Call Requests using its selected Registration Talk Group ID.

Enable the "Use Multigroup ID" option if this SU will be using its Multigroup ID as its Default Emergency Revert Group ID.

If the SU will be using some other Group as its Default Emergency Revert Group, enable the "Use" option and enter the Group number to be used in the programmable field. There must be a matching Group record for this ID in the XRC 9000.

Important: If a Default Emergency Revert Group is used, then the same Default Emergency Revert Group ID must be configured in both the SU (using MOTOTRBO Connect Plus Option Board CPS) and in the XRC 9000 user record (using MOTOTRBO Connect Plus Network Manager). It is critical for this information to match in both places. A mismatch of Default Emergency Revert Group information is a critical programming error that will cause undesired operation.

4.9.19.5 Programming the Repeater's Emergency Call Hang Time

Emergency Hang Time: The Emergency Call Hang Time must be configured with the same value for all Connect Plus repeaters and sites in the same network. The method for setting the Emergency Call Hang Times depends on the XRC 9000's software version. For Connect Plus releases prior to Release 1.1, the Emergency Call Hang Time is programmed into the repeater using the MOTOTRBO CPS General Settings. Beginning with Connect Plus Release 1.1, the Emergency Call Hang Time value configured with MOTOTRBO CPS will be overwritten with the Emergency Call Hang Time configured with the MOTOTRBO Connect Plus Network Manager.

When the Emergency Call Hang Time setting was moved to the MOTOTRBO Connect Plus Network Manager in Release 1.1, the upper end of the programmable range was significantly increased (from a maximum of 7 seconds in MOTORBO CPS to a maximum of 600 seconds in the MOTOTRBO Connect Plus Network Manager). Systems that migrate from the CPS-configured Emergency Call Hang Time to Network Manager-configured Emergency Call Hang Time must observe the following rule: Do not set the Emergency Call Hang time to a value higher than what can be supported via MOTOTRBO CPS configuration (7 seconds) until all sites have been upgraded to Release 1.1.

Many systems set the Emergency Call Hang Time to a higher value than the Group Call Hang Time and the Private Call Hang Time. This provides increased time for talk-back during the Emergency Call and helps prevent the assigned Emergency timeslot from being released too soon. Beginning with Release 1.1, the Network Manger allows the Emergency Call Hang Time to be

configured up to a maximum of 600 seconds. For whatever value is configured for the Emergency Call Hang Time, the repeater will stay on the air (with the Hang Time) for the full configured duration after the last key-up in the call. Prior to setting the Emergency Call Hang Time to a long value, the Radio System Administrator should carefully consider how a long Hang Time can affect operation:

1. Radios that were currently in the Emergency Call will not be able to easily leave the call (if at all) until the Emergency Call Hang Time expires. This is especially true for the Emergency initiator, but it is also true for radios that were merely receiving the Emergency. Even if the user changes the Selected Talk Group, the radio will be immediately drawn back into the call (after re-registering with the site) if the call is occurring on the user's Emergency Revert Group ID, Multigroup ID, or a Group ID that is an active member of a currently enabled scan list.

2. Until the Emergency Call Hang Time expires, late joiners will continue to join the call, even if no one is currently speaking.

3. If any radio user presses PTT before the Emergency Call Hang Time expires, it will reset the Emergency Call Hang Time to its full value at the end of the transmission, thereby prolonging the operation described in #1 and #2.

4.9.19.6 Emergency Handling Considerations

Configuring a communication system (like MOTOTRBO Connect Plus) to handle emergency situations requires some up front design. In emergency situations, it is ideal that when a user initiates an emergency, he is immediately routed to someone who can handle his emergency situation. In order for this occur, several things must be in place:

- The Connect Plus SU and the XRC 9000 should already be configured with the Emergency Settings desired by the customer. The configuration is impacted by questions such as the following:
    - Who is allowed to initiate an Emergency Call?
    - What should the ergo look like for the initiating radio?
    - Who is allowed to receive an Emergency Call?
    - What should the ergo look like for the receiving radio?
    - What ID should be used for the Emergency Call?
    - How long should the Emergency Hang Time be between key-ups?
- The radio user should be trained in (a) what circumstances constitute an emergency, (b) how to initiate the Emergency Call on the SU (c) what to do when initiating and/or receiving an Emergency Call and (d) the organization's emergency protocol & procedures, which should address the following:
    - Who is responsible for responding to the emergency?
    - Who is responsible for handling the emergency communications?

- Who is allowed (or not allowed) to talk during the Emergency Call?
- Who decides when the emergency is over?

The considerations listed above apply both to Connect Plus and to non-Connect Plus digital modes. However, there are some considerations that apply to other digital modes that do not apply to Connect Plus. These include the following:

- In Connect Plus, there is no option for a stand-alone Emergency Alarm. Therefore, it is not necessary to decide between configuring the call initiator for Emergency Alarm only, or Emergency Alarm followed by Emergency Call. In Connect Plus, the XRC 9000 always responds to an Emergency Call Request by assigning the Emergency Call.

- In Connect Plus, it is not necessary to decide in advance which site, repeater and timeslot to use for Emergency. The Emergency Call Request is sent to the registered site, and the call is assigned to a repeater and slot by the XRC 9000 controller.

- In other MOTOTRBO digital modes, it is very important to understand the interactions between the Selected Channel, the Emergency Revert Channel, and the Data Revert Channel. In Connect Plus, the Control Channel timeslot is the most important path between the system and the SU. The controller decides which repeater and slot to use for Emergency Call and/or Emergency Location Update, and informs SUs via messaging on the Control Channel timeslot.

- In Connect Plus, it is not necessary to decide which supervisor radios should send over-the-air acknowledgement to the Emergency. In Connect Plus, the XRC 9000 controller individually acknowledges each Emergency Call Request. Over-the-air acknowledgement by a subscriber unit is neither necessary nor supported in Connect Plus. Because of this difference, the roles of “Monitoring Supervisor” and “Acknowledging Supervisor”, which are usually identified as two separate roles in other MOTOTRBO Digital Modes (see MOTOTRBO System Planner for more information on user roles), can be fulfilled by a single individual in Connect Plus.

- In Connect Plus, it is not necessary to assign a different individual to monitor for (and respond to) emergency at each network site. This is because the Connect Plus infrastructure will automatically route the Emergency Call to each and every site where the Group ID used for the emergency is currently registered.

Identify Emergency Initiators

One of the first steps is to identify the radio users that may find it necessary to request an Emergency Call. The following questions are pertinent to Emergency Initiators:

- Who is allowed to initiate an Emergency Call? Emergency initiators require the “Emergency Init” privilege on the SU’s user record in the XRC 9000 controller (using MOTOTRBO Connect Plus Network Manager).

- What should the ergo look like for the initiating radio? MOTOTRBO Connect Plus Option Board CPS provides configurable options to determine whether the radio sends a “Regular” or “Silent” emergency. It also provides an option to determine whether or not the radio should do an automatic “hot mic” key-up at the beginning of the emergency call, and – if so – for how long.

Identify Emergency Receivers and/or Responders

Another important step is to identify which radios should be able to receive an Emergency Call, and which individuals are responsible for responding to the emergency.

An “Emergency Receiver” is a person that is allowed to receive an emergency call, but doesn’t necessarily have the responsibility for responding to the crisis. The primary role of the “Emergency Receiver” is to help make sure that the “Emergency Responder” is aware of the emergency, and to render assistance when and if requested.

The “Emergency Responder” is an Emergency Receiver with responsibilities above and beyond those of other receivers. The “Emergency Responder” takes an active role in coordinating the emergency response and resolving the crisis.

The following questions are pertinent to Emergency Receivers and Responders

- Who is allowed to receive an Emergency Call? These radio users should be equipped with display capable radios (since the non-display portable and numeric display mobile provide no special ergo while receiving an Emergency Call). Additionally, these display radios should be configured with the Group ID(s) that will be used during the Emergency Call(s).

- What should the ergo look like for the receiving radio? There are a couple of programmable options for Emergency Receive ergo; “Emergency Alert Tone” and “Emergency Call Indication”

    - Emergency Alert Tone is considered to be a more aggressive form of emergency receive ergo that is especially appropriate for Emergency Responders. The recurring tone and toggling display will each persist until manually cleared by the radio user. Clearing the tone and clearing the toggling display are separate operations.

    - Emergency Call Indication is considered to be a less aggressive form of emergency receive ergo. It involves the display only (no tone) and does not have to be manually cleared. The toggling display automatically returns to normal when the Emergency Call ends. This option is appropriate for Emergency Receivers.

It should be noted that both Emergency Alert Tone and Emergency Call Indication can be enabled in the same radio. Another option is to enable neither receive option. In this case, the radio receives the Emergency Call just like other Group Calls.

Radio Users with Multiple Roles

It should be noted that a single individual may be both an Emergency Initiator and an Emergency Receiver, and it is also possible for a single person to be in all three categories (Emergency Initiator, Emergency Receiver, and Emergency Responder.) When a single individual has multiple roles, this should be considered with programming the SU with MOTOTRBO Connect Plus Option Board CPS.

Selecting which Group ID is used for the Emergency Call

One of the most important decisions when configuring the Emergency Options for a Connect Plus radio is which Group ID to use for the Emergency Call. This is determined by the “Revert Group” setting. MOTOTRBO Connect Plus Option Board CPS provides two programmable options per Connect Plus zone; “Selected Registration Talk Group ID” or “Default Emergency Revert Group”.

If “Selected Registration Talk Group ID” is chosen as the Revert Group, the Emergency Group ID is determined by the currently selected position on the Channel Selector Knob (portable) or Channel Rocker Knob (mobile). When the radio user presses “Emergency On”, the SU will send the Emergency using the Registration Talk Group ID as configured for that position with MOTOTRBO Option Board Connect Plus CPS. In most cases, this will be the same as the selected Group Contact name. However, when the selected Contact Name is a Private Call ID or Site All Call ID, the Group ID used for the emergency is configurable by selecting any Group from the Zone Contact list (except Site All Call) as the Registration Group ID.

If “Default Emergency Revert Group” is selected as the Revert Group, the Emergency Call Request is sent using the “Default Emergency Revert Group” programmed onto the General Settings screen. There is just one “Default Emergency Revert Group” per SU, and the Group number programmed into this field must match the Default Emergency Revert Group programmed in the XRC 9000 user record for this SU (using MOTOTRBO Connect Plus Network Manager).

There are several factors to consider when deciding which programmable option to use for the Revert Group.

Default Emergency Revert Group offers several attractive advantages. It allows the Emergency to always be sent on one specific Group ID, regardless of which position is currently selected on the Channel Rocker Knob (portable) or Channel Rocker (mobile). This strategy is sometimes referred to as a “centralized” approach for Emergency handling.

Because the Default Emergency Revert Group is programmed into the controller, the XRC 9000 automatically registers the SU to this group, no matter where it roams in the Connect Plus network. In effect, this can increase the number of Groups that a single SU carries network-wide from two to three (by adding the Default Emergency Revert Group to the SU’s currently Selected Registration Group ID and the SU’s Multigroup ID.) The SU automatically scans for Emergency Calls on its Default Registration Group ID anytime that it is idle no matter where it is located in the network. On the plus side, this makes it likely that the SU will hear the Emergency Call, no matter which site the call is started at. A possible disadvantage is that it will be quite difficult for a receiving SU to “escape” from an Emergency Call in-progress in order to conduct voice communications on a different call (a different Group ID or a Private Call). Even if the radio user changes his/her radio to a different position on the Channel Selector Knob(portable) or Channel Rocker (mobile), the radio will likely scan right back into the Emergency Call before the radio user can initiate the new call.

As a general rule, the “Selected Registration Talk Group ID” option would make it easier for a receiving SU to “escape” from an Emergency Call (by selecting a different Registration Talk Group). This would allow the SU to more easily conduct voice communications on a Private Call or a different Talk Group during an emergency call in-progress. The exception to this statement is if the SU’s Multigroup ID happened to be the currently selected Registration Talk Group ID. If the Emergency Call is sent on the Multigroup ID, the receiving SU will likely keep scanning back into the Emergency Call – even if the user selects a different Registration Talk Group ID. Another advantage of the “Selected Registration Talk Group” option is that it causes the radio to request the Emergency Call on the SU’s normal communications group. This is sometimes referred to as a “tactical” approach for emergency handling, and may be advantageous for some smaller organizations. A potential drawback to this option is the fact that the SU’s Emergency Group can change, depending on the currently selected Channel Selector Knob or Channel Rocker position. Because of this, a significant listener (such as a supervisor radio) can miss the Emergency Call if selected to a different position.

Although MOTOTRBO Connect Plus Option Board CPS makes it possible to choose “Registration Talk Group ID” as the Revert Group in one Connect Plus zone and “Default Emergency Revert Group” as the Revert Group in a different Connect Plus zone, this strategy is generally not recommended. Other radio users and the XRC 9000 controller do not know which Connect Plus zone is currently selected in a specific SU. Because of this (and also for the sake of consistency),

it usually makes more sense to choose just one Revert Group strategy, and to utilize that strategy across all Connect Plus zones.

4.9.19.7 Conducting Emergency Drills

Once an emergency plan has been formulated, and it has been configured into the various components of the Connect Plus radio system, the next step is to conduct a well-conceived emergency drill prior to the first occurrence of an actual emergency.

The Emergency Drill provides the following benefits:

- It helps catch configuration issues that can prevent the Emergency Call from operating as intended. It is very important to detect and correct any such issues prior to the first real emergency.
- It helps radio users become familiar with the emergency operation of the Connect Plus SU and the Connect Plus infrastructure. Otherwise, the radio may user may never experience this emergency operation and ergo prior to the first actual emergency.
- It helps radio users practice the organization's protocol and procedures for initiating and responding to an emergency situation.
- It helps identify the "weak links" in the organization's emergency plan. (Those things that require more thought, additional practice, or both).

If is important to note that an Emergency Drill should not just be a one-time event. Emergency drills should be scheduled at regular intervals in order so that everyone will stay current on emergency procedures and to discover configuration issues or other problems with the radio system.

4.9.20 Configuring Selectable Group Scan

Section "Group Scan in Connect Plus System" provides a detailed discussion of how Selectable Group Scan operates in Connect Plus. This section discusses how the SU is configured for Selectable Group Scan with MOTOTRBO Connect Plus Option Board CPS.

The following must be configured:

1. The individual that programs the SU must create the Group Scan list. A different scan list can be created for each Connect Plus zone. The Scan List has two columns, "Available" and "Members", and two buttons, "Add" and "Remove".
    a. To place a Group ID on the Configurable Group Scan list, the Group must be moved from the "Available" column to the "Members"" column on the Zone Scan tab.
    b. MOTOTRBO Connect Plus Option Board CPS automatically places a Group in the "Available" column when it has been assigned a Channel Selector Knob position (portable radio) or Channel Rocker position (mobile radio) for that Connect Plus zone.

c. The Multigroup ID and the Site All Call ID will never appear in the “Available” column. This is unnecessary since the Connect Plus SU automatically responds to calls on these IDs.

d. The “Selected” Registration Group, the “Multigroup” (if configured in the SU) and the “Site All Call” appear in the “Members” column to remind the individual programming the SU that the radio always listens for these IDs. They cannot be removed from the “Members” column.

2. Once the scan list is configured, the radio user must have a way to enable and disable the Selectable Group Scan feature.

   a. The most common method is to configure a “Scan On/Off” button. This programmable button can be assigned to either a “short” or “long” button press. It is available for all radio models.

   b. In order for users of display radios to enable/disable the Selectable Group Scan feature via the menu, the “Scan” checkbox must be enabled in the “*Menu->Scan*” screen.

   c. Regardless of the method used to enable/disable the scan feature (programmable button or menu option), the current state (scan “on” or scan “off”) is applied to all Connect Plus zones with a selectable scan list. The Connect Plus SU will remember the current state (scan “on” or scan “off”) through a power cycle.

3. In order for the radio user to be able to edit the scan list via the menu, the “Edit List” checkbox on the “*Menu->Scan*” screen must be selected as well.

   a. When the “Edit List” option is enabled, the radio user has the ability (via the radio menu) to enable/disable scan functionality for individual scan list members. This is done by using the radio menu to scroll through the list of scan members.

   b. The scrollable scan list will show an entry for each Group alias that was moved from the “Available” column to the “Members” column with MOTOTRBO Connect Plus CPS. The scrollable scan list does not show Groups that are always & automatically scanned (such as the Multigroup ID and the Site All Call ID).

   c. An asterisk (*) denotes a scan list member that is currently active (meaning that the radio will scan for this ID when the scan feature is enabled and the radio is registered to its Preferred Site).

   d. The absence of the asterisk indicates that the radio will NOT scan for this member (unless it happens to be SU’s currently registered Group).

   e. When a scan list member appears on the display, and the radio user presses “OK”, the radio provides a prompt to either “Enable” or “Disable” scan for the selected member (depending on the member’s current state).

   f. The ability to toggle scan on and off for individual scan list members is only available for IDs placed on the scan list with MOTOTRBO Connect Plus CPS.

g. It is not possible to add a new member to the Configurable Group Scan list via the menu, nor is it possible to permanently delete a member from the Configurable Group Scan list via the menu.

4. The “Edit List” feature makes it possible for the radio user to disable scan for a specific list member if communications on that Group become a nuisance to the radio user. In doing so, the radio user should be aware of the following:

   a. This will not cause the radio to exit an ongoing call. However, it will prevent the radio from scanning into subsequent calls on this Group (assuming that it isn’t the SU’s registered Group) until the list member is enabled again.

   b. When a scan list member has been disabled via the menu, this setting is retained through a power cycle. The scan list member is not automatically re-enabled up power-up.

Note: Because the editable scan list is only available to display radios, non-display units scan for all list members whenever Selectable Group Scan is enabled and the radio is registered to its Preferred Site. This is also true for display units that were not configured with the “Edit List” option.

4.9.21 Fleet Mapping Considerations for Other Call Features

The system designer should be familiar with the operation of other Connect Plus call features discussed in the System Feature Overview Section. These features include:

- Remote Monitor
- Radio Check
- Call Alert
- Radio Disable
- Radio Enable

Of the features listed above, only Call Alert can be initiated by a non-display or limited display radio (via a programmed “One Touch Call” button). All other features can only be initiated via the Menu, which requires a display radio.

When initiating one of these features via the menu, there are two ways to select the destination ID:

1. Select a Private Call Contact from the Zone Contact List as the Destination ID
2. Enter the Destination Private Call ID via Manual Dial. This requires a radio keypad

In most networks, the ability to initiate these features will be limited to supervisor radios. Connect Plus CPS programming and XRC 9000 programming (via the MOTOTRBO Connect Plus Network Manager) both play a role when implementing these features:

Initiating a Remote Monitor

SU Programming (Connect Plus CPS)	Controller programming (Network Manager)
Enable the Remote Monitor Menu option	Enable the “Remote Monitor Init” privilege on the SU record corresponding to the initiating radio

Receiving a Remote Monitor

SU Programming (Connect Plus CPS)	Controller programming (Network Manager)
No special programming required	Enable the “Remote Monitor Receive” privilege on the SU record corresponding to the destination radio

Initiating a Radio Check

SU Programming (Connect Plus CPS)	Controller programming (Network Manager)
Enable the Radio Check Menu option	Enable the “Radio Check Init” privilege on the SU record corresponding to the initiating radio

Receiving a Radio Check

SU Programming (Connect Plus CPS)	Controller programming (Network Manager)
No special programming required	No special programming required

Initiating a Call Alert

SU Programming (Connect Plus CPS)	Controller programming (Network Manager)
Enable the Call Alert Menu option	Enable the “Call Alert Init” privilege on the SU record corresponding to the initiating radio

Receiving a Call Alert

SU Programming (Connect Plus CPS)	Controller programming (Network Manager)
No special programming required	No special programming required

Disabling another SU

SU Programming (Connect Plus CPS)	Controller programming (Network Manager)
Enable the Radio Disable Menu option	Enable the “Radio Disable Init” privilege on the SU record corresponding to the initiating radio

Being Disabled by another SU

SU Programming (Connect Plus CPS)	Controller programming (Network Manager)
No special programming required	Enable the “Radio Disable Receive” privilege on the SU record corresponding to the destination radio. This only applies to a Disable Command sent by another SU. The controller can disable any SU.

Enabling another SU

SU Programming (Connect Plus CPS)	Controller programming (Network Manager)
Enable the Radio Enable Menu option	Enable the “Radio Enable Init” privilege on the SU record corresponding to the initiating radio

Being Enabled by another SU

SU Programming (Connect Plus CPS)	**Controller programming (Network Manager)**
No special programming required	Enable the “Radio Enable Receive” privilege on the SU record corresponding to the destination radio. This only applies to an Enable Command sent by another SU. The controller can enable any SU.

4.9.22 Fleet Mapping Considerations for OTA File Transfer

An important Fleet Mapping decision is whether an SU should be enabled to receive Option Board Firmware Files and Network Frequency Files over-the-air (OTA). This is controlled via Connect Plus CPS programming. To enable the option, check the box labeled “Enable OTA File Transfer”. This setting is configurable for each Connect Plus zone.

By default, this codeplug option is NOT enabled. Prior to enabling the option, the System Administrator should be very familiar with how the feature operates. For more information, see the discussion on OTA File Transfer in the System Feature Overview Section.

Note: This Connect Plus CPS setting does not affect OTA Transfer of the Option Board codeplug. The System Administrator grants permission for Option Board codeplug OTA transfer to take place by acknowledging a Network Manager message when uploading a new Option Board codeplug for a specific radio.

4.10 Configurable Timers: Connect Plus CPS

The following table discusses configurable timers for the Connect Plus Option Board. These timers are configured with Connect Plus Customer Programming Software (Connect Plus CPS).

Timer Name	**Description**	**Notes**
Long Press Duration	Sets the duration a button is required to be pressed (and held down), for it to be interpreted as a long press.	Set on the “Buttons Screen” and applies to all Connect Plus zones
Menu Hang Time	Sets the amount of time that the radio remains in the menu mode, after which the radio reverts back to the Home screen. If the duration is set to 0, the radio remains infinitely in this mode.	Set on the “Menu Screen” and applies to all Connect Plus zones
PTT Time Out Time	The Time-Out Timer (TOT) is the duration that the radio can continuously transmit before the transmission is automatically terminated by the radio. PTT must be released (and pressed again) before the radio will make another attempt to transmit.	Configurable per Connect Plus zone
Remote Monitor Duration Time	Sets the duration that this radio will automatically transmit with microphone open	Configurable per Connect Plus zone

	when it is being remote monitored. The radio user will not be aware that he/she is being monitored. To prevent this radio from being remote monitored, uncheck the “Remote Monitor Receive” checkbox on the User Record in the Connect Plus controller.	
Unconfirmed File Xfer Dwell Time	During Unconfirmed File Transfer this value determines how long the radio will remain on the trunk-to timeslot without decoding any valid file packets. If the timer expires and no valid packet is decoded, the radio returns to the Control Channel timeslot. If the OTA File Transfer was for Option Board Firmware or the Network Frequency File, the Option Board starts its “File Transfer Attempt Interval Time” upon returning to the Control Channel timeslot.	Configurable per Connect Plus zone
File Transfer Attempt Interval Time	When the radio has been involved in an Option Board Firmware or Network Frequency File OTA Transfer, and it leaves the trunk-to timeslot with an incomplete file (for any reason), the radio starts the File Transfer Attempt Interval Time. The timer must expire before the radio will automatically attempt to resume the file transfer.	Configurable per Connect Plus zone
CSBK Roam Delay Time	Determines how long the radio will continue to listen to the current Control Channel when it doesn’t decode any valid Control Channel messages. If the timer expires, and the radio hasn’t decoded a valid message, the radio starts to search.	Configurable per Connect Plus zone
Roam Dwell Time	When searching for a site, this is the amount of time the radio remains on each search frequency waiting to detect digital signaling. If digital signaling is detected, the radio waits an additional time to identify the site (via control channel messaging) and measure RSSI. If this time expires and the radio has not detected digital signaling, it then proceeds to search the next frequency on the list.	Configurable per Connect Plus zone
Reacquire Time	When the radio loses acceptable signal from its current site and begins searching, a countdown timer is set to this value. If during the search process the radio again finds the site it just lost and this timer has not expired and the radio has not attempted to register at another site, the radio returns to the registered state without transmitting a registration request to the site. This feature can help reduce registration traffic on the control channel and extend portable battery	Configurable per Connect Plus zone

	life.	
BSI Wait Time	If the radio decodes a control channel message indicating that the control channel repeater is getting ready to start Base Station Identification, the Option Board will wait this amount of time prior to looking for another site (however, the radio will still display “Searching” during BSI transmission). If BSI concludes prior to the expiration of this timer, the Option Board remains with the same site and control channel. Because the repeater reverts to analog mode during BSI, it is important to note that BSI on the control channel repeater will cause significant operational problems to radios using the site and should be avoided if at all possible. During BSI, calls and registration cannot be initiated, and the control channel sends no messages for calls in-progress. If the control channel repeater must do BSI, this value should be set to the length of time required to send the Morse Code identification, plus an extra 5 seconds to allow adequate time for the digital-to-analog and analog-to-digital transitions.	Configurable per Connect Plus zone
RSSI Roam Delay Time	The radio starts this timer when the received signal strength from the control channel drops to RSSI minimum or lower. If the signal strength rises above RSSI Minimum before the timer expires, the radio stops the timer. If the timer expires and the received signal strength is still at this value or lower, the radio starts to search.	Configurable per Connect Plus zone
(Emergency) Hot Mic Duration	If the Mode is selected as Emergency Call with Voice to Follow, after the SU synchs with the assigned repeater and slot, the Hot Mic feature is activated whereby the radio automatically begins transmitting voice for the duration indicated by the Hot Mic Duration. There is no need to press the Push-To-Talk (PTT) button during this time in order to transmit voice. The transmission is sent as Emergency key-up. Once this duration expires, the radio automatically dekeys (unless the radio user has manually pressed PTT prior to expiration of the timer).	
(Tilt Alarm) Alarm Tone Delay Time	Determines how long the radio can remain tilted beyond the configured Activation Angle before the radio begins to play the Alert Tone.	Portable Radio Only. Requires purchase of Man Down feature.
(Tilt Alarm) Alarm Activation Time	Determines how long the Alert Tone will play before the radio automatically initiates an	Portable Radio Only. Requires purchase of

	Emergency Call.	Man Down feature.
(Anti-Movement Alarm) Alarm Tone Delay Time	Determines how long the radio can remain motionless before the radio begins to play the Alert Tone.	Portable Radio Only. Requires purchase of Man Down feature.
(Anti-Movement Alarm) Alarm Activation Time	Determines how long the Alert Tone will play before the radio automatically initiates an Emergency Call.	Portable Radio Only. Requires purchase of Man Down feature.
(Movement Alarm) Alarm Tone Delay Time	Determines how long the radio can remain in motion before the radio begins to play the Alert Tone.	Portable Radio Only. Requires purchase of Man Down feature.
(Movement Alarm) Alarm Activation Time	Determines how long the Alert Tone will play before the radio automatically initiates an Emergency Call.	Portable Radio Only. Requires purchase of Man Down feature.

4.11 Configurable Timers: MOTOTRBO Connect Plus Network Manager

The following table discusses configurable timers for the XRC 9000 Controller. These times are configured with the MOTOTRBO Connect Plus Network Manager Software.

Timer Name	Description	Notes
Multisite Ping Interval	Defines the ping interval the controller uses to verify the communications link with other network sites. Each site pings only the higher-numbered sites at this interval.	Site Configuration Screen
Group Call Inactivity Timer	For Connect Plus Releases prior to Release 1.1, this setting determines how long the controller waits during a Group Call to release a trunk-to timeslot for other call assignments if it detects no IP activity on the timeslot and receives no repeater message indicating end of call. This must be set at least 1 second longer than the Group Call Hang Time in the repeaters, and this must be set the same at all network sites. Beginning with Connect Plus Release 1.1, it is no longer necessary to configure the Group Call Inactivity Time with the Network Manager. This setting is replaced by the Network Manager parameter for Group Call Hang Time.	Site Configuration Screen
Private Call Inactivity Timer	For Connect Plus Releases prior to Release 1.1, this setting determines how long the controller waits during a Private Call to release a trunk-to timeslot for other call assignments if it detects no IP activity on the timeslot and receives no repeater message indicating end of call. This must be set at least 1 second longer than the Private	Site Configuration Screen

	Call Hang Time in the repeaters, and this must be set the same at all network sites. Beginning with Connect Plus Release 1.1, it is no longer necessary to configure the Private Call Inactivity Time with the Network Manager. This setting is replaced by the Network Manager parameter for Private Call Hang Time.	
Emergency Call Inactivity Timer	For Connect Plus Releases prior to Release 1.1, this setting determines how long the controller waits during a Emergency Call to release a trunk-to timeslot for other call assignments if it detects no IP activity on the timeslot and receives no repeater message indicating end of call. This must be set at least 1 second longer than the Emergency Call Hang Time in the repeaters, and this must be set the same at all network sites. Beginning with Connect Plus Release 1.1, it is no longer necessary to configure the Emergency Call Inactivity Time with the Network Manager. This setting is replaced by the Network Manager parameter for Emergency Call Hang Time.	Site Configuration Screen
Group Call Hang Time	For Connect Plus releases prior to Release 1.1, the Group Call Hang Time is programmed into the repeater via MOTOTRBO CPS. Beginning with Connect Plus Release 1.1, the Group Call Hang Time value configured with MOTOTRBO CPS will be overwritten with the Group Call Hang Time configured with the MOTOTRBO Connect Plus Network Manager. See section "Setting Repeater Hang Times in Connect Plus" in Connect Plus, for more information.	Site Configuration Screen
Private Call Hang Time	For Connect Plus releases prior to Release 1.1, the Private Call Hang Time is programmed into the repeater via MOTOTRBO CPS. Beginning with Connect Plus Release 1.1, the Private Call Hang Time value configured with MOTOTRBO CPS will be overwritten with the Private Call Hang Time configured with the MOTOTRBO Connect Plus Network Manager. See section "Setting Repeater Hang Times in Connect Plus" in Connect Plus, for more information.	Site Configuration Screen
Emergency Call Hang Time	For Connect Plus releases prior to Release 1.1, the Emergency Call Hang Time is programmed into the repeater via MOTOTRBO CPS. Beginning with Connect Plus Release 1.1, the Emergency Call Hang Time value configured with MOTOTRBO CPS will be overwritten with the Emergency Call Hang Time configured with the MOTOTRBO Connect Plus Network Manager. See sections "Setting Repeater Hang Times in Connect Plus" and "Programming the	Site Configuration Screen

	Repeater's Emergency Call Hang Time" for more information.	
Arbitration Time	Upon receiving IP voice packets, the controller waits the arbitration time prior to forwarding the voice packets to the repeater for transmission. In the event of near-simultaneous key-ups at different sites during the same call, arbitration increases the chances that the same audio will be heard at all sites involved in the call. This timer is only available when the XRC 9000 controller is enabled for multisite operation.	Site Configuration Screen
CSBK Call Retry Interval	Determines the interval that must expire before the controller initiates a CSBK Call Retry	Site Configuration Screen
SU Inactivity Time	This timer is set per controller, but it is tracked separately for each registered SU. The Timer is reset whenever the controller detects a transmission from the SU. This includes registrations, Call Requests, Voice Transmissions, etc. If the timer expires, and the controller shows that the SU is still registered to the site, the Controller will send the SU a "Controller Initiated Radio Check". If the SU answers the Radio Check, the controller resets the SU Inactivity Time and leaves the unit registered to the site. If the SU does not respond to the Radio Check, the controller will re-send the Radio Check as determined by the "CSBK Call Retry" Parameter. If the SU fails to respond to any of the Radio Checks, the Controller will de-register the SU from the site. This helps conserve resources by detecting which SU's are no longer available or in range to receive calls.	Site Configuration Screen
BSI Interval	This timer controls determines how often the repeater will send its Base Station Identification (BSI), which is also called CWID. The ID itself (what the repeater actually sends in Morse Code) is set in the repeater, not in the Controller. It is important to note that BSI (CWID) on the control channel repeater will cause significant operational problems to radios using the site and should be avoided if at all possible.	This is settable per repeater. If a repeater should not send CWID, it should not be entered on the repeater list. If it is on the list for some reason, the BSI interval should be set to zero.
Time to Beacon	Determines how long the controller will "beacon" a special control channel message to inform SU's of file availability. This time must be equal to or greater than the "Time to Dedicate". Anytime that "Time to Dedicate" has expired, but "Time to Beacon" has not, the file is still available – but by	OTA File Upload Screen

	request only. A setting of 65,535 minutes tells the controller that the Beacon message should never expire.	
Time to Dedicate	Determines how long the repeater and timeslot configured above will be used for the dedicated channel file transfer. During this time, the timeslot cannot be used for other calls. SU's may join or leave the dedicated channel transfer at various times (the radio user can cancel out of the transfer). A setting of 65,535 minutes tells the controller that the dedicated channel transfer should never expire. Important: "Time to Beacon" must be equal to or greater than the "Time to Dedicate".	OTA File Upload Screen

4.12 Backup Power Source

Emergency backup power systems usually consist of two components: an Uninterrupted Power Supply (UPS) and a generator. This section only describes the UPS; the selection of the generator is beyond the scope of this document. A UPS can serve a number of purposes such as filtering out power events, conditioning and providing power if primary power source fails. On the average, the time a UPS is expected to do this is under five minutes which gives enough time to shut down equipment and for the backup power generator to take over the load.

Depending on your configuration and needs, the following areas require different emphasis:
• Surge Suppression
• Power Conditioning
• Battery Backup

It is required that the XRC 9000 and its supporting network equipment (i.e. router, switches, and repeaters) are backed up by UPS. The XRC 9000 is a 50 W unit. It is recommended to check the power requirements of other devices (such as repeaters and network equipment) when calculating the required capacity of a UPS system.

To determine the UPS capacity:

1. List all equipment to be protected by the UPS.
2. Write down the voltage and amperage for each device.
3. Multiply the voltage by the amperage of each device to calculate the Volt/Amps (VA).

NOTE: Some equipment may be marked with a power consumption measured in Watts. To convert Watts to VA, simply divide Watts by 0.65 (for a power factor of 0.65), or multiply by 1.54. The power factor refers to the relationship between the apparent power (volt-amps) required by the device and the actual power (watts) produced by the device.

4. Total the VA for all devices you want to protect with the UPS and enter it in the Subtotal field.
5. Multiply the subtotal found in Step 4 by 0.25 and enter it as the Growth Factor field. This number takes into account room for future growth. This growth factor allows for a 5% rate of growth for each year over a five-year period.

6. Add the Growth Factor value to the Subtotal value to get the Required VA. Now you can select the appropriate UPS model by choosing a model that has a VA rating at least as large as the Required VA that you calculated.

Standard UPS units for the XRC 9000 Controller and networking equipment are included in the Price Books.

4.13 Grounding and Surge Suppression

Proper site grounding and surge suppression are important considerations for safe and reliable operation of the Connect Plus trunking system. Refer to the Motorola Quality Standards Fixed Network Equipment Installation Manual R56 [5] for more details.

Appendix A Acronyms

ACK	Acknowledgment
ADK	Application Development Kit
ADSL	Asymmetric Digital Subscriber Line
ARS	Automatic Registration Service
BSI	Base Station Identification
CAI	Common Air Interface
CPS	Customer Programming Software
CSA	Canadian Standards Association
CSBK	Control Signaling Block
CWID	Continuous Wave Identification (same as BSI)
DMR	Digital Mobile Radio (ETSI standard)
DSL	Digital Subscriber Line
ESN	Electronic Serial Number
ETSI	European Telecommunications and Standard Institute
FCC	Federal Communications Commission
FDMA	Frequency Division Multiple Access
GPS	Global Positioning System
HTTP	Hyper Text Transport Protocol
IP	Internet Protocol
ISDN	Integrated Services Digital Network
ISP	Internet Service Provider
LAN	Local Area Network
LRRP	Location Request Response Protocol
MCDD	Multi-Channel Device Driver
NAK	Negative ACK (acknowledgment)
OTA	Over the Air
PDU	Protocol Data Unit
PTT	Push To Talk
QoS	Quality of Service
RDAC	Radio Diagnostic and Control
RSSI	Received Signal Strength Indication
SIT	Subscriber Inactivity Timer
SMTP	Simple Mail Transport Protocol
SU	Subscriber Unit
TOT	Time Out Timer
TCP	Transmission Control Protocol
TDMA	Time Division Multiple Access
TMS	Text Messaging Service
UDP	User Datagram Protocol
UPS	Uninterrupted Power Supply
USB	Universal Serial Bus
VPN	Virtual Private Network
VOX	Voice Operated Transmission
WAN	Wide Area Network
XML	Extensible Mark-up Language

Appendix B Sample (Suggested) Network Topology

Figure B 1 shows a multisite configuration with 6 Connect Plus sites with 3 repeaters per site, providing 5 trunked channels. The network topology is private LAN/WAN, which does not require any special port forwarding or network address translation. Each XRC 9000 controller can directly communicate with the other site controllers via their configured IP addresses. The IP addresses are chosen from the private IPv4 address space and can be used with any Connect Plus installation, because IP packets originating from the Connect Plus devices are not routed to the public Internet, and conversely, no device in the public Internet domain can directly send IP packets targeting a device with a private IP address.

The setup in Figure B 1 also shows managed network switches with at least 4 ports available for the Connect Plus equipment. Note that although the switches have assigned IP addresses this is not required and the only purpose for such setting is to allow remote IP access to the switch for configuration purposes. The reader should not confuse a switch with a router, which usually is the default IP gateway for the devices that reside on router's designated subnet.

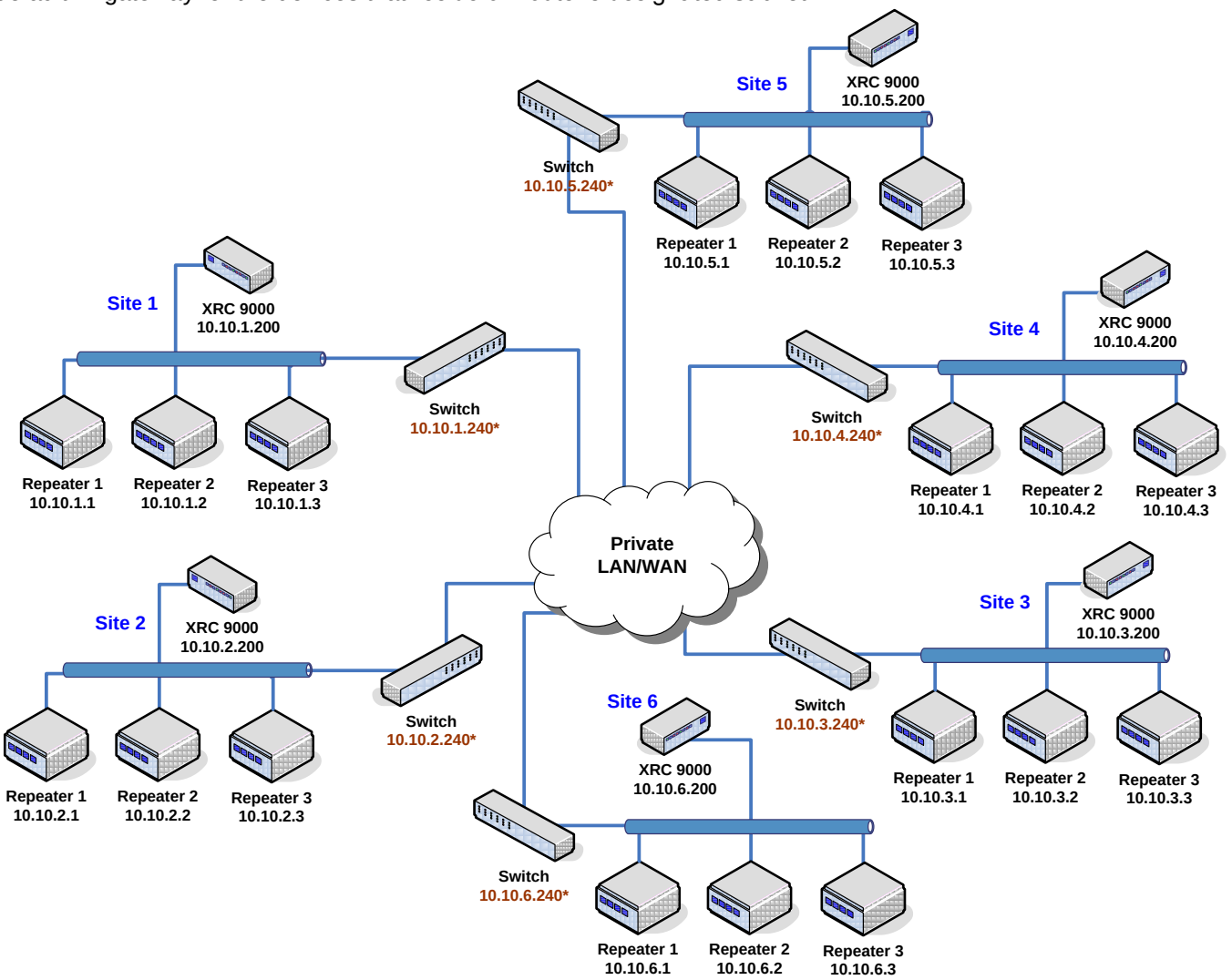


Figure B 1 Sample Network Topology with Private IP Plan

Appendix C Fleetmap Strategy to Facilitate Merging Multiple Systems

There are certain guidelines that should be followed when setting up radios in separate multi-site systems that may be linked together at a later date. The guidelines are related to how the radio fleet map is designed by the System Manager and how this fleet map information is entered in the Connect Plus Network Manager (NM). While the guidelines described in this section are specifically written for separate multisite systems that may be linked together in the future, many of the same principles also apply to single site systems that may be linked together as a multisite system at some future date.

The fleet map design guidelines are intended to minimize radio programming and NM updates at the time of linking one or more systems together.

GUIDELINES

Basically, radio, talk group, and Multigroup ID assignment should be looked at as if there was one single system from the beginning. Let's assume as an example a customer is setting up 2 separate systems today: **System A** (5 RF sites) and **System B** (4 RF sites) and is planning to link all 9 sites at a later date to form **System C**.

1) **Do not duplicate radio ID's**.

Radio IDs should be unique across all systems. For example: if user ID 05 is being used in **System A**, then user ID 05 should not be used in **System B**. This practice will minimize radio programming and NM database updates at the time of linking the systems.

2) **Do not duplicate Group ID's.**

Group IDs should be unique across all systems. For example: if group ID 01 is being used in **System A**, then group ID 01 should not be used in **System B**. This practice will minimize radio programming and NM database updates at the time of linking the systems.

3) **Do not duplicate Multigroup ID's.**

Multigroup ID's should be unique across all systems. Example, if customer X is using Multigroup 10000 on **System A** then multi group 10000 should not be used on **System B**. This practice will minimize radio programming and NM database updates at the time of linking the systems.

One possibility for this 2 system scenario for example, is to use ODD IDs for **System A** and EVEN IDs for **System B**.

4) **Site ID's must be unique.**

Ensure each site ID is unique after linking both **Systems A** and **B** together.

This is how the site ID assignment may look on this example before linking the systems.

System A	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Site ID	1	2	3	4	5	-

System B	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Site ID	1	2	3	4	-	-

This is how the site ID assignment will look after linking the 2 systems.

System C	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9
Site ID	1	2	3	4	5	6	7	8	9

5) **Use same Network ID (NID) for all controllers.**

Having all controllers in **System A** and **System B** with the same NID from the beginning ensures that the XRC 9000 controllers will not need to be updated with the final NID.

Similarly, having all radios with the same NID from the beginning ensures that the radios will not be required to be brought in for reprogramming with the new NID. A new frequency file will have to be sent over-the-air (OTA) in order to let the radios know about the new sites available in the final **System C** configuration.

The Network ID is not a configurable parameter in the Network Manager. If all controllers should have the same Network ID, this should be communicated at time of purchase. If this is not known at time of purchase, a controller's Network ID can be changed at a later date, but it will necessitate the reprogramming of the subscriber radios.

6) **Network Manager User database.**

It is expected that some database updates are required when joining **System A** and **System B** together but these updates could be minimized by following some simple guidelines. **System A** database may be transferred to the new sites coming from **System B** (sites 6, 7, 8, and 9 on this example) as a starting point. Final system database must be updated to reflect all new subscriber and site records. The last step will be to enable the EVEN IDs so that all users can utilize **System C**.

Example for Radios IDs (same could apply to group and Multigroup IDs):

Initial Setup
Both system databases are initially independent. ODD IDs are being used for **System A** and EVEN IDs are being used for **System B**.

System A User Database
ODD IDs Enabled

System B User Database
EVEN IDs Enabled

Let's assume **System A** database will be the one used for final configuration of **System C**. In the time prior to linking the 2 systems together, **System A** database can be prepared in advance by

creating the EVEN IDs from **System B**, but keeping them disabled.

Interim Setup

Both system databases are still independent, but now (EVEN) ID's from **System B** exist on **System A** database although they are disabled.

System A User Database
ODD IDs Enabled
EVEN IDs Disabled

System B User Database
EVEN IDs Enabled

At the time of linking the 2 systems together all EVEN IDs in **System A** database will be enabled and as a result we will have a **System C** database ready.

Final Setup

System A database now includes all combined ID's required, so it can be considered the final **System C** database.

System C User Database
ODD IDs Enabled
EVEN IDs Enabled

Alternate option for user database management

If the two (or multiple) systems have different frequencies, this greatly reduces the chances that radios will attempt to register on the wrong system (prior to combining the systems). Because of this, you can use an alternate method managing both systems by using one system as the main entry point for all user information.

Example, Enter all the users information for BOTH systems on **System A**, make a back up copy of the user database for **System A**. Access the Network Manager for **System B**, restore the user database from **System A** to **System B**. Both systems will now have the complete user database for all users. When the two systems are connected together to form **System C**, the databases will already be common between the two systems.

Note: Although you are using a common database for both Systems A and B guidelines 1, 2, and 3 still apply: you need to keep every radio, group, and Multigroup ID unique across all systems.