System Release 7.17
ASTRO® 25
INTEGRATED VOICE AND DATA

Call Processing and Mobility Management

NOVEMBER 2016

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Document History

Version	Description	Date
MN003239A01-A	Original release of the *Call Processing and Mobility Management* manual.	November 2016

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About Call Processing and Mobility Management

Describes at depth the behavior of various ASTRO® 25 system infrastructure components and subscriber radios as they process calls and manage subscriber mobility.

Call processing is the sequence of events the system goes through to process a call request. A trunked radio communication system enables people to communicate with each other whenever they need to and from wherever they are in the coverage area.

Mobility management encompasses the system tasks, which track active individuals and group members located in an area at any given time. Mobility Management uses the information supplied by the static configuration and the information supplied by the subscriber radios as they register, access, and move about the system.

Dynamic Transcoding allows the same group or unit to unit call to have:

- TDMA-only sites
- FDMA-only sites
- Dynamic sites granted as TDMA
- Dynamic sites granted as FDMA due to FDMA-only radios affiliated to the call.
- Dynamic sites granted as FDMA due to all TDMA-capable channels in use.

To achieve this, the Dynamic Transcoder devices installed at each zone core translates audio between FDMA and TDMA formats. Transcoding is only applicable to Dynamic Dual Mode (DDM) talkgroups, multigroups, agencygroups, and supergroups, private calls, and foreign talkgroups configured as transcode-capable.

Features for conventional voice call processing, conventional call processing and talkgroups and trunked data call processing and High Performance Data (HPD) call processing are not in the scope of this manual. For information about these features, see the following ASTRO® 25 system manuals:

- *Conventional Operations*
- *Conventional Data Service*
- *Packet Data Resource Management*
- *Trunked Data Services*

What is Covered In This Manual

This manual contains the following chapters:

- Trunked Call Processing Description on page 27 presents call processing, mobility management, and the capabilities within the ASTRO® 25 system technology, and the types of radio calls that can be made in the ASTRO® 25 system.
- Trunked Call Processing Technical Overview on page 49 describes the subsystem technology provided within the ASTRO® 25 system.
- Trunked Call Processing Configuration on page 73 describes the configuration, the foundation upon which all other aspects of call processing are built.
- Trunked Call Processing Operation on page 89 describes trunked radio communication system operation, fallback modes, and group-based services.
- Trunked Call Processing Troubleshooting on page 115 describes troubleshooting of call processing and mobility management failures.

- System Service Mode on page 141 describes the functions of the System Service Mode in an ASTRO® 25 system release.

Helpful Background Information

Motorola Solutions offers various courses designed to assist in learning about the system. For information, go to http://www.motorolasolutions.com/training to view the current course offerings and technology paths.

Related Information

See the following documents for associated information about the radio system.

Related Information	Purpose
Standards and Guidelines for Communication Sites (6881089E50)	Provides standards and guidelines that should be followed when setting up a Motorola communications site. Also known as the R56 manual. This may be purchased on CD 9880384V8 by calling the North America Parts Organization at 800–422–4210 (or the international number: 302–444–9842).
Unified Network Configurator	Covers the use of Unified Network Configurator (UNC), a sophisticated network configuration tool that provides controlled and validated configuration management for system devices including routers, LAN switches, site controllers, and base radios, and is used to set up sites for the ASTRO® 25 system. UNC has two components: VoyenceControl and Unified Network Configurator Wizards (UNCW).
Virtual Management Server Software	Provides procedures for implementing and managing VMware ESXi-based virtual server hosts on the common Hewlett-Packard® hardware platform in an ASTRO® 25 system. Includes common procedures for virtual machines/virtual appliances on the virtual server host.
Virtual Management Server Hardware	Provides information for implementing, maintaining, and replacing common Hewlett-Packard® hardware for servers in an ASTRO® 25 system.
Master Site — Infrastructure	Covers site-level information required to install and maintain equipment at the ASTRO® 25 system master site.
Private Network Management Servers	Provides information on the installation, configuration, and management of the Private Network Management (PNM) servers, namely, Air Traffic Router (ATR), User Configuration Server (UCS), Unified Event Manager (UEM), Zone Database Server (ZDS), System Statistical Server (SSS), and Zone Statistical Server (ZSS).
Backup and Restore Services	Provides information relating to the implementation and management of a backup service for supported devices in an ASTRO® 25 system. This manual addresses server and client functions required for these services, and provides information relating to the implementation and replacement of

Table continued…

Related Information	Purpose
	the Network Attached Storage (NAS) hardware/software component.
Authentication Services	Provides information relating to the implementation and management of the Active Directory (AD) service, Remote Authentication Dial-In User Service (RADIUS), and Domain Name Service (DNS) in ASTRO® 25 systems.
Securing Protocols with SSH	Provides information relating to the implementation and management of the Secure SHell (SSH) protocol for secure transmission of data between devices in an ASTRO® 25 system.
System Overview and Documentation	Provides an overview of the ASTRO® 25 new system features, documentation set, technical illustrations, and system-level disaster recovery that support the ASTRO® 25 radio communication system.
Dynamic Transcoder User Guide	Provides overview and procedures for implementing and managing a dynamic transcoder hosted in an ESXi-based virtual server.

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Chapter 1

Trunked Call Processing Description

This chapter provides a high-level description of call processing and mobility management, the types of radio calls that can be made in the ASTRO® 25 system, and the function it serves on your system.

1.1 ASTRO 25 System Technology

At the center of the ASTRO® 25 system is a transport core designed to carry voice, data, and management information through Internet Protocol (IP) packets.

The packet transport technology is beneficial for providing the following system characteristics:

- Scalable platform: The ASTRO® 25 system supports seven zones and 100 sites per zone.
- Digital platform: The platform is capable of supporting the open standard Improved Multi-Band Excitation (IMBE) protocol and Advance Multi-Band Excitation (AMBE+2) protocol for voice transmission.
- Capacity to transport vocoded and encrypted audio: The transport core provides the ability to transfer vocoded and encrypted audio transparently. Once the voice is vocoded and/or encrypted at a source, the digital information is completely passed through the network without conversions required. The conversion to the original audio format is required only at the destination receiver.
- Secure operation: The ASTRO® 25 system supports subscriber radio-to-subscriber radio and subscriber radio-to-dispatch console secure operations.
- Dynamic Dual Mode (DDM) operation: The ASTRO® 25 system provides the ability to support for APCO-compliant P25 TDMA support. The Fixed Network Equipment only supports P25 TDMA. Trunked TDMA supports all call types that trunked Frequency Division Multiple Access (FDMA) supports. The system can operate in one of the following modes at any given time: FDMA-only, FDMA and P25 TDMA.

NOTICE: The term TDMA is a general term used to describe the support of P25 TDMA throughout the manual.

NOTICE: For Call Processing in a Trunking subsystem (Tsub) refer to *Edge Availability with Wireline Console Feature Guide for Trunking Subsystems* manual.

1.1.1 Dynamic Dual Mode User Capability

Dynamic Dual Mode (DDM) ASTRO® 25 system feature comprises two parts:

1. The first is **DDM Channel** which allows a single channel to operate in either Frequency Division Multiple Access (FDMA) mode or Time Division Multiple Access (TDMA) mode, depending upon the channel assignment from the Zone Controller (ZC) or Site Controller (SC).
2. The second is **DDM Talkgroup**(without transcoding) which allows the talkgroup FDMA/TDMA mode to dynamically switch based on the minimum common TDMA capability of all affiliated subscriber radios. **DDM Channel** and **DDM Talkgroup** system options are purchased separately. If your ASTRO® 25 system is not TDMA capable, proceed to What Is Call Processing? on page 37.

NOTICE: With dynamic transcoding, the DDM Talkgroup allows the sites in the call to be independently assigned as FDMA or TDMA to maximize channel efficiency.

TDMA allows up to two active voice calls to transmit on the same channel resource. It does this by dividing the time of a 12.5–kHz radio frequency into two alternating talk paths for TDMA voice calls.

NOTICE: The Fixed Network Equipment (FNE) supports only P25 TDMA.

The DDM technology uses the RF spectrum in the Motorola ASTRO® 25 radio communication system with 6.25–kHz equivalent spectral efficiency. The FDMA mode operates in one call per 12.5–kHz channel, while TDMA operates in two voice paths per 12.5–kHz channel. The subscriber radios and dispatch consoles are dynamically assigned channel resources based on their signaling information and affiliated RF site types. RF sites are FDMA-only or TDMA-capable. This method results in an efficient, effective and dynamic way to allocate channel resources without subscriber radio user or console user intervention.

While the modulation rates and types for the control channel are the same in P25 TDMA as in FDMA , those for the voice channel are different. Both repeater and simulcast sites use the same modulation type. The outbound voice channel data rate is 12 Kbps using Harmonized Differential Quadrature Phase Shift Keying (H-DQPSK) modulation. The inbound voice channel data rate is 12 Kbps using Harmonized Continuous Phase Modulation (HCPM). The increase in the data rates on the voice channel relative to the control channel and the use of different modulations on the voice channel and control channel have an effect on coverage.

Not all RF sites need to be the same type. Individual channels can be FMDA-only, TDMA, or DDM. During site trunking, all talkgroups default to DDM operation (same as TDMA). Site Failsoft is still FDMA-only even on TDMA-only channels.

1.1.1.1
DDM Subscriber Radio User with Full and Location Registration

As part of the full and location registration processes, a subscriber radio provides Frequency Division Multiple Access (FDMA)-only or Dynamic Dual Mode (DDM) capability information.

A Time Division Multiple Access (TDMA)-capable system determines the subscriber radio and talkgroup dynamic operation mode based on the following information:

- Registration
- Affiliation
- Location

The subscriber radio, upon registration, determines the DDM capability, by indicating it is FDMA-only or TDMA. The capability information is provided in the unit and location registration message. Only the APX subscriber radios are capable of being programmed for trunked FDMA and TDMA capability.

The capabilities that the APX subscriber radio registers with are determined by the code version loaded in the subscriber radio, the subscriber radio TDMA H option presence and the Customer Programming Software (CPS) settings in the CPS ASTRO® 25 trunking system configuration. The Fixed Network Equipment (FNE) (zone controller) for call processing describes operation with radios either as FDMA-only radios or DDM-capable radios.

1.1.1.2
MCC 7500 Gateway Dispatch Console Zone Capability

Both card-based and Voice Processor Module (VPM)-based MCC 7500 dispatch consoles are capable of supporting half-rate Advance Multi-Band Excitation plus two (AMBE+2) calls sent out as Time Division Multiple Access (TDMA) calls over the air. The Zone Controller (ZC) determines the ability of the dispatch console type to support the calls when each individual MCC 7500 position goes in service. The dispatch console **in service** message informs the ZC whether it is full-rate only or half-rate capable.

Only VPM-based MCC 7500 dispatch consoles are capable of AMBE+2 calls that may be sent out as P25 TDMA over the air.

The system (ZC) is informed of the ability of this console type to support half rate (TDMA over the air) calls (or not) when each individual MCC 7500 console position goes in service.

If a system is to support Frequency Division Multiple Access (FDMA) and P25 TDMA over the air, VPM-based MCC 7500 consoles go in service as “half-rate capable” — card-based MCC 7500 consoles go into service as “full-rate only” (FDMA only over the air).

The Telephone Media Gateway (TMG) interconnect sub-system (for telephone interconnect), is capable of supporting FDMA/P25 TDMA calls.

1.1.1.3
DDM Site Capability

The ASTRO® 25 RF sites and subsystems are capable of operating in Frequency Division Multiple Access (FDMA)-only and/or Time Division Multiple Access (TDMA) operation. FDMA-only RF sites and subsystems support all RF bands and configurations. TDMA-capable RF sites and subsystems are supported in 700/800/900 MHz, VHF (136–174 MHz), UHF R1 (380–435 MHz) and UHF R2 (435–524 MHz) frequency bands in an ASTRO® 25 system.

For TDMA-capable RF sites and subsystems, the system determines which mode is used to assign calls, FDMA or TDMA, over-the-air in dynamic manner. Dynamic Dual Mode (DDM) supports FDMA-only subscriber radios or the subscriber radios at FDMA-only sites to interact with the TDMA-capable subscriber radios.

Trunked single site subsystems and trunked multisite IP-based subsystems support TDMA-only (voice) channels at a site. Due to the possibility of having TDMA-only voice capability at a site, considerations for this include:

- A channel configured for TDMA-only cannot support FDMA-only voice calls.
- Channels configured as TDMA-only may still serve as an FDMA control channel, an FDMA Integrated Voice and Data (IV&D) channel or an FDMA Base Station Identification (BSI) channel. No special settings are required.
- The system automatically site access denies an FDMA-only radio off a site that only has TDMA-only channels in service. This keeps FDMA-only radios from being stranded on a site in which the FDMA-only radio has no chance of participating in any voice calls.
- FDMA-only talkgroups are not serviced on a site that only has TDMA-only channels in service. Call requests on the FDMA-only talkgroup are rejected and audio would not be available on the FMDA-only talkgroup at the site.
- Radios at a site with only FDMA-only channels in service cannot talk directly to radios at sites with only TDMA-only channels in service. A console patch would be required to allow radios to communicate between the two sites.
- Only TDMA interconnect and TDMA private calls could be serviced at a site that only has TDMA-only channels in service. If a radio in a telephone interconnect call or unit–to–unit call in FDMA-only mode attempts to affiliate to the site in this case, the call is ended.
- IV&D data calls are allowed on sites that only have TDMA-only voice channels in service. IV&D data calls do continue to be assigned in an FDMA mode on the entire voice channel (IV&D data is not sent in TDMA slots).

NOTICE: The Zone Controller (ZC) does not use “configured” FDMA-only, TDMA-only, or DDM channel capability when assigning calls or performing operations as described above. The ZC only considers “in service” channels. Therefore, if all configured FDMA-only or FDMA/TDMA capable channels were to fail at the site, and the site remained in a trunked state with only TDMA-only channels in service, the rules for TDMA-only channels/site capability described above would apply.

The following trunked RF sites allow FDMA-only, TDMA-only, and DDM:

- 700/800 MHz, VHF (136–174 MHz), UHF R1 (380–435 MHz) and UHF R2 (435–524 MHz) ASTRO® 25 repeater site — GCP 8000 Site Controllers and GTR 8000 Expandable Site Subsystems
- 700/800 MHz, VHF (136–174 MHz), UHF R1 (380–435 MHz) and UHF R2 (435–524 MHz) and IP simulcast site subsystems — GCP 8000 Site Controllers, GTR 8000 Base Radios or GTR 8000 Expandable Site Subsystems, and GCM 8000 Comparators

The DDM-capable RF sites/subsystems support the following calls:

- FDMA voice calls
- TDMA voice calls
- DDM voice calls
- Assigned IV&D channels in data mode

NOTICE: High-performance data support is considered separate on a different RF site.

The following sites do not support DDM channels.

- ASTRO® 25 repeater site with PSC 9000 Site Controllers
- Circuit simulcast and associated RX-only sites
- Single transmitter receiver voting sites (circuit simulcast)
- 900 MHz

NOTICE: The capabilities of an existing FDMA site is expanded to operate in DDM. For more information on the process for expanding an FDMA-only capable site to be TDMA capable, refer to the *Dynamic Dual Mode for TDMA Operation* manual.

NOTICE: The RF subsystems with members affiliated to TDMA-only talkgroups are required to be TDMA capable RF subsystems. Refer to Group-Based Call Services on page 38 for more information.

1.1.1.4
DDM User Configuration Server Talkgroup, Multigroup and Agencygroup

The Provisioning Manager (PM) allows each talkgroup, multigroup and agencygroup to be configured as Frequency Division Multiple Access (FDMA)-only, Time Division Multiple Access (TDMA)-only, or Dynamic Dual Mode (DDM).

NOTICE: The RF subsystems with members affiliated to talkgroups are required to be DDM-capable RF subsystems.

1.1.1.4.1
DDM User Configuration Server Talkgroups

In the Provisioning Manager (PM), when creating a talkgroup, consider the following:

- For a talkgroup configured as Frequency Division Multiple Access (FDMA) only, calls are processed by the system in the FDMA mode.
- For a talkgroup configured as Time Division Multiple Access (TDMA) only, calls are processed by the system in the TDMA mode. Note that RF subsystems with members affiliated to such groups must be Dynamic Dual Mode (DDM)-capable RF sub-systems.
- All talkgroups that are part of TDMA multigroup must be configured as TDMA-only talkgroups or DDM talkgroups.

- Radios affiliated with TDMA-only talkgroups are capable of receiving FDMA multigroup calls. Although the manager allows such configuration, it is not recommended.
- All talkgroups that are part of any multigroup associated with a TDMA agencygroup must be configured as TDMA-only talkgroups or DDM talkgroups.

1.1.1.4.2
DDM User Configuration Server Multigroups

Adding a multigroup is the same as adding a talkgroup, but one or more talkgroups must be associated with the multigroup. A multigroup comprises several talkgroups whose members occasionally need to communicate as a group.

When creating a new multigroup in the Provisioning Manager (PM), keep in mind:

- A multigroup call requires a channel at each site with an affiliated multigroup member, resulting in a potentially large impact on system resources.
- The home zone of the multigroup must be the same as the home zone of all the talkgroups included in the multigroup.
- PM supports up to 254 talkgroups in one multigroup.
- A talkgroup can belong to only one multigroup.
- For a multigroup configured as Frequency Division Multiple Access (FDMA)-only, calls are processed by the system in the FDMA mode.
- For a multigroup configured as Time Division Multiple Access (TDMA)-only, calls are processed by the system in the TDMA mode. Note that RF subsystems with members affiliated to such groups must be Dynamic Dual Mode (DDM)-capable RF subsystems.
- All talkgroups that are part of TDMA multigroup must be configured either as TDMA-only talkgroups or as DDM talkgroups.
- Radios affiliated to TDMA-only talkgroups are capable of receiving FDMA multigroup calls. Although the manager allows for such a configuration, it is not recommended.
- All talkgroups that are part of any multigroup associated with TDMA agencygroup must be configured as TDMA-only talkgroups or DDM talkgroups.
- All multigroups grouped in TDMA-only agencygroups must be configured as TDMA-only multigroups or DDM multigroups.
- Operate the multigroup in the system either in FDMA or the TDMA mode based on the lowest common denominator FDMA/TDMA capabilities of all the radios affiliated to the multigroup.

1.1.1.4.3
DDM User Configuration Server Agencygroups

Adding an agencygroup is the same as adding a multigroup, but one or more multigroups must be associated with the agencygroup. An agencygroup comprises several multigroups whose members occasionally need to communicate as a group. The groups relationship is strictly hierarchical and thus a multigroup cannot contain an agencygroup.

When creating a new agencygroup, keep in mind:

- Frequency Division Multiple Access (FDMA)-only agencygroups contain FDMA-only, Time Division Multiple Access (TDMA)-only and Dynamic Dual Mode (DDM) multigroup and talkgroups.
- TDMA-only agencygroups contain TDMA-only and DDM multigroup and talkgroup. The Provisioning Manager (PM) does not allow an FDMA-only multigroup or FDMA-only talkgroup to be added to an TDMA-only agencygroup.
- DDM agencygroups can contain a DDM multigroup/talkgroup and an FDMA-only multigroup/talkgroup and a TDMA-only multigroup/talkgroup, all configured as part of a DDM agencygroup.

- All agencygroups can have the highest interrupt priority for calls with the exception of emergency calls if so configured.
- All agencygroups can support emergency calls and alarms if so configured.
- All agencygroups support the same encryption as talkgroups.
- Home zone mapping must be configured and submitted before multigroups are added to the agencygroup.
- Agencygroups are distributed to Zone Controllers (ZC) and consoles, and are treated as multigroups.

For more specific configuration information in adding talkgroups, multigroups and agencygroups, see the *Provisioning Manager* manual.

1.1.1.5
System Compatibility

The ASTRO® 25 digital platform supports Dynamic Dual Mode (DDM) operation. The platform co-exists and is compatible with the following:

- Project 25 Phase 1 Integrated Voice and Data (IV&D) Frequency Division Multiple Access (FDMA)-only sites (single call in a 12.5-kHz channel)
- Project 25 Phase 1 Integrated (FDMA) IV&D with DDM sites (achieve 2:1 TDMA (and FDMA) spectrum efficiency with two calls in a 12.5–kHz channel)
- High-performance data subsystems
- MCC 7500 consoles
- IP simulcast (supports up to 15 remote sites and supports up to 30 channels)
- Repeater sites (up to 28 channels)
- Analog mutual aid
- Conventional Resources — Analog, MDC1200, digital (v.24/IP) and mixed mode
- TDMA simulcast and multicast

The APX 7000/7500 subscriber radios operate in 700/800/900 MHz, and VHF under FDMA-only. Other subscriber radios operate in 700 MHz and 800 MHz. Time Division Multiple Access (TDMA) supports 700 MHz, 800 MHz, VHF (136–174 MHz), and UHF R1 (380–435 MHz).

1.1.1.6
Call Processing Components

Various components from the subsystems contribute to the communication service of Dynamic Dual Mode (DMM), Zone Controller (ZC), subscriber radios and encryption modes. The components in the following sections play a significant role for the ASTRO® 25 communication system to operate in DDM.

1.1.1.6.1
Zone Controller

The Zone Controller (ZC) receives and processes subscriber radio registration information.

1.1.1.6.2
Subscriber Radios

The Motorola APX 7000/7500 subscriber radios are capable of using a Motorola voice channel for Time Division Multiple Access (TDMA) operation. For more details, see the *Radio Features* manual.

1.1.1.6.3

Encryption Modes FDMA Mode

The APX 7000/7500 subscriber radios support the following encryption modes in Frequency Division Multiple Access (FDMA) mode:

- DES-XL
- AES-256
- DES-OFB
- ADP (rc4)
- DVP-XL

NOTICE:
The MCC 7500 console does not support DES-XL.

The APX 7000/7500 subscriber radios support the DES-XL.

1.1.1.6.4

Encryption Modes P25 TDMA

A Time Division Multiple Access (TDMA)-capable system supports the following encryption modes in P25 TDMA mode:

- AES-256
- DES-OFB
- ADP (rc4)

1.2

Channel and Active Call Capacity

The channel capacity for a site is defined as follows:

- A repeater site supports up to 28 physical channels at each site (one control channel and up to 27 voice channels).
- An IP simulcast subsystem supports up to 30 physical channels at each site (one control channel and up to 29 voice channels).

NOTICE: The control channel operates in Frequency Division Multiple Access (FDMA) mode for both FDMA and Time Division Multiple Access (TDMA) call request. This operation allows the system to support both FDMA and TDMA voice calls.

Integrated data is also supported and assigned for FDMA operation. Although TDMA operation supports up to two TDMA calls per voice channel, the control channel signaling throughput limits the capacity at each trunked RF site to 36 active calls. The Zone Controller (ZC) maintains a call count to ensure that the limit of 36 active calls is not exceeded.

The total number of active calls in a site can be the sum of the following types:

- FDMA voice calls
- TDMA voice calls
- Assigned Integrated Voice & Data (IV&D) channels in data mode

1.2.1

Call Capacity Limits for Implicit-only Sites

Implicit channel identification effectively uses the control channel bandwidth, sending only a single-channel frequency for each channel assignment. It allows the system to implicitly send band plan

information in bits over the control channel using the 16–identifier (ID) method. The subscriber radio uses this and other stored information to synthesize, transmit and receive frequencies.

The maximum number of channels can only be supported if all the channels at a site have channel frequencies defined as “implicit.” The control channel can only handle and maintain a maximum of 36 simultaneous implicit call assignments.

NOTICE: The Configuration/Service Software (CSS) application allows setting up a channel as either implicit or explicit.

1.2.2
Call Capacity Limits for Sites with Explicit Channels

A Time Division Multiple Access (TDMA)-capable channel that is configured as implicit must be able to have its TX and RX frequencies defined implicitly by both a Frequency Division Multiple Access (FDMA) band plan element and a TDMA band plan element. It does not allow the frequencies to be defined by implicit in one mode and explicit in the other mode.

Because the VHF (136-174 MHz) frequency band is not structured into predefined TX and RX pairs, no default band plans exist for it. The VHF (136-174 MHz) channel frequencies may need to be assigned explicitly to remain within the 16 total band plan limit of the system. The limit of 36 active calls is too high for the control channel to maintain when the site must support explicit calls. The call capacity limit at the site must be reduced based on the number of explicit channels at the site to support enough FDMA calls. This limitation is due to explicit packets being longer than implicit packets, thereby increasing the access times for all calls. Explicit channel identification means that a subscriber radio has to be given both TX and RX frequencies.

Explicit is different than *implicit* in the following ways:

- Explicit is less efficient than implicit because explicit channel grants require more transmission time.
- Explicit is intended for use where unstructured frequency plans are the only option (that is, each or many channel pairs have a different TX-RX offset).
- Explicit is designed to cover a wide bandwidth using a few elements, thus freeing up elements for use in other bands.
- Explicit increases the probability that another frequency can be added to the system at a later time, without having to redesign the band plan.

1.2.2.1
Site Call Load Capacity Compared to Channel Support

A repeater site or an IP simulcast subsystem with Dynamic Dual Mode (DDM) technology can auto-calculate the site call load capacity limits for all sites, including Frequency Division Multiple Access (FDMA)-only and Time Division Multiple Access (TDMA)-only sites. This value is based on the number of channels with explicitly defined frequencies at each site. The **Site Call Load Capacity** field in the Configuration/Service Software (CSS) for the GCP 8000 Site Controller is calculated based on the site call load capacity versus channels supported.

Table 1: Site Call Load Capacity Compared to Channel Support

Number of Explicit Channels	Site Call Load Capacity	Site Size for FDMA-only Site (voice and data)	Site Size for TDMA-only Site (voice only)
0	36	28 or 30 (Site Type Dependent)	19

Table continued...

Number of Explicit Channels	Site Call Load Capacity	Site Size for FDMA-only Site (voice and data)	Site Size for TDMA-only Site (voice only)
1	24	25	13
2	22	23	12
3	18	19	10
4	16	17	9
5	14	15	8
= or >6	12	13	7

1.3
System Architecture

The ASTRO® 25 communication system architecture supporting the Dynamic Dual Mode (DDM) operation supports a variety of different sites and subsystems.

NOTICE: The Dynamic Transcoding feature supports group call and unit-to-unit communication between FDMA subscriber radios on one site with TDMA subscriber radios on a separate TDMA-capable site while preserving the FDMA and TDMA modes of operation at each respective site. The Dynamic Transcoding feature also supports group call and unit-to-unit communication between subscriber radios on an FDMA-only site with TDMA subscriber radios in a TDMA-capable site while preserving the FDMA and TDMA modes of operation at each respective site.

The following sites and subsystems are Frequency Division Multiple Access (FDMA)-only capable:

- ASTRO® 25 repeater site (with PSC 96000 Site Controller)
- IP simulcast subsystem (FDMA-only capable)
- Circuit simulcast subsystem
- Circuit simulcast single transmit/receive voting subsystem
- MCC 7500 Dispatch console – IMBE vocoder

The following are Time Division Multiple Access (TDMA) capable:

- ASTRO® 25 repeater site (with GCP 8000 Site Controller)
- IP simulcast subsystem
- MCC 7500 Dispatch console – AMBE+2 Vocoder
- ASTRO® 25 Express System (Single-Site Trunking System)
- L1/L2 Express Remote Site

As part of the system architecture, the DDM operation is only supported by RF sites employing the GTR 8000 Base Radios along with G-series equipment.

NOTICE: The capabilities of an existing FDMA site are expanded to operate in DDM in an ASTRO® 25 repeater site and IP simulcast subsystem. For more information on the process for expanding an FDMA-only capable site to be DDM or Phase 2 capable, see the *Dynamic Dual Mode for TDMA Operations* manual.

1.4 Channel Assignment Priority for Available Channels

Channels at a site are configured with capabilities that determine their channel assignment priority. An incoming call is assigned to the channel whose configured capability has the lowest priority compared to the other available channels. The following capabilities are prioritized from highest to lowest:

- Sub-band Restricted (SBR)
- Dynamic Frequency Blocking (DFB)
- Protected
- Most Preferred Control Channel
- Dynamic Channel Access Type
- Second Most Preferred Control Channel
- Voice Capable
- BSI
- Third Most Preferred Control Channel
- Fourth Most Preferred Control Channel
- Control Capable
- Reserved Access Capable (Enhanced Data Capable)

The following are some examples of channel assignment priority:

- Voice Call Request for Two Available Channels:
  - Channel 1 with Dynamic Frequency Blocking (DFB) and Voice Capable
  - Channel 2 with Most Preferred Control Channel, Voice Capable, BSI and Control

The zone controller selects channel 2 because it has the least priority of combined capabilities. Since channel 1 is configured for DFB, it has a higher priority compared to channel 2.

- Enhanced Data Request for Three Available Channels:
  - Channel 1 with Protected, Voice Capable, and Reserved Access Capable
  - Channel 2 with Voice Capable, Sub-band Restricted (SBR), BSI, and Reserved Access Capable
  - Channel 3 Voice Capable and Reserved Access Capable

The zone controller selects channel 3 because it has the least priority of combined capabilities. Since channel 1 is configured for Protected, it has a higher priority compared to channel 3. Since channel 2 is configured for SBR and BSI, it has a higher priority compared to channel 3.

- FDMA Voice Call Request for Two Available Channels:
  - Channel 1 with Dynamic Channel Access Type and Voice Capable
  - Channel 2 with BSI and Control Capable and FDMA only

The zone controller selects channel 2 because it has the least priority of combined capabilities. Since channel 1 is configured for Dynamic Channel Access it has a higher priority compared to channel 2.

1.5 Intersystem Data Functionality

Intersystem Data feature provides trunking IV&D unicast packet data service for subscribers that have automatically roamed to ISSI 8000 connected ASTRO® 25 systems. A proprietary mechanism is used to provide packet data service between a foreign subscriber and its home system CEN. Packet data is exchanged between a foreign subscriber and its home system CEN data application servers via the

foreign system RNI, foreign system CEN, and home system CEN. The foreign system CEN and home system CEN must be IP connected.

Both clear and secure data are supported between a foreign subscriber and its home system. The foreign subscriber is able to send and receive unicast IV&D data with its home system while it roams across sites or across zones in the foreign system.

System level feature license is required for providing data service for foreign subscribers in the License Manager.

The Zone Controller provides mobility push and mobility query response support for any subscribers in a working ID range to the IV&D PDG. The Zone Controller provides all types of mobility push for subscribers in a working ID range. This includes zone entry registration, zone entry roaming, site update, zone exit deregistration, and zone exit roaming.

The PDR and RNG send HLR and VLR query requests respectively to the ZC. The ZC sends HLR query responses to the PDR. The ZC sends VLR query responses and mobility pushes to the RNG.

A subscriber that is configured for automatic roaming and configured for foreign data access attempts to context activate after successfully registering on a foreign system. The subscriber uses the new working unit ID assigned during registration in the context activation request. The subscriber is assigned a new IP address on a successful context activation. The new IP address assignment triggers the data applications in the subscriber to register with its home system data application servers. The subscriber's home system data application servers is reachable using the destination IP address. The IP address of the subscriber's home system data application servers remains the same when the subscriber is roaming in a foreign system.

There is no increase in total data capacity at the system or zone level to support data service for foreign subscribers. An ASTRO® 25 system must have data capacity available before allowing any foreign subscribers to use data. The specification for the maximum number of active data users and the rate of messages per hour is the same.

1.6 What Is Call Processing?

Call processing is the sequence of events that the system goes through to process a call request. A trunked system enables people to communicate with one another whenever required and from wherever they are in the coverage area. All communications within the system are processed as a call. A call is a specific instance of the system providing a call service to a properly configured, registered, and affiliated user of the system. The basics of call processing in a Motorola ASTRO® 25 trunked system include a description of the hardware components used in call processing, the types of calls available, and the flow a call takes as it makes its way through the system.

A subscriber radio's interface to the ASTRO® 25 system is similar to the single-site trunked system. Enhancements made to the signaling allow the subscriber radios to automatically register at their current site, notify the system as they move through different sites, and receive control channel accessibility at adjacent sites.

1.7 What Is Mobility Management?

Mobility management encompasses the system tasks that continuously track active individual subscriber radio and group affiliations across the system. Mobility management uses the information supplied by the static configuration and the subscriber radios as they register, access, and move about the system.

Individual subscriber radios must register at sites in the system. This registration allows them to make and receive individual-based call services. In addition, subscriber radios affiliate with a talkgroup so they can participate in talkgroup calls and use other group-based call services.

The system determines whether to accept or deny a request for registration/affiliation based on the configuration settings established in Provisioning Manager (PM) and in the subscriber radio itself. Mobility management is the primary function performed by the dynamic user configuration.

For detailed information about these features and capabilities, see the following ASTRO® 25 system manuals:

- *Channel Partitioning*
- *Radio Authentication*

1.8 Call Services

An ASTRO® 25 radio communication system capable of Dynamic Dual Mode (DDM) operation handles voice call communications using Frequency Division Multiple Access (FDMA) or Time Division Multiple Access (TDMA) channel resources. The trunked system supports several types of call services categorized by type of call service or by type of origin:

- Group-based calls are services that facilitate group (one-to-many) communication. Examples of group-based calls include:
  - talkgroup calls
  - multigroup calls
  - agencygroup calls
  - supergroup operation calls
- Emergency services are specialized, high-priority version of a talkgroup or multigroup call. Examples of emergency calls/transmissions include:
  - emergency calls
  - emergency alarm
- Individual calls are services that facilitate individual user-to-user communication. Examples of individual calls include:
  - private calls
  - call alert
- Enhanced Telephone Interconnect calls:
- Dispatch console calls originate from dispatch consoles and are supported by the ASTRO® 25 radio communication system. Examples of dispatch console calls include:
  - Phone patch calls
  - Audio patch calls
- Data calls are Integrated Voice and Data (IV&D) and High Performance Data (HPD) calls, and are supported by the ASTRO® 25 radio communication system. All IV&D calls use channel resources in FDMA mode. For IV&D and HPD call processing, see the *Data Services* manual.

NOTICE: When a participating site or foreign system must grant a TDMA call, while another participating site or foreign system must grant an FDMA call, the group call must be transcoded. Transcoding is only allowed on dynamic talkgroups, dynamic supergroups, dynamic agencygroups, or dynamic multigroups. See*Dynamic Transcoder User Guide* manual for details.

1.8.1 Group-Based Call Services

The ASTRO® 25 system offers several types of group-based call services.

1.8.1.1

Call Services Talkgroup Calls

The mode of the call the subscriber radio supports is dependent on the Frequency Division Multiple Access (FDMA)-only or the Time Division Multiple Access (TDMA) capability of both the subscriber radio and the site at which it is located. The type of channel resource allocated (FDMA or TDMA) for a talkgroup call is determined by a static or dynamic method to establish the talkgroup signaling mode. Each talkgroup is configured in the Provisioning Manager (PM) to operate in one of the following modes:

- FDMA only – Channel resources provide one call for the channel resource.
- TDMA only – Channel resources provide two calls for the channel resource.
- Dynamic Dual Mode (DDM) – Channel resources operate based on the operating characteristics and capabilities of subscriber radios and system infrastructure components.

The Zone Controller (ZC) evaluates dynamic talkgroups (without transcoding) to be in FDMA operation mode when one of the following conditions is satisfied:

- At least one FDMA-only subscriber radio is affiliated to the talkgroup.
- At least one subscriber radio is affiliated at an FDMA-only capable site.
- At least one MCC 7500 dispatch console is affiliated to the talkgroup and uses the IMBE vocoder type of full-rate only.
- At least one site among talkgroup Requested Site Mask is an FDMA-only capable site.
- At least one site among talkgroup Critical Site Mask is an FDMA-only capable site.

For a talkgroup call configured as TDMA-only, the calls are processed by the system in TDMA mode. The ZC evaluates dynamic talkgroups to be in the TDMA operation mode when the following conditions are satisfied:

- All affiliated subscriber radios are TDMA capable.
- All affiliated subscriber radios are at TDMA-capable sites.
- All MCC 7500 dispatch consoles affiliated to the talkgroup indicate use of AMBE+2 vocoder type of half-rate.
- All sites among talkgroup Requested Site Mask are TDMA-capable sites.
- All sites among talkgroup Critical Site Mask are TDMA-capable sites.

NOTICE: With dynamic transcoding, the DDM Talkgroup allows the sites in the call to be independently assigned as FDMA or TDMA to maximize channel efficiency.

With FDMA-only talkgroups, the FDMA-only and TDMA-capable members affiliate to it. With dynamic talkgroups, the operation mode is determined by the ZC.

NOTICE: When talkgroups are configured from static to dynamic, the talkgroup's signaling mode is re-evaluated using the rules above.

For a talkgroup configured as dynamic, the system dynamically determines the mode of the call. The dynamic mode of the talkgroup is determined by the subscriber radio or dispatch console affiliated to the talkgroup, along with the location of the affiliated talkgroup members. See the following examples:

- When one FDMA-only subscriber radio or dispatch console is affiliated to a dynamic talkgroup, the talkgroup operates in FDMA mode.
- When all affiliated consoles are half-rate (TDMA) capable, all affiliated subscriber radios are TDMA capable and at TDMA-capable sites. The dynamic talkgroup operates in TDMA mode.
- When all affiliated subscriber radios or MCC 7500 dispatch consoles are TDMA-capable, and at least one TDMA subscriber radio is at an FDMA-only capable RF site, the dynamic talkgroup operates in FDMA mode.

A talkgroup mode can remain in TDMA mode and reject any FDMA-only radio (or TDMA roaming to a site with only FDMA-only channels in service) affiliating with the talkgroup to increase efficiency of resources on the system. To accomplish this, the ZC could issue a **Site Access** denial message to a registering Mobile Station (MS) if the MS is in a TDMA-only configured talkgroup, and the site the MS is entering is FDMA-only. This may be accomplished via the Valid Sites features.

NOTICE:
All Site Trunking mode defaults all talkgroups as dynamic talkgroups.

The modes in Dynamic Capability of TDMA Subscriber Radios of the RF Site on page 40 are valid when a site is in wide-area trunking. When in site trunking, a TDMA-only capable site assigns a call in a mode which supports all subscriber radios registered at the site, while an FDMA-only site assigns only calls in FDMA mode. When a site enters Site Failsoft, all normally trunked working channels enter a conventional mode of operation, which supports only FDMA-only mode. When in Site Trunking and Site Failsoft modes, communication to the console and telephone interconnect functionality are lost.

1.8.1.1.1
Dynamic Capability of TDMA Subscriber Radios of the RF Site

The system assigns the dynamic talkgroup calls depending on the Time Division Multiple Access (TDMA) capability of the subscriber radio and capability of the RF site type.

Table 2: Dynamic Capability of TDMA Subscriber Radios of the RF Site

Dynamic Talkgroup with TDMA Capable Subscriber Radios	Channel Resource System Assignment
Frequency Division Multiple Access (FDMA)-only	Assigns the call to an FDMA channel resource to allow participation for all subscriber radios
Site supports only FDMA channel resources	Assigns the call to an FDMA channel resource
Site with TDMA channel resources	Assigns the call to a TDMA channel resource for efficient usage.

1.8.1.2
Call Services Multigroup Calls

The multigroup mode on the subscriber radio transmits in a first-come, first-served basis. Up to 15 talkgroups are monitored in the subscriber radio Customer Programming Software (CPS). The multigroups in the subscriber radio and the Zone Controller (ZC) have the same configuration. The subscriber radio selected in the multigroup mode on the subscriber radio monitors the activity associated with the selected group depending on the affiliation of the zone between the monitored talkgroup and the subscriber radio. The audio does not pass between zones exclusively for a subscriber radio scanning talkgroup activity while in multigroup mode.

A multigroup call is set to wait for all talkgroups in the group to complete any pending calls. Alternatively, a multigroup call is set to interrupt existing talkgroup communications. The call does not wait for transmitting users in the associated talkgroups to stop keying their subscriber radios. The subscriber radio users join the call in progress when they release their Push-to-Talk (PTT) buttons.

The multigroups are flagged as follows:

- Frequency Division Multiple Access (FDMA)-only — any talkgroup is configured as part of the multigroup including FDMA-only, Time Division Multiple Access (TDMA)-only, and dynamic talkgroups. All talkgroup members transit and receive audio of the active FDMA-only multigroup call.

- TDMA-only — the Provisioning Manager (PM) does not allow an FDMA-only talkgroup to be added to an TDMA-only multigroup.
- Dynamic Dual Mode (DDM).

A multigroup operates in FDMA mode under one of the following conditions:

- A member talkgroup operates in FDMA mode.
- An FDMA-only subscriber radio is affiliated to the multigroup.
- A TDMA subscriber radio is affiliated to the multigroup at an FDMA-only capable site.
- A full-rate FDMA-only, Improved Multi-Band Excitation (IMBE), MCC 7500 dispatch console is affiliated to the multigroup.
- An FDMA-only capable critical site is associated with the multigroup.
- An FDMA-only user designated site is associated with the multigroup

The multigroup operates in TDMA mode when all the above is false.

In an TDMA-capable system, the ZC does not assign channels for multigroup scanners under the following conditions:

- A subscriber radio registered at an FDMA-only capable site is scanning a TDMA talkgroup. (The talkgroup is dynamic TDMA or configured TDMA-only.)
- And a FDMA-only subscriber radio is scanning a TDMA talkgroup. (The talkgroup is dynamic TDMA or configured TDMA-only.)

A multigroup scanner is a subscriber radio affiliated to a multigroup. Multigroups are updated based on the FDMA or TDMA mode of the talkgroups present in the multigroup.

NOTICE: TDMA-only and dynamic talkgroups are allowed in the TDMA multigroups. The multigroup call is always in the TDMA mode.

The ZC evaluates dynamic multigroups to be in FDMA operation mode when any of the following conditions are satisfied:

- One talkgroup part of the multigroup is flagged as FDMA-only.
- One dynamic talkgroup part of the multigroup is evaluated to be in FDMA mode.
- The multigroup is evaluated to be in FDMA mode.

The ZC evaluates the dynamic multigroup to be in TDMA operation mode when all of the following conditions are satisfied:

- All the non-dynamic talkgroups of the multigroup is flagged as TDMA-only.
- All the dynamic talkgroups of the multigroup is evaluated to be in TDMA mode.
- The multigroup itself is evaluated to be in TDMA mode.

When the multigroups operate in the dynamic mode, they provide the highest level of interoperability with the talkgroup in the multigroup.

When the Network Management adds or deletes a talkgroup in a multigroup, the ZC evaluates the FDMA or TDMA mode of the dynamic multigroup.

1.8.1.3
Call Services Agencygroup

An agencygroup transmits calls to several multigroups simultaneously by selecting an agencygroup. Agencygroup calls are processed in the same manner as multigroup calls. Any subscriber radio affiliated with any multigroup in the agencygroup (must reside in a multigroup) receives the call. All talkgroups that are members of the multigroups in an agencygroup receive the agencygroup call. Agencygroup calls use message trunking to receive calls to transmit back to the agencygroup.

Agencygroup calls occur from dispatch consoles or subscriber radios. Agencygroup calls are configured in the subscriber radios as the highest priority scan talkgroup in the subscriber radio.

Agencygroup calls are flagged as follows:

- Frequency Division Multiple Access (FDMA)-only
- Dynamic Dual Mode (DDM)
- Time Division Multiple Access (TDMA)-only. The Provisioning Manager (PM) does not allow FDMA-only multigroups in TDMA-only agencygroups.

An agencygroup operates in FDMA mode under one of the following conditions:

- A member multigroup operates in FDMA mode.
- An FDMA-only subscriber radio is affiliated to the agencygroup.
- A TDMA subscriber radio is affiliated to the agencygroup at an FDMA-only capable site.
- A full-rate FDMA-only, Improved Multi-Band Excitation (IMBE), MCC 7500 dispatch console is affiliated to the agencygroup.
- An FDMA-only capable critical site is associated with the agencygroup.
- An FDMA-only user designated site is associated with the agencygroup.

The agencygroup operates in TDMA mode when all the above is false.

The zone controller (ZC) evaluates dynamic agencygroups to be in FDMA operation mode when any of the following conditions are satisfied:

- One multigroup part of the agencygroup is flagged as FDMA-only.
- One dynamic multigroup part of the agencygroup is evaluated to be in FDMA mode.
- The agencygroup is evaluated to be in FDMA mode.

The ZC evaluates the dynamic agencygroup to be in TDMA operation mode when all of the following conditions are satisfied:

- All the non-dynamic multigroups of the agencygroup are flagged as TDMA-only.
- All the dynamic multigroups of the agencygroup are currently evaluated to be in TDMA mode.
- The agencygroup itself is evaluated to be in TDMA mode.

1.8.1.4
Call Services Supergroup Operation

Supergroups are used for patch and MultiSELects (MSEL) from a dispatch console. When the zone controller (ZC) determines the Frequency Division Multiple Access (FDMA)/Time Division Multiple Access (TDMA) operation mode of the talkgroup changes due to the affiliation, the ZC evaluates the FDMA/TDMA mode to determine when the supergroup call set up is changed to a different FDMA or TDMA mode.

When creating supergroups, the system is required to ensure that any TDMA-only talkgroups and any Dynamic talkgroups operating in TDMA mode uses a TDMA-capable resource. When creating a supergroup for a console patch or MSEL transmissions:

- FDMA-only talkgroups may be added to a supergroup with other FDMA-only talkgroups or Dynamic talkgroups operating in an FDMA mode.
- TDMA-only talkgroups may be added to a supergroup with other TDMA-only talkgroups or Dynamic talkgroups operating in a TDMA mode.

If any Dynamic talkgroup that is part of a supergroup changes access type modes, the Dynamic talkgroup must be removed from the supergroup and potentially added to a supergroup operating in

the new access mode (if another talkgroup(s) is involved in the patch or MSEL with which to create a supergroup).

NOTICE: Multigroups must be updated based on the FDMA/TDMA mode of the talkgroups present in the multigroup. Multigroups may be flagged as TDMA-only; in this case, all talkgroups part of the multigroup must also be flagged as TDMA-only or Dynamic. FDMA-only talkgroups are not allowed to be part of a TDMA-only multigroup.

1.8.2
Emergency Services

This section describes emergency alarms and calls. See Emergency Services Operation on page 101 for more information.

1.8.2.1
Emergency Alarm

The emergency alarm service occurs when the emergency button on a subscriber radio is pressed. An emergency alarm is transmitted through the control channel. This alarm is forwarded to any consoles monitoring the subscriber radio's currently selected talkgroup or multigroup. Any active Radio Control Manager (RCM) positions with the currently selected talkgroup or multigroup as part of their list of attachments also receive and display the emergency signal. The subscriber radio can be configured to enter emergency call mode automatically when the emergency button is pressed.

1.8.2.2
Emergency Calls

An emergency call is a specialized, high-priority version of a talkgroup or multigroup call. Emergency calls always have the highest priority in the system. When an emergency call request is made during a time when all voice channels are busy, the request takes priority over any other type of call request.

Emergency calls are processed by the system in one of two ways: top of queue or ruthless preemption.

Emergency calls have a longer hangtime, so the radios stay on the voice channel longer and delay seeing the Site Selectable Alert on the control channel

1.8.3
Emergency Services – Individual Call Services

Individual calls provide for user-to-user communication. The individual call types are as follows:

- Private
- Call Alert

The type of channel resource, Frequency Division Multiple Access (FDMA), or Time Division Multiple Access (TDMA), allocated for individual calls is based on the capability of the subscriber radio or dispatch console and affiliated RF site.

When a subscriber radio involved in a TDMA private or interconnect call registers to an FDMA-only capable site, the call is transmission trunked. The call is ended immediately when the current transmission is completed. The user starts or reinitiates the call in FDMA mode.

1.8.3.1
Private Calls

Private calls allow properly equipped subscriber radios in the same system to enter into one-to-one conversations. The sender enters into the private conversation mode, selects a target subscriber radio by dialing an ID on a keypad, and presses the Push-To-Talk (PTT) to initiate the call. Based on the

model of the subscriber radio, the target subscriber radio emits two beeps or telephone type ringing to indicate a private conversation request is received. Subscriber radios can be programmed as follows:

- To receive calls only.
- To make calls from a programmed list only.
- With the capability to call other subscriber radios from a list or through the keypad.

NOTICE: When a radio transmits during a private call it does not return to the control channel. This eliminates the opportunity to see the broadcast message by chance on PTT to pick up site selectable alert.

1.8.3.2
Call Alert

The Call Alert feature allows an authorized caller to leave a notification in an unattended subscriber radio. This notification indicates that a system user wishes to communicate with another user of the alerted subscriber radio. The initiator may be a dispatcher or another subscriber radio user. No voice communication is involved in Call Alert.

A Call Alert also causes an audible and visual alerting indication to the target radio that can be seen if the target radio is attended. The initiator of the call alert is informed of the success or failure of the alert attempt.

1.8.4
Enhanced Telephone Interconnect

The Enhanced Telephone Interconnect (ETI) is a Voice-Over-IP (VoIP) subsystem that provides individual subscriber radios the ability to access the Public Switched Telephone Network (PSTN) using Internet Protocol (IP) Private Branch Exchange (PBX) equipment.

The ETI subsystem allows a subscriber radio user the ability to dial telephones (fixed or cellular phones) from an ASTRO® 25 subscriber radio to initiate a half-duplex phone conversation. It also allows a telephone user the ability to dial subscriber radios directly using a telephone number reserved for the ASTRO® 25 subscriber radio (Direct Dial Number), or indirectly by dialing a central number to access the home zone of the subscriber followed by over-dialing to access the subscriber by entering in the subscriber ID to initiate the call.

When integrated into the ASTRO® 25 trunked radio system, the ETI subsystem provides high-quality telephone interconnect features. The ETI subsystem can be integrated per zone or per system.

A telephone user is able to dial subscriber radios using one of two techniques:

- Directly dial a subscriber radio using a telephone number explicitly reserved for the ASTRO® 25 subscriber radio (Direct Dial Number).
- Dial a central number for the ASTRO® 25 system and then use over dialing to enter the subscriber ID to initiate a call.

The zone controller dynamically determines the mode of the call based on the capabilities of the resources must support the call at the time it is set up. The call mode is Time Division Multiple Access (TDMA) if the following conditions are true:

- The subscriber radio is registered at a site that supports TDMA
- The subscriber radio supports TDMA

If either of these conditions is not met, the call mode is P25 Phase 1, Frequency Division Multiple Access (FDMA).

The subscriber radio may roam after the call has been initiated. Once the call becomes active, the mode of the call cannot change. If the subscriber roams into a site that cannot support the mode of the

call, the call is terminated. This situation could occur if an TDMA-capable subscriber radio roams from an TDMA-capable site to a site that supports only P25 Phase 1 (FDMA).

NOTICE: ETI functionality is not available on conventional channel resources. See the *Enhanced Telephone Interconnect* manual for system configuration, call requests, installation requirements, and operational configurations.

Telephone Interconnect calls conflicts with site selectable alerts. A TI call can last a long time which keeps the subscriber on the voice channel for a long time and the subscriber does not go back to the control channel when it transmits. This keeps the subscriber from seeing the site selectable alert indication in a broadcast message on the control channel and therefore the subscriber will not have a timely indication of site selectable alert initiation, change, or stop.

1.8.5
Console Calls

The console call types are as follows:

Talkgroup calls
A talkgroup call is the basic method of communication in a trunked radio communication system. Most of the conversations that a subscriber radio user participates in are talkgroup calls.

Multigroup calls
A multigroup call involves two or more talkgroups. The user can transmit a message to several talkgroups simultaneously by selecting a multigroup.

Agencygroup calls
An agencygroup call involves multigroups. The user can transmit a message to several multigroups simultaneously by selecting an agencygroup.

Supergroup calls
A super group call is used when resources are designated as regroupable at network management and meet all regrouping criteria, can be regrouped into a "Supergroup" by the zone controller. Any calls that happen on that supergroup do not need to be audio patched to the other members of the supergroup. All members automatically hear the audio. If a talkgroup that is not a member of the supergroup is patched to the call and that talkgroup is regroupable, it is added to the supergroup.

Emergency calls
An emergency call is a specialized, high-priority version of a talkgroup or multigroup call. Emergency calls always have the highest priority in the system.

Private calls
Private call allows properly equipped subscriber radios in the same system to enter into one-to-one conversations.

Phone Patch calls
The phone patch call allows two-way dispatcher to connect an incoming phone call to a subscriber radio.

Audio Patch calls
Occur when a console joins or “patches” audio from two or more channel resources together to allow consoles or radios using the channel resources to share audio transmissions. “Patch” is a generic term that allows one console to tie two or more resources together to share audio transmissions.

Enhanced Console Telephony
Provides radio system dispatchers the ability to answer and initiate phone calls from an MCC 7500 Dispatch Console with a Voice Processor Module (VPM). It enables a dispatcher to patch a radio user in the field to a phone caller, talk with emergency or support personnel over the phone if necessary, and contact other agencies over the phone that may not be part of the radio system.

For additional information on functionality, see the *MCC 7500 Dispatch Console with Voice Processor Module* and *Console Sites* manuals.

1.9
Dynamic Sub-band Restriction

This section provides information about the Motorola Flexible 700/800 Mixed Site and Talkgroup User Operation capability. This capability is sometimes referred to as Dynamic Sub-Band Restriction (D-SBR) and is used in Motorola's ASTRO® 25 systems. D-SBR provides a solution to the problem of 700 MHz channel under use at 700/800 mixed sites. It solves this problem by dynamically determining the type of channel resource needed at a site based on the type of sub-band radios registered at a particular site for the call.

Channel assignment for group calls using D-SBR is made based on the SBR status of the talkgroup. If an RF site supports both 800 MHz and 700 MHz channels, an 800 MHz channel is assigned if the radios present at the RF site are affiliated with an SBR talkgroup. To maximize the channel use improvement while preventing some adverse effects that may be caused by D-SBR, usage of D-SBR is limited to normal group calls which make up the majority of calls in the ASTRO® 25 system. The D-SBR channel selection algorithm can be used for the following types of group calls:

- Single talkgroup calls
- Multigroup calls
- Supergroup calls

For more information and Other Band Trunking (OBT) call processing flows, see the *Fleetmapping and Band Plan Management* manual.

1.10
ISSI 8000/CSSI 8000 Intersystem Gateway

The Intersystem Gateway (ISGW) is a server application residing on a virtual machine (VM). The ISGW supports an Inter-RF Subsystem Interface (ISSI) and a Console Subsystem Interface (CSSI) providing an ASTRO® 25 system with an interconnectivity solution for P25–compatible systems and consoles. With the ISGW, associated licenses for ISSI and CSSI support, and the appropriate firewalls, the ASTRO® 25 system can interface with other P25-compliant systems (ISSI 8000) and other P25-compliant (third-party) consoles (CSSI 8000).

The ISSI 8000/CSSI 8000 feature provides interconnectivity for P25-compatible systems and consoles to interface with an ASTRO® 25 system. The ISSI 8000/CSSI 8000 functionality allows an ASTRO® 25 system to connect up to 24 foreign P25 systems based on the P25 ISSI standard. The other P25 systems can be ASTRO® 25 systems or third-party systems. Additionally, the other P25 systems can be trunked radio systems or third-party console subsystems. If the P25 system is a trunked radio system with RF sites, the interface is known as ISSI 8000. If the P25 system is a third-party console subsystem, the interface is known as CSSI 8000.

For more information, see the *ISSI 8000/CSSI 8000 - Intersystem Gateway* manual.

1.11
ISSI.1 Network Gateway

The Inter SubSystem Interface (ISSI).1 Network Gateway is a feature that enables connectivity across two systems by mapping talkgroup IDs from one system (A) to another system (B) in “common talkgroup ID mode” when affiliated to an ISSI talkgroup. It also enables manual roaming of existing subscriber radios with the necessary pre-provisioning.

The ISSI.1 Network Gateway application connects disparate trunked networks with different system, Wide Area Communication Network (WACN), or Radio Frequency SubSystem (RFSS) IDs. The ISSI.1 Network Gateway application uses an available ASTRO® 25 Zone Controller (ZC) site link to connect

over a wireline P25 ISSI interface to another network's ISSI standard interface. The ISSI.1 Network Gateway registers and affiliates each of its configured IDs.

The ISSI.1 Network Gateway supports the following ASTRO® 25 system call types:

- ISSI group call
- ISSI emergency group call
- Encrypted ISSI group call
- Manual intersystem roaming

Calls involving the ISSI.1 Network Gateway use Frequency Division Multiple Access (FDMA). Subscribers can be configured as Dynamic Dual Mode (DDM), but they are always negotiated to FDMA because the gateway registers as an FMDA-only subscriber.

For more information and ISSI call processing flows, see the *ISSI.1 Network Gateway* manual for more information.

1.12 Private Call Management

This feature is introduced to protect channel availability for mainstream operations. While still allowing for private call conversations, you can set a limit in the Unified Network Configurator (UNC) for the number of simultaneous calls allowed on a per RF-site basis. This feature primarily impacts radio operators placing private calls on trunked channels but it also impacts dispatchers using a Private Call to connect directly with a subscriber. While a dispatcher might also use a private call to perform an Intercom function to another dispatcher, intercom functionality is unaffected by this feature.

Placing a limit on private call resource consumption on a per-RF-site basis is a static setting and is not controlled dynamically. A static limit on number of private calls per RF site allows system administrator to set the maximum private call resource consumption per RF site so that once this limit is reached, active calls are allowed to continue and terminate normally, but no additional private calls are initiated. With this feature implemented, when two subscribers are in two different RF sites, both sites must have available private call allocation before the subscribers can start or receive a new private call. For a subscriber and a console operator to be able to initiate and receive private calls, the RF site must have remaining private call allocation left. This limit on private calls does not apply to an NM/Dispatcher site.

1.13 Base Station Identification

FCC regulations require that radio systems identify themselves over the air periodically using the system's assigned FCC call sign which also known as Base Station Identifier (BSI). The ASTRO® 25 Trunked system supports the transmissions of the BSI call signs:

- By International Morse Code in analog mode:
  - The transmissions are originated from the trunked system from the zone controller periodically using the available channel resources configured with the BSI capability.*
  - Channels assigned for BSI transmission are not available for other call services until the BSI transmission is completed.
  - Supports a configurable BSI interval.
  - Supports up to 20 characters of call signs for a channel.
  - Supported for all trunked RF site types.
  - Supported in fall back mode of Site Trunking.
- By digital transmission. This is allowed for systems which are licensed on frequency bands on an exclusive basis:

- Supports the digital BSI transmission on control channels periodically and on the traffic channels at the start of a call and additionally the messages may be sent periodically during the call.
- Proprietary digital BSI messages are used but are available with information provided to sufficient to decode the transmitted BSI call signs.
- Supports up to 8 characters of the call sign for a channel.*
- Supported in sites and subsystems of IP Simulcast and single transmit/receive voting subsystem, ASTRO® 25 repeater site with GTR 8000 and ASTRO® 25 Express.
- Supported in fall back mode of Site Failsoft.

NOTICE: *The 800 MHz and 900 MHz trunked systems are required to transmit BSI only on the lowest frequency in the base station trunk group assigned to the licensee, while VHF and UHF trunked systems must transmit station identification on every assigned frequency. ASTRO® 25 Trunked system does not support the BSI transmission in Morse Code on the channels configured for Control or Dynamic Frequency Blocking (DFB). Digital transmissions of BSI are used if required by FCC depending on the channel frequency bands which are licensed.

*FCC permits a single call sign for commonly owned facilities that are operated as part of a single system.

Chapter 2

Trunked Call Processing Technical Overview

This chapter describes the trunking technology provided within the ASTRO® 25 system.

2.1 ASTRO 25 Technology Technical Overview

This section describes ASTRO® 25 multicast technology, the transport network, and the call processing subsystem.

2.1.1 Multicast Routing Technology

IP Multicast Routing, commonly referred to as multicast, is a method of transmitting messages (datagrams) between a number of sites which are part of a multicast group. This differs from unicast, which transmits messages between two endpoints, and broadcast, which transmits messages from a single source to all hosts on a network.

Multicast employs a concept known as a Rendezvous Point (RP), in which a router or a set of routers is identified as an RP for an associated multicast group address range. This is also known as a core router. The function of the RP router is to receive multicast transmissions from an originating site, and then fan them out to other sites and zones, creating a multicast "tree" for each multicast group.

Multicast is closely aligned with the talkgroup concept. With multicast, the transmitting subscriber radio's audio is distributed to the appropriate sites by the RP router. Without multicast, the transmitting subscriber radio would have to send a separate copy of each packet of a transmission to each receiving site. Multicast transmissions are sent only to those sites which have subscribed or "joined" the specific multicast group. Once the join message is received, the routers propagate multicast traffic to the appropriate sites and zones. Multicast trees for audio traffic are set up on service request, and are present only for the duration of the call.

A range of class-D IP addresses (addresses beginning with 224-239) is designated as multicast group addresses.

2.1.1.1 The Call Model

The main purpose of an ASTRO® 25 system is to provide voice and data communication services to subscriber radios and dispatchers throughout the system. The following describes how a talkgroup voice call is serviced by the system.

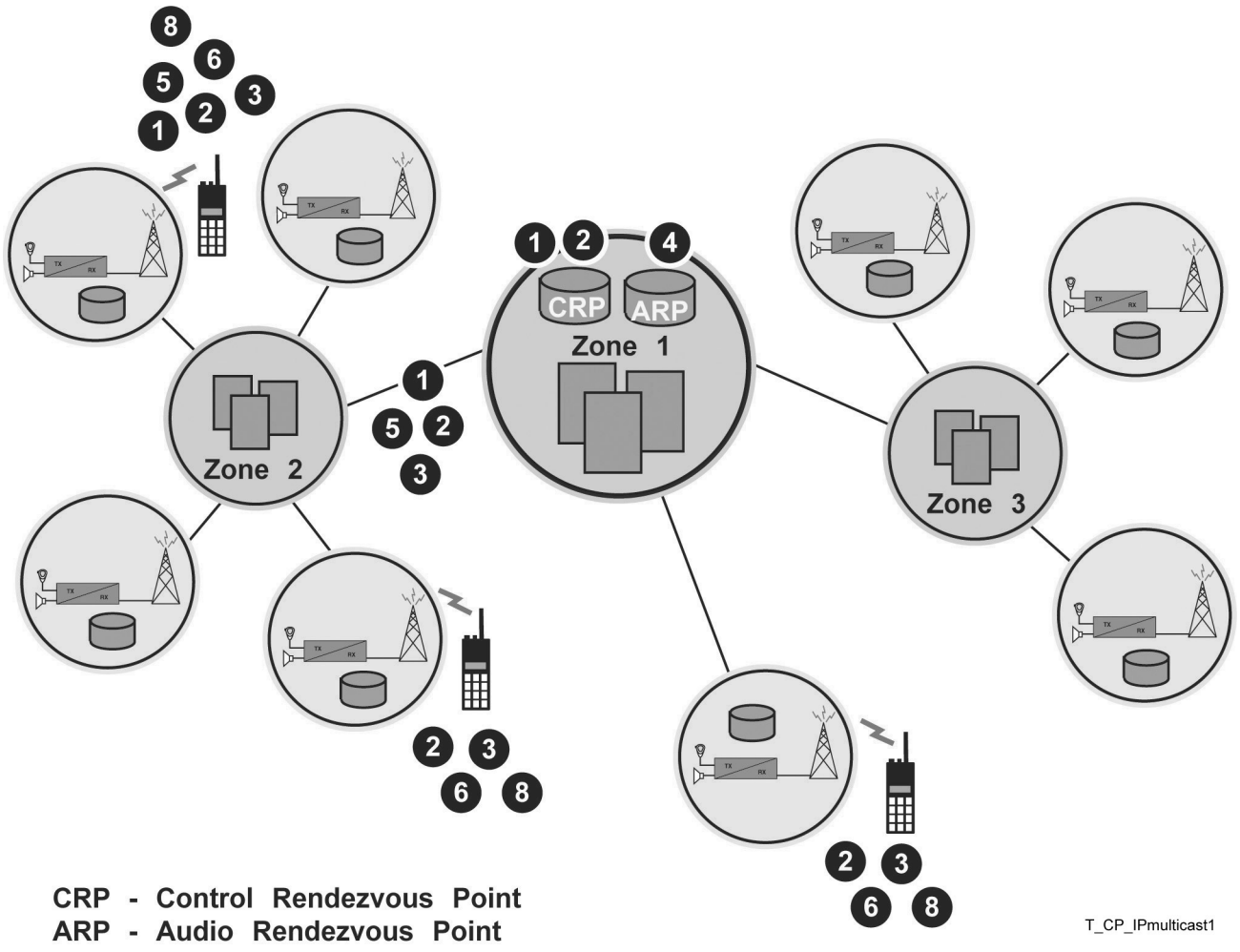
1 A subscriber radio user presses the Push-To-Talk (PTT) button to talk to other users in the talkgroup. The radio transmits a Call Request on the RF control channel at the site. The control channel receives the Call Request and forwards it to the site Ethernet LAN. Before placing the Call Request packet on the site Ethernet LAN, the base radio encapsulates the Call Request message in a User Datagram Protocol (UDP)/IP datagram with the Zone Controller’s (ZC) destination IP address.

NOTICE: UDP is a transport layer protocol that resides on top of the IP. UDP provides a transaction-oriented, best-effort delivery service. IP is the internet layer protocol tasked with defining how data is transferred across the network, how devices are addressed, and how to route data appropriately. IP defines a standard addressing method and how to fragment, transport, and reassemble data packets.

2. The IP packet network routes the Call Request packet to the ZC. Upon receiving the Call Request message, the ZC checks an internal database to determine the location of all members in the requested talkgroup (such as RF sites and remote dispatch sites locations). The ZC then assigns a multicast group address to the call, and sends the assigned multicast group address to all the participating RF sites, remote dispatch resources, MCC 7500 at the Master Site/ZC. This message is referred to as a Call Grant message and is sent in an IP datagram.
3. Upon receiving the Call Grant message, the RF and dispatch sites extract the IP multicast address from the Call Grant. The assigned voice channels at IR sites, the comparators at simulcast subsystems generate a group Join message. The group Join message is an IP control packet.
4. Upon receiving the IP group Join message, the RF and dispatch Site Router/Gateways communicate with Rendezvous Point (RP) routers in the system to set up an IP multicast distribution tree. This tree is used to distribute voice payload traffic to all sites participating in the call.
5. The subscriber radio begins transmitting vocoded audio on the assigned RF voice channel at its site. The voice channel receives the audio and the audio is placed in an IP datagram destined to the assigned IP multicast address (as assigned in the Call Grant). The IP multicast packet is placed on the Ethernet LAN.
6. The IP multicast audio stream is distributed to all the RF and dispatch sites through the RP router and IP multicast tree.
7. When the first user dekeys and a second member of the talkgroup transmits while the call is still active (repeater call hangtime has not expired), the same multicast tree is used. The voice channel receives vocoded audio at the new source site, and the vocoded audio is placed in an IP packet destined for the group's RP router. The IP packet flows down the same IP multicast tree generated earlier by the routers.
8. When the call is over (expiration of the message timer), the sites (RF or dispatch) generate an IP group Leave message. The Leave messages cause the multicast tree to be taken down.

NOTICE: The preferred mode of operation for an ASTRO ® 25 system is message trunking with PTT-ID. This parameter is programmed in the system, through the Provisioning Manager (PM) as message trunking, and in the subscriber radios, through their programming software, as PTT-ID.

Figure 1: Call Processing



NOTICE: System gateway devices provide an alternative solution to various routers in the system. See the *System Gateways – GGM 8000* manual for details.

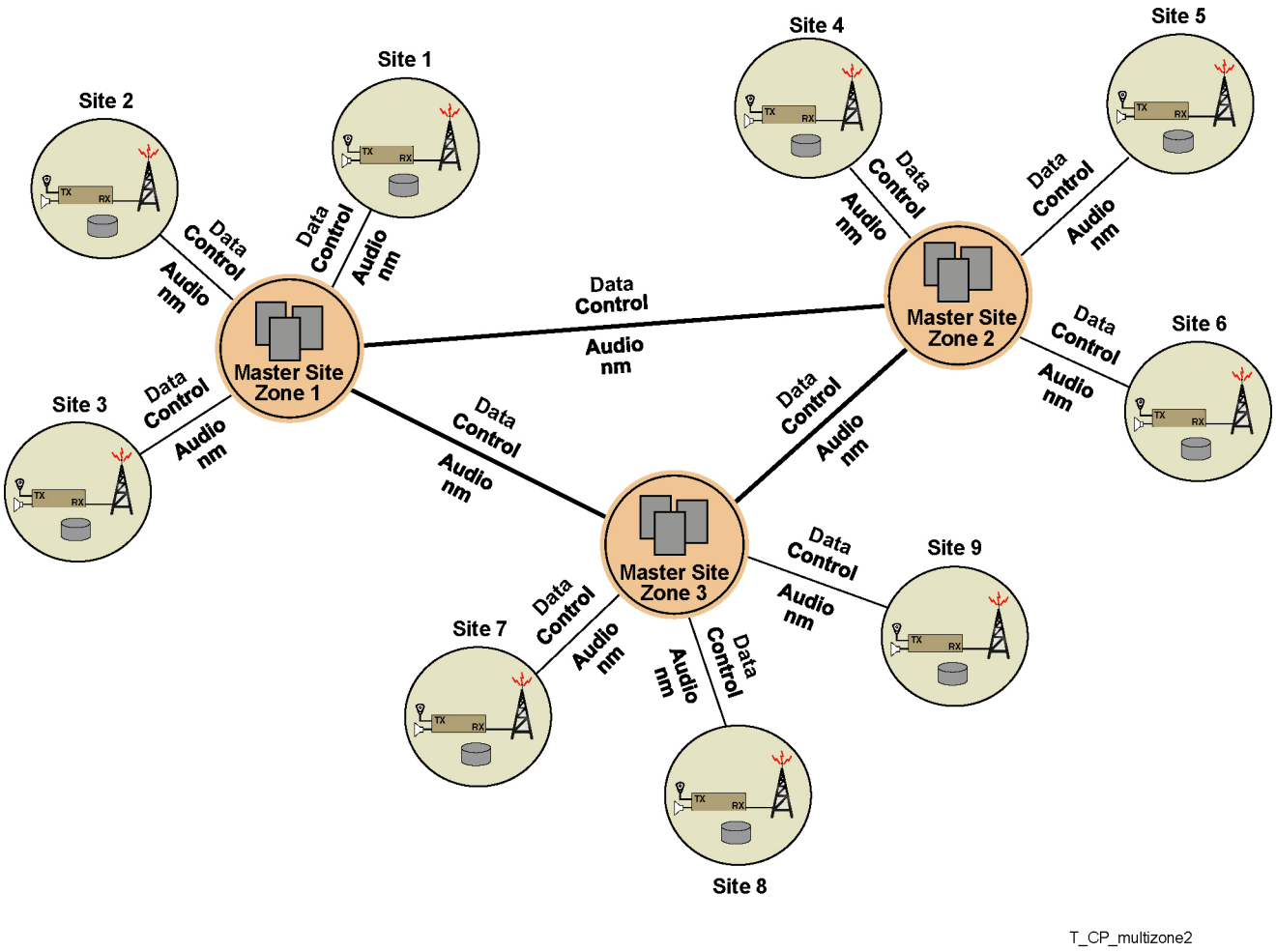
2.1.2
Traffic Planes in Transport Network

Four logical traffic planes are set up in the transport network. The traffic planes describe the communications paths which exist within the network, and describe the traffic types carried over those paths. The following traffic planes exist in an ASTRO® 25 system:

- Voice Control Plane
- Audio Plane
- Network Management Plane
- Classic Data Services

ASTRO® 25 systems use the same physical link for traffic from all three planes.

Figure 2: ASTRO® 25 System Logical Traffic Planes



2.1.2.1 Voice Control Plane

The traffic between the Zone Controller (ZC) and the RF sites within a zone, and between ZCs in different zones is called Voice Control traffic. The logical plane used to transport this information is called the Voice Control Plane. Voice Control traffic is responsible for setting up the audio path between the transmitting site and the receiving site or sites. The ZC, through the voice control plane, receives talkgroup requests and sends messages to appropriate sites, assigning an IP multicast group address to be used for the call. Control communication from the ZC to the RF sites is accomplished using multicast. Unicast is used for transmissions from the RF sites back to the ZC.

2.1.2.2 Audio Plane

The Audio Plane is made up of the unicast routes and multicast trees set up by voice control. Multicast is used to carry audio packets for all call types (group calls, private calls, telephone interconnect calls) between the subscriber radios or dispatch consoles in the system, both intrazone and interzone.

2.1.2.3

Network Management Plane

The Network Management Plane carries all the unicast network management traffic between the ASTRO® 25 network devices (for example, routers and switches), and the Operations Support System's network management servers and terminals.

Table 3: Required Call Processing Equipment

Component	Function
Zone Controller (ZC) application	The Zone Controller application resides on a Virtual Management Server (VMS) host when supported by the Common Server Architecture (CSA). The zone controller application processes service requests, location information, and outbound commands. It also maintains the Home Location Register/Visitor Location Register (HLR/VLR) databases containing subscriber radio and talkgroup record information. Because it is available to the zone controller, this information makes it possible for the zone controller to re-establish wide-area trunking in a single-zone system, and InterZone trunking in a multiple-zone system when necessary. The HLR and VLR determine access rights and location of subscriber radios and talkgroups. The zone controller receives and stores subscriber data, configuration data (RF sites, call parameters, and so on), and Home Zone mapping updates downloaded from the Unified Network Configurator (UNC). If the zone controller receives updated subscriber data for a radio that is home to the zone, it updates the HLR, but it also stores subscriber data not currently part of the HLR. When the zone controller receives the complete subscriber data download, all the subscriber data is stored to support Home Zone map updates. The zone controller also manages and processes call activities in the zone, and generates grant, busy, or reject messages to the subscribers, while it manages the registration of resources and keeps track of mobility management information for talkgroups mapped to the zone. The zone controller communicates through its Ethernet ports with the system and its network management applications through the master LAN switch. Communication links are established with the sites (site links) and with other zones (InterZone links) in the system. Communication links are also established with the Telephone Media Gateway (TMG) and IP Private Branch exchange (PBX), as well as various other subsystems to support call processing. See the *Zone Controller* manual for details.
Gateway (Control) Router	Provides the routing path for call processing control information and becomes the Rendezvous Point (RP) for ZC-to-RF Site Control Paths (SCPs). In multiple zone systems, the gateway (control) router also serves as the RP for the audio, and control planes in the system due to the multicast address sent by the ZC.
Core Routers	Act as the distribution point for audio, control information, and network management traffic destined for the same zone sites. Information is transmitted within IP packets.

Table continued…

Component	Function
Exit Routers	Act as the distribution point for audio, control information, and network management traffic destined for other zones. Information is transmitted within Frame Relay packets.
Master Site Ethernet/Site LAN Switch	Provides the backbone for the routers within the Master Site/Zone Core to pass IP traffic. The ZC communicates over this switch to: • Reach the network management servers for subscriber radio and InterZone information • Perform intrazone and interzone transmissions
Master Site/Zone Core Cooperative WAN Routing (if present)	The Cooperative WAN Routing encapsulates the Frame Relay information into Multilink Frame Relay packets (MFR) (Inverse Multiplexing Asynchronous Transfer Mode (ATM) (IMA) packets) for transmission to other zones. It also passes the packets destined for the same zone sites as Frame Relay.
S2500 Remote Site Router or GGM 8000 Gateways	Serves as the site interface to wide-area infrastructure. Receives and transmits control, audio, and management information. Accomplishes the Frame Relay - Ethernet conversions. As an option, redundant site router/gateways can be installed at the sites.
Remote RF Sites/subsystems	Remote sites and/or digital simulcast subsystems serve as the RF interface between the subscriber radios and the system.
Inter SubSystem Interface (ISSI).1 Network Gateway	Allows disparate trunked networks with different system, Wide-Area Communication Network (WACN), and/or RF Sub-System (RFSS) IDs to communicate.
Telephone Media Gateway	A device based on the Voice Processor Module (VPM) hardware that translates audio between the ASTRO® 25 AMBE audio and IP PBX server G.711 audio. The TMG supports both encrypted and clear audio to and from the ASTRO® 25 network. All audio exchanged with the IP PBX server is clear.

NOTICE: The gateway router performs control and data router functionality.

2.1.2.4
Classic Data Services

The Integrated Voice and Data (IV&D) data service is a feature available for implementation on ASTRO® 25 Integrated Voice and Data systems. It enables radio subscribers to connect mobile data devices to their ASTRO® 25 subscriber units for wireless access to fixed enterprise data networks through the ASTRO® 25 radio infrastructure.

NOTICE: During a data session the subscriber do not receive any alerts.

Data services encompass the following topics

- Classic IV&D Data Services
- Transit 25 Data Services for Fleet Communication
- High Performance Data (HPD) Services
- Conventional Data Services

For additional information on data services, see the *Conventional Data Services* and the *HPD – Packet Data Resource Management* manuals.

2.1.2.5

Enhanced Data Services

Enhanced Data is a Motorola Solutions proprietary (not P25 standard) inbound-only packet data service optimized for applications that periodically send short messages from a subscriber or attached device to a host in the Customer Enterprise Network (CEN). Enhanced Data is only supported on ASTRO® 25 Trunked IV&D systems with GTR series site equipment and APX subscriber units. Datagrams carried via Enhanced Data must use UDP/IPv4 for network transport between the subscriber or attached device and the CEN. The subscriber uses the Enhanced Data service when the following conditions are met:

- The radio has the Enhanced Data option.
- Radio is enabled for Enhanced Data in the Provisioning Manager application.
- The UDP Destination Port number in an inbound datagram matches one of the Enhanced Data Port numbers in the subscriber, configured through Customer Programming Software (CPS).
- The site includes a channel enabled for Reserved Access capability, which means that the channel supports Enhanced Data.
- Message size does not exceed the maximum packet size allowed for Enhanced Data. If the message is over the limit, it can be sent via classic, depending on a radio setting.

Neither TCP nor IPv6 are supported for datagram transport. Optionally, either Header Compression (UDP/IP) or IPSec encryption via the Encrypted Integrated Data (EID) feature can be used together with Enhanced Data. An Enhanced Data message can contain a maximum of 384 bytes of data, including user payload and all headers. Any data messages larger than this size are sent using Classic Data.

Enhanced Data introduces a new type of data channel to support short, periodic inbound data messages, such as Location (supported systems: GNSS, BeiDou, Glonass, Galileo). The Enhanced Data channel is a trunked resource at a Radio Frequency (RF) site and is allocated on first request from an Enhanced Data subscriber, then dynamically based on a periodic evaluation of the Enhanced Data load at the site. The Enhanced Data channel is based on the timing and signaling characteristics of the Phase 2 TDMA channel. However, both logical TDMA channels are used in tandem to provide Enhanced Data service. It is not possible to run Enhanced Data on one logical channel and voice on the other logical channel. Only inbound packet data messaging is supported. No outbound packet data messaging is supported on Enhanced Data channels. Context activation on a Classic Data channel is required before Enhanced Data messaging can be performed.

An inbound datagram is sent using a reservation scheme where the subscriber computes the number of TDMA time slots required to send the message and makes a request to the infrastructure for the slots. The infrastructure schedules the requested slots, and the scheduling is communicated to the subscriber via outbound signaling on the Enhanced Data channel. The subscriber then sends its message using the assigned scheduling, and each slot is acknowledged by the infrastructure over the air. Any slots of data that are not successfully acknowledged are retransmitted by the subscriber. Retries are performed until the infrastructure indicates the entire message has been successfully received or a predefined retry limit has been reached.

The Enhanced Data feature increases the safety of field users, by providing a practical outdoor tracking solution. The feature provides each active subscriber with an inbound data service for sending in periodic location and status updates. These short messages are used by dispatchers to track the radio users' status and location on Computer Aided Dispatch (CAD) consoles. Enhanced Data ensures a wide-area, mission-critical, portable and mobile coverage and offers a better utilization of the system resources. Enhanced Data is optimized for variable reporting rates and designed to support applications with message profiles similar to Location, such as PremierOne™ Responder Location.

The Enhanced Data feature can be used by Public Safety agencies, including police, fire, and EMS, as well as Transit agencies and city services, such as snow plow fleets.

2.1.2.5.1
Enhanced Data Service Capabilities

For details on the Enhanced Data Service capabilities and call processing information see the *Trunked Data Services* manual.

2.1.3
Call Processing Subsystem

The call processing subsystem, mobility management, Zone Controller (ZC) and interzone communication comprise the functional part of the ASTRO® 25 trunking system, with components primarily associated with the Master Site/ZC.

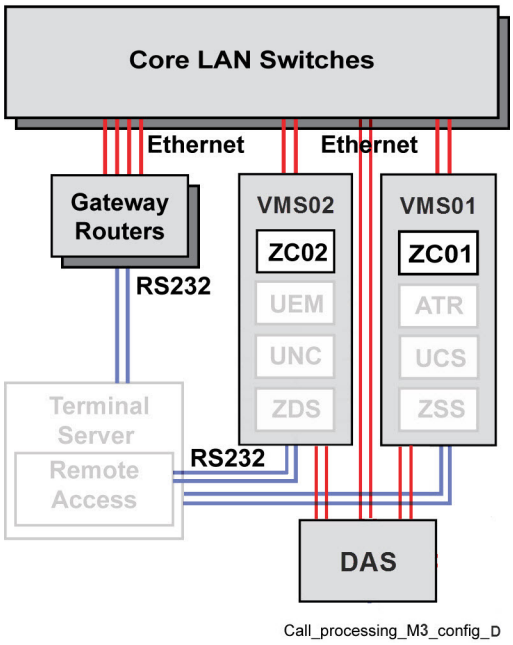
The ZC provides trunked call processing for RF subsystems and telephone interconnect subsystem devices. It is the central processing at the Master Site/Zone Core providing call processing and mobility management for the system. The ZC uses the subscriber radio or dispatch console Frequency Division Multiple Access (FDMA) or Time Division Multiple Access (TDMA) capability and subscriber radio location information to determine the talkgroup signaling type. The subscriber radio or dispatch registration indicates the FDMA or TDMA capability to ZC.

Talkgroup modes change from TDMA to FDMA during active talkgroup calls and are transmission trunked. Individual modes change form TDMA to FDMA during active calls and are transmission trunked.

The ZC provides adaptability to technology enhancements and better planning of future communication needs and migration. If a loss of wide-area communications is detected due to a failure internal to the active ZC, a redundant ZC configuration provides automatic switchover to the standby controller. Notification can be sent to the user if other components fail, allowing the user to manually switch to the standby ZC, if desired.

For call processing subsystems using Common Server Architecture (CSA), the ZCs are hosted in the Virtual Management Servers (VMS). The VMSs are based on the HP DL360 or HP DL120 hardware platform and provide a Virtual Machine (VM) environment for server applications.

Figure 3: Call Processing Subsystem CSA



NOTICE:
System Gateway devices provide an alternative solution to various routers in the system. See the *System Gateways – GGM 8000* manual for details.

See the *Dynamic System Resilience* manual for additional configurations.

2.2 Mobility Management

Mobility management describes the activities performed by the Fixed Network Equipment (FNE), management software, and the control software in the subscriber radios. These activities enable subscriber radio users to roam and communicate throughout the system without the need for user intervention.

During initial power-up, the subscriber radio uses its pre-programmed list of control channels to determine which of the available sites it locks on to. Subsequent power-up activity causes the subscriber radio to check its list of adjacent control channel for availability. Once locked on to a site, the subscriber radio attempts to register itself with the site. The FNE management software controls whether or not a subscriber radio is allowed to register. The system then keeps track of the location of that subscriber radio, and the talkgroup to which the subscriber radio is affiliated.

Mobility information allows the system to know the site and zone location of every active, registered subscriber radio. The system also knows which groups (both talkgroups and multigroups) have affiliated members, and their site and zone locations. When the system is aware of the locations of all users and their talkgroup affiliations, it is possible to identify the sites that need a voice channel assigned when a user presses the Push-To-Talk (PTT) button on their subscriber radio to make a call request.

For information on subscriber authentication and capabilities and features for controlling unauthorized subscribers to ASTRO® 25 trunked radio communication systems, see the *Radio Authentication* manual.

2.2.1 Registration

Registration is the means by which a subscriber radio makes its presence known to the Fixed Network Equipment (FNE) in a geographical area. The subscriber radio establishes and maintains a control channel link with the system as it moves from site to site within a zone, or from a site in one zone to a site in another zone.

Mobility management is discussed from the two different views comprising the overall process:

- The subscriber radio's view
- The FNE's view

In general, location information is used for site and group affiliations. When a subscriber radio registers or roams to a new site, the Zone Controller (ZC) checks whether the subscriber radio/talkgroup member is at a valid site, according to the valid site settings made in the Provisioning Manager (PM). If the subscriber radio is valid at the site, the ZC updates the location of the subscriber radio/talkgroup member in its mobility Home Location Register/Visitor Location Register (HLR/VLR) databases. For more information on subscriber authentication and capabilities and features for controlling unauthorized subscribers to ASTRO® 25 trunked radio communication systems, see the *Radio Authentication* manual.

For more information, see DDM Subscriber Radio User with Full and Location Registration on page 28.

2.2.2
Mobility as Viewed by the Radio

To a subscriber radio, the system is not about ASTRO® 25 repeater sites and IP simulcast subsystems, but is simply a collection of control channels and sites. The subscriber radio constantly monitors its RF environment and automatically switches to the best site available, based on received signal strength, internal programming, and responses to registration and affiliation requests sent to the Fixed Network Equipment (FNE).

2.2.2.1
Finding a Valid Control Channel

When a newly programmed subscriber radio enters the system, it references a preprogramming list of control channels to find a valid channel to lock on to. If the subscriber radio cannot find a valid control channel on the preprogramming list, it resorts to full spectrum scanning, if enabled, to find a channel.

2.2.2.2
Registration and Affiliation

When a valid control channel is found, the subscriber radio goes through a registration/affiliation request sequence. This sequence registers the subscriber radio with the system and affiliates the subscriber radio with the selected talkgroup or multigroup.

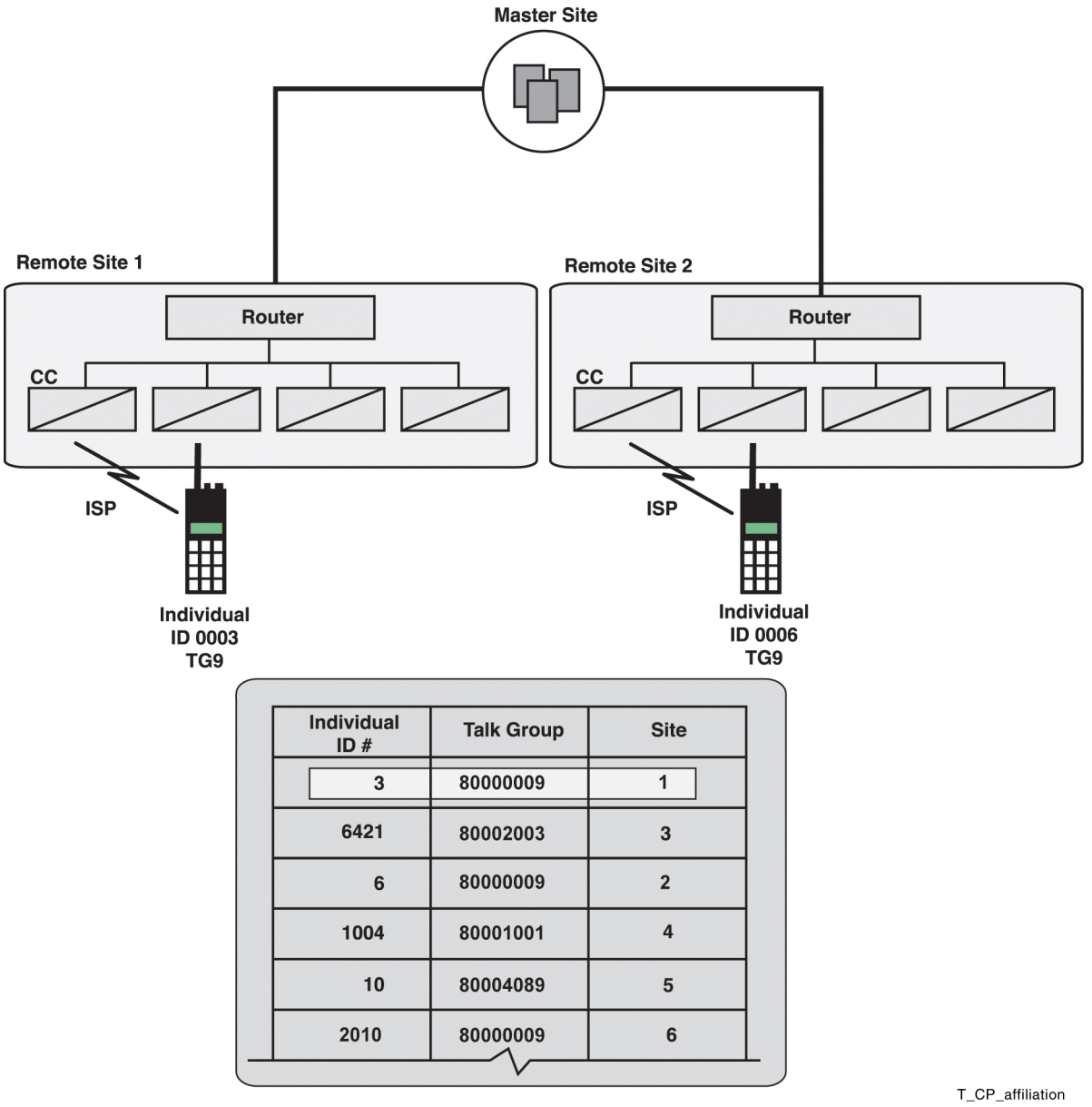
If the registration/affiliation is accepted by the Fixed Network Equipment (FNE), as defined by the Valid Sites and Access Denial settings, the subscriber radio sets the current site as its home site and is now ready to make and receive calls.

If the registration/affiliation request is not accepted by the FNE, as defined by the Valid Sites and Access Denial settings, the subscriber radio continues to search for a valid site and system, repeating the registration/affiliation request sequence each time a control channel with the correct frequency and acceptable signal strength is found.

If a subscriber radio is in a coverage area where it can receive outbound communication (system to subscriber radio), but inbound communication (subscriber radio to system) is not possible, the subscriber radio is not able to request services. The subscriber radio can provide notification of this condition to the user by means of a tone, the subscriber radio display, or a combination of tone and display.

Registration and affiliation is a logical path the registration takes between the subscriber radio and the zone controller.

Figure 4: Registration and Affiliation



2.2.2.2.1

Types of Registration and Affiliation Requests

A subscriber radio sends three types of registration/affiliation requests to the Fixed Network Equipment (FNE):

- Unit registration
- Group affiliation
- Location registration

2.2.2.2.2

Situations When a Radio Must Register/Affiliate

A subscriber radio makes registration/affiliation requests in three different situations:

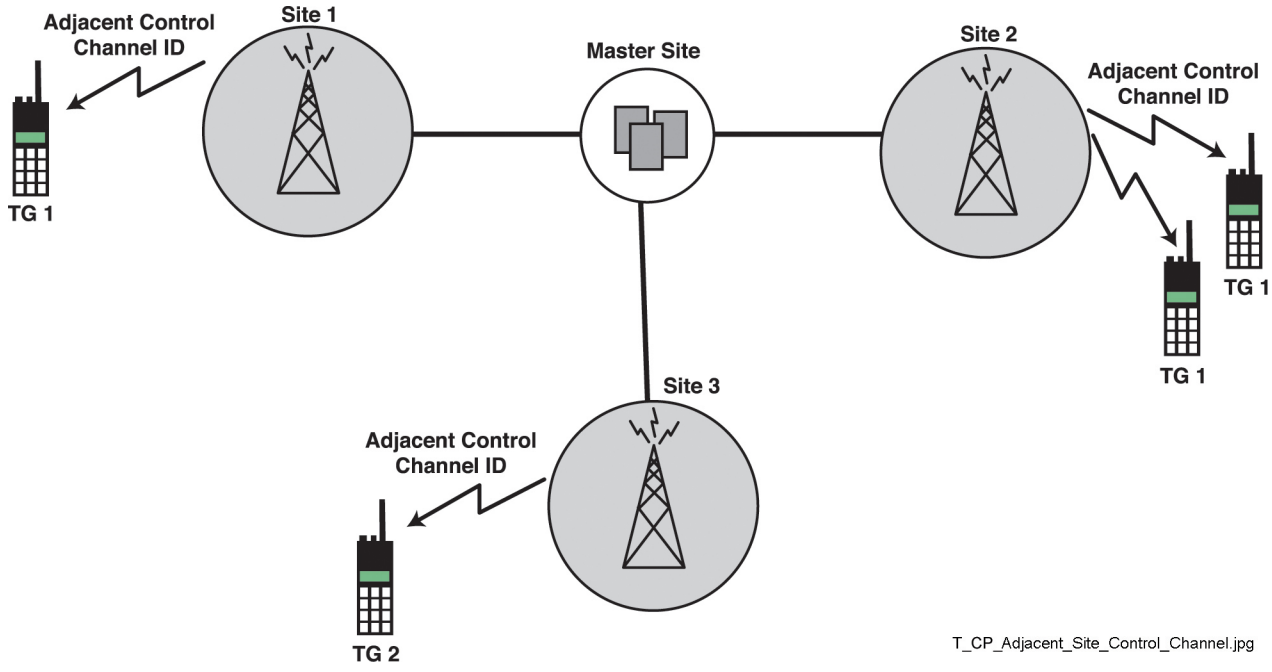
- When a subscriber radio initially enters the system or powers up, the subscriber radio performs a full registration (a unit registration followed immediately by a talkgroup affiliation).
- When the subscriber radio user changes the talkgroup selection, the subscriber radio sends only a talkgroup affiliation request because it is not necessary to reregister.
- When the subscriber radio switches sites, it performs a location registration. Essentially a compact version of a full registration procedure, location registration passes the individual ID to the Fixed Network Equipment (FNE). No talkgroup affiliation is necessary.

NOTICE: Subscriber radios in a system send a de-affiliation message when the user turns off the subscriber radio. The message causes the appropriate zone controller to take the subscriber radio off the list of active subscriber radios. Special circuitry allows the subscriber radio to send this signal before completely powering down.

2.2.2.3 Adjacent Site List Control Channel List

When a subscriber radio has registered at a site, it begins receiving Adjacent Site Broadcast (ASB) packets from the site. A site broadcasts ASB packets for each adjacent site to inform the subscriber radios of possible control channel availability. Adjacent sites are programmed in the Unified Network Configurator (UNC) Wizard (under **System Level Configuration** in the navigation tree). When the zone controller receives this information as part of the bulk download from the Provisioning Manager (PM), it sends the appropriate Adjacent Sites List (ASL) to the sites. The sites transmit the ASB packets to the subscriber radios. Upon reception of the packets, the subscriber radios build an ASL in their memory. In addition, each subscriber radio maintains a second dynamic list that contains the identification of up to three backup control channels at its current site.

Figure 5: Adjacent Site Information



When the ASL is populated, the subscriber radio periodically ranks the sites on the list. Each site is evaluated against a number of parameters comprising the overall quality value for the site. After each of these evaluation sequences, the subscriber radio checks the quality values of each site in the list. If an adjacent site has a higher quality value than the current site, the subscriber radio automatically switches to that better-quality site, registers with the system, and then makes the new site the home site. At the new home site, the subscriber radio begins receiving ASB packets, repopulates its ASL, and continues the process of evaluating and ranking the sites in the ASL.

2.2.2.4

Adjacent Site List and Adjacent Control Channels Requirements and Considerations

By default, the system is typically configured to identify up to seven adjacent sites. In some topologies, it is useful to expand the number of sites in the Adjacent Sites List (ASL). For some systems, the number of adjacent sites in the ASL can be expanded to 15 sites. Before the ASL can be expanded to 15 sites, the subscriber radios must be expanded Adjacent Site Broadcast (ASB) capable. That is, the subscriber radios must be able to accept the expanded number of sites. This setting is configured by the **Support Expanded ASB Capable** setting in the Unified Network Configurator Wizard (UNCW) (a **Yes/No** parameter).

XTS/XTL subscriber radio software was updated in the A6.4 (2005) time frame to be capable of expanded site list (up to 15 adjacent sites) operation. APX radios are all expanded site list capable. Set **Support Expanded ASB Capable** to **No** only if your system has XTS/XTL radios still operating with subscriber software older than the 2005 time frame.

Expanded ASB capability applies only to the subscribers located in ASTRO® 25 sites. Subscribers from sites connected through SmartX converters cannot be expanded ASB capable and should leave the default setting of **No** for **Support Expanded ASB Capable** in the UNCW **System Configuration** tab. Alternatively, this setting can be set to **Yes** with no more than seven adjacent sites defined for each SmartX site.

See the *UNC Wizard* online help for more information.

IMPORTANT: Use care when enabling the feature to expand the number of adjacent sites to 15. Problems can occur if this parameter is enabled when subscriber radios that have not been upgraded for this feature are on the system. For details, contact the Motorola Solution Support Center (SSC).

2.2.2.5

Radio Signal Strength Indicator

As part of its ranking evaluation, the subscriber radio samples the signal strength of each site in its Adjacent Sites List (ASL). Several samples for each site are averaged to create a filtered strength value for that particular site. The filtered value is compared against the Radio Signal Strength Indicator (RSSI) threshold values programmed into the subscriber radio. This comparison determines the signal strength value for the site. The five values are as follows:

- Excellent
- Very Good
- Good
- Acceptable
- Poor

The RSSI value is one of the parameters which determines a site's overall quality value. For example, an RSSI level of Poor dramatically lowers a site's quality value. If the current home site is rated Poor, and an adjacent site is rated Acceptable or better, the subscriber radio switches to the better site.

If all sites in the ASL are ranked with at least one Acceptable RSSI value (and all other ranking parameters are the same), the RSSI value must move up at least two levels before a site switch occurs. For example, an RSSI value must move from Acceptable to Very Good, or a Good level must move to Excellent before it causes a subscriber radio to switch sites.

2.2.2.5.1

RSSI Example Scenario

Following is an example of a typical Radio Signal Strength Indicator (RSSI) scenario:

- A subscriber radio user moves through the coverage area of one site into the coverage area of an adjacent site.
- All ranking parameters (other than RSSI) are the same between two sites.
- The RSSI value of the current home site begins to drop, while the RSSI value of the adjacent site begins to rise.
- At some point, the quality values change sufficiently to influence the overall quality value for each of the two sites, and the subscriber radio then switches from the current home site to the new site.

2.2.2.6
Preferred Site

Preferred site is another contributing parameter to the overall quality value of sites in the Adjacent Sites List (ASL). This parameter is programmed into the subscriber radio with one of four settings:

- Always Preferred
- Preferred
- No Preference
- Least Preferred

While each of the four settings can influence a site's quality value, they cannot individually cause a subscriber radio to switch to another site. For example, a subscriber radio switches to a Least Preferred site with an excellent Radio Signal Strength Indicator (RSSI) value over a Preferred site with a Poor RSSI value. However, if both sites have the same RSSI value, the subscriber radio selects the Preferred site over a No Preference or Least Preferred site.

NOTICE: A subscriber radio cannot be forced to go to a particular site based on the programming in the subscriber radio. Too many factors are involved in determining the quality value for a site. If necessary, ensure that a subscriber radio does not go to a specific site by using the valid site and site access denial settings in the Provisioning Manager (PM) application.

A setting of Always Preferred has a much greater impact on determining the quality value for a site than the other preferred site settings. A subscriber radio attempts to stay at an Always Preferred site until the RSSI value drops to Poor.

2.2.2.6.1
Site Preference During Site Trunking

If a site loses contact with the Master Site/Zone Core, it enters site trunking (subscriber radios at the site can communicate only with subscriber radios registered at this same site). A subscriber radio programmed with that site as Always Preferred stays at that site (assuming at least one Acceptable Radio Signal Strength Indicator (RSSI) value). For any other site preference setting, the subscriber radio attempts to switch to a wide-area site when the current site goes to site trunking.

2.2.2.7
Timing of Site Switches

For the subscriber radio user, Radio Signal Strength Indicator (RSSI) sampling, and site switching are transparent and require no user intervention. If the subscriber radio is idle on the control channel and the indicators determine it must register at another site, the subscriber radio simply changes to a control channel from its Adjacent Control Channel (ACC) list and completes a location registration.

A subscriber radio does not switch sites while it is transmitting on a voice channel. If the subscriber radio user is transmitting at the time a site switch becomes necessary, the subscriber radio waits to switch sites until the user releases the Push-To-Talk (PTT) button.

2.2.2.7.1

Site Trunking – User Requested Compared to Non-User Requested

When a site enters site trunking due to a network management user request, the site controller immediately informs the subscriber radio. The Site Trunking Indicator Holdoff Timer (STIHT) is not used to delay notification of the site trunking mode of operation to the subscriber radios.

When a site enters site trunking due to a situation other than a network management user request, the site controller uses the STIHT to slightly delay notification to the subscriber radios about the site trunking condition. Site trunking notification is sent when the STIHT expires.

2.2.2.7.2

Random Holdoff Timers

When a site goes into site trunking mode, subscriber radios registered at the site and with their internal site preference parameter set for other than Always Preferred try to leave and find another site still in wide-area trunking mode. If a large number of subscriber radios all try to switch at once, as could be the case if the current site goes into site trunking, the inbound control channel of adjacent sites may flood with registration request packets. Random Holdoff Timers (RHOTs) are designed to prevent this.

RHOTs spread out the registration requests over a longer time period. RHOTs force a subscriber radio to calculate a random value that determines when that subscriber radio attempts to register at the new site. Since each subscriber radio comes up with a slightly different value, the registration requests are spread out, and the inbound control channel of adjacent sites do not become overloaded.

2.2.2.7.3

Types of Random Holdoff Timers

Two Random Holdoff Timer (RHOT) values are used with subscriber radios:

- Failure Random Holdoff Timer (FRHOT) is the time value sent by wide-area sites adjacent to a failed site. It controls the time within which a subscriber radio attempts to randomly register at an adjacent site when the current home site transitions to site trunking or directly to Site Failsoft. The subscriber radios must wait from a random time up to when the FRHOT time expires before it can register to an adjacent wide-area site. This value is configured at the site level and transmitted to the subscriber radios listening to the control channel.
- Recovery Random Holdoff Timer (RRHOT) is the time value sent by wide-area sites adjacent to a site which has recovered. Subscriber radios are allowed to roam back to the recovered site in a random time period up to the time period specified by the RRHOT. This value is configured at the site level and transmitted to the subscriber radios listening to the control channel. The use of FRHOT and RRHOT is illustrated in the following example:
  - A site goes into site trunking due to a network transport failure. The subscriber radios at the site switch to an available adjacent site and randomly register based on the FRHOT time period.
  - The network problem is quickly corrected and the failed site transitions back to wide area. Because this site has a better signal quality, radios that had left the site attempt to return.
  - Each subscriber radio attempts to switch back to the restored site randomly within their programmed RRHOT value.

2.2.2.7.4

Random Holdoff Timer Value Settings

The Random Holdoff Timer (RHOT) values are set in the ASTRO® 25 repeater site and IP simulcast subsystem records in the Unified Network Configurator (UNC). The range is 1 to 60 minutes, and the default value for these timers is set to 16 minutes which is sufficient to cover most situations. If a need to adjust the timers to cover a special case occurs, the following guideline is recommended.

Choose a Failure Random Holdoff Timer (FRHOT) and Recovery Random Holdoff Timer (RRHOT) value equivalent to the maximum number of subscriber radios at the site, multiplied by one second. For example, if a maximum number of 900 subscriber radios affiliate to the site is expected, set the timer for 15 minutes (900/60 seconds). This period accommodates one location registration per second at the site in addition to the normal requests for service.

NOTICE: Calculated values may be rounded to the next available time increment.

2.2.3
Group Call Handoff TDMA

A subscriber radio in Time Division Multiple Access (TDMA) mode maintains all types of group calls automatically when it roams into any Dual-Phase site in the system. When a subscriber radio engages in a TDMA group call and roams to a Frequency Division Multiple Access (FDMA)-only capable site, the call is transmission trunked and the FDMA-only capable site is included in an FDMA call.

The dynamic operation adds a user back into a call on the next call start. Active subscriber radios in TDMA mode calls for dynamic talkgroups that roam into an FDMA-only capable site and are transmission trunked. The group calls are started in FDMA mode upon the next new call.

Group calls on talkgroups configured as TDMA-only are not transmission trunked. The subscriber radio is not added into the call and the call continues as normal.

NOTICE: When a participating site or foreign system must grant a TDMA call, while another participating site or foreign system must grant an FDMA call, the group call must be transcoded. Transcoding is only allowed on dynamic talkgroups, dynamic supergroups, dynamic agencygroups, or dynamic multigroups. See*Dynamic Transcoder User Guide* manual for details.

2.2.4
Mobility as Viewed by the Fixed Network Equipment

The Fixed Network Equipment (FNE) has two functions in mobility management:

- To respond to the registration/affiliation requests from subscriber radios
- To track the current zone/site location of each registered individual subscriber radio and each affiliated talkgroup member

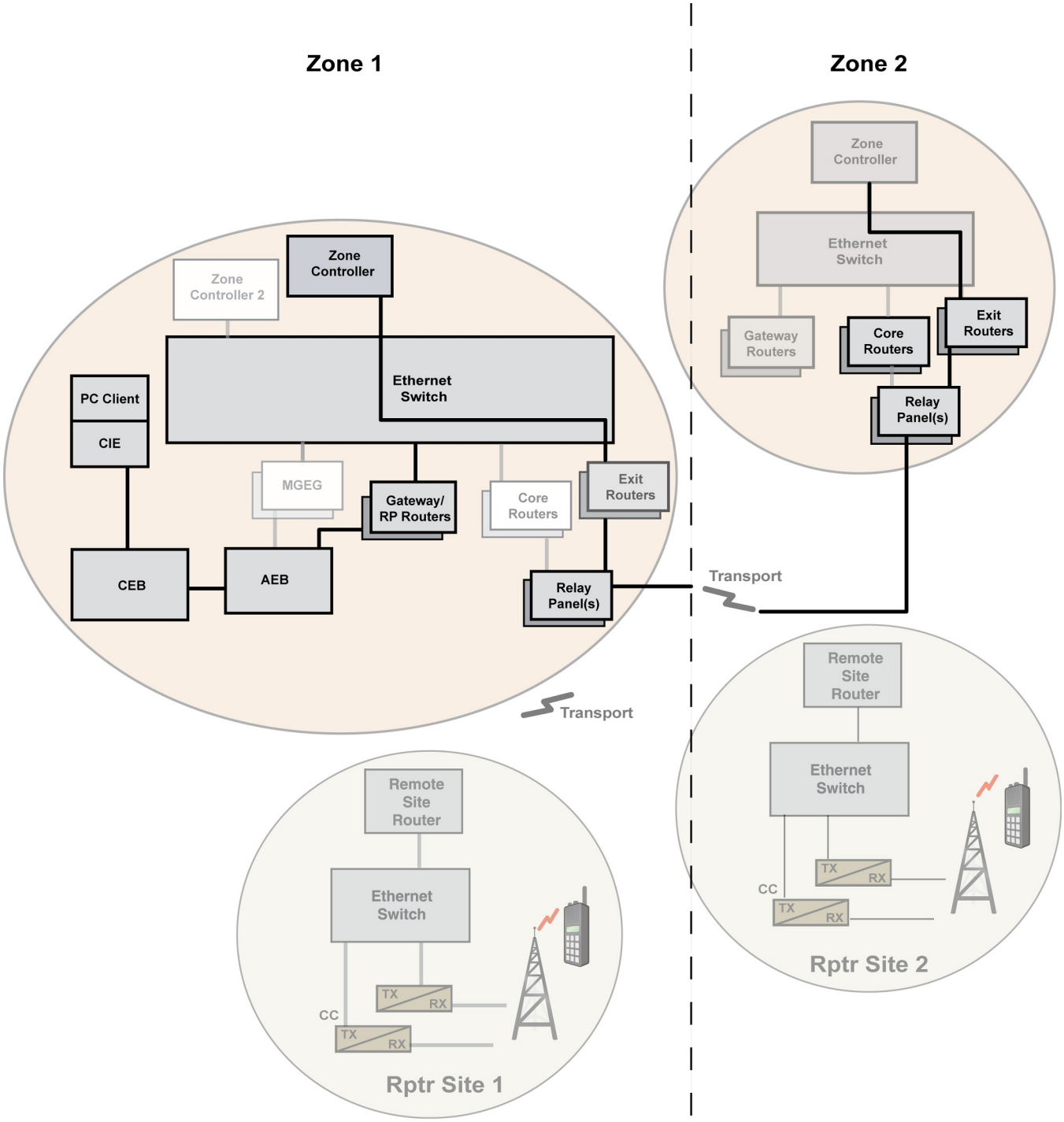
To respond to registration/affiliation requests from a subscriber radio, the FNE in a zone where the subscriber radio is registering needs a copy of the access control information for that individual and/or group. The FNE in each zone also needs a place to store the site location of a subscriber radio and group member.

2.2.5
Zone Controller InterZone Communications

In a system with more than one zone, each Zone Controller (ZC) communicates with the ZCs in the other zones to coordinate multizone calls, determine InterZone trunking status relative to each other, and share mobility information. Each ZC communicates with other zones via the exit routers through two InterZone Control Paths (IZCPs) between each pair of zones. The ZC has redundant Ethernet links to the Master Site Ethernet/Site LAN switch through the gateway routers. An IZCP to each zone is associated with each of the two gateway routers. The ZC uses these links to send command messages through the exit routers. One of the exit routers transports the messages encapsulated in frame relay packets in the destination zone.

NOTICE: When one participating site or foreign system must grant a TDMA call while another participating site or foreign system must grant an FDMA call, the group call will need to be transcoded. The transcoding is only allowed on dynamic talkgroups, dynamic supergroups, dynamic agencygroups, or dynamic multigroups. See the *Dynamic Transcoder* manual for details.

Figure 6: Multizone Call Services



NOTICE: System gateway devices provide an alternative solution to various routers in the system. See the *System Gateways – GGM 8000* manual for details.

2.2.5.1
Dynamic Frequency Blocking

The Dynamic Frequency Blocking (DFB) feature applies only to RF sites/subsystems in wide-area trunking mode. This feature allows ASTRO® 25 systems to operate with a small number of inter-channel interferences. The interferences are dynamically avoided by coordinating the use of channels known to interfere with channels at other sites in the system.

The system allows either a Frequency Division Multiple Access (FDMA) or Time Division Multiple Access (TDMA) call to block the assignment of the same frequency (DFB support) at an adjacent site that has been configured as a DFB-contending channel.

DFB continues to work on a channel basis, independent of FDMA or TDMA assignments.

The FDMA or TDMA calls are assigned to a DFB-capable channel. A single TDMA call on an interfering channel blocks the entire channel.

2.2.5.2
FDMA/TDMA RF Access Protection

The system provides an access protection method similar to conventional Private Line/Digital Private Line (PL/DPL) for RF protection between sites and subscriber radios for both Frequency Division Multiple Access (FDMA) and Time Division Multiple Access (TDMA) calls. This access code capability mitigates interference between subscriber radios and RF sites.

The Dynamic Network Access Code (DNAC) is used by RF sites and subscriber radios in the FDMA and TDMA mode.

A subscriber radio user uses the NAC learned from the control channel at a site and applies it to qualify the voice channel signaling. The site uses the NAC to qualify the inbound subscriber audio. TDMA also uses this NAC.

P25 TDMA combines the 20–bit Wide Area Communication Network (WACN) ID, the 12–bit system ID, and the 12–bit NAC to form a scrambling seed used for P25 TDMA channel access qualification.

In Motorola systems, the upper 8 bits of the NAC match the upper 8 bits of the system ID. The lower 4 bits of the NAC are configured by the system administrator on a site-by-site basis. The lower 4 bits of the NAC are also called the Access Code Index (ACI). A maximum of 16 unique NACs are available on a Motorola P25 trunking system. NACs are used on a per-site/per-simulcast subsystem basis, and may be reused within a system with geographic separation.

For compatibility with Harris radio system infrastructure where the upper 8 bits of the NAC may be independent of the system ID, the Motorola subscriber radio can be optionally configured to not validate the upper 8 bits (system ID part) of the NAC.

2.2.6
InterZone Communication Controlling Zone

Assignment of a controlling zone for InterZone call services is based on the type of call. For multizone individual calls, the zone location of the subscriber radio that first transmits the audio becomes the controlling zone for the call, while the zone of the call recipient becomes the participating zone. For talkgroup calls, the home zone of the talkgroup, as defined in the Group Home Locations Register (GHLR) in the group's home zone, becomes the controlling zone, and all other zones with talkgroup members become participating zones.

Throughout the call, all control data and audio are routed from the originator's zone to the controlling zone, and then the audio is routed from the controlling zone to all participating zones. The controlling zone controller is responsible for managing the call and organizing all participating zone controllers into the call.

2.3

Home Location Register and Zone Controller

A Home Location Register (HLR) is a database for a Zone Controller (ZC) and Packet Data Router (PDR). Because the home zone is responsible for controlling all voice group calls for a talkgroup, the ZC coordinates the assignment of resources based on the home zone map and the information stored in its HLR and Visitor Location Registers (VLR). The PDR uses the HLR in a similar manner.

When a system is first installed, home zone subscriber radio and talkgroup information is entered into the Provisioning Manager (PM). When this data is entered for all the zones in the system, each subscriber radio and talkgroup is assigned a home zone.

NOTICE: The PM is a single point of data entry for the entire system to prevent any mismatched records. The talkgroup consists of the information that identifies a group of radios that communicate and interact with each other in the system. The HLR supports up to 128,000 subscriber unit IDs. The per-zone mapping is limited to 64,000 subscriber units IDs. This group can also be a small subset of a multigroup. The talkgroup object has two default records: SZ $INIT and SZ$DEF. Talkgroup IDs are 8–digit decimal numbers, beginning with 80000001. Talkgroups and multigroups are created from the same pool of 8–digit decimal numbers. The PM keeps a zone- and system-level count of the number of subscriber unit IDs and disallows distribution of the subscriber data if these limits are exceeded. For detailed information on home zone mapping, talkgroup ID ranges and subscriber ID limit check, see the *Provisioning Manager* manual.

The home zone information for a particular zone is transferred to that zone's ZC in the form of an HLR. The same HLR is also transferred to the PDR module in the packet data gateway. The PDR module uses the HLR to process data calls in a similar way that the ZC uses the HLR to process voice calls.

An HLR for each zone contains subscriber radio and talkgroup information (home zone information) designated for that zone. The HLR database includes the following information:

- Privileges and capabilities of subscriber radios
- Current zone location of subscriber radios
- Talkgroup affiliation of subscriber radios
- Capabilities of talkgroups
- Current zone location of talkgroups

The HLR comprises two components:

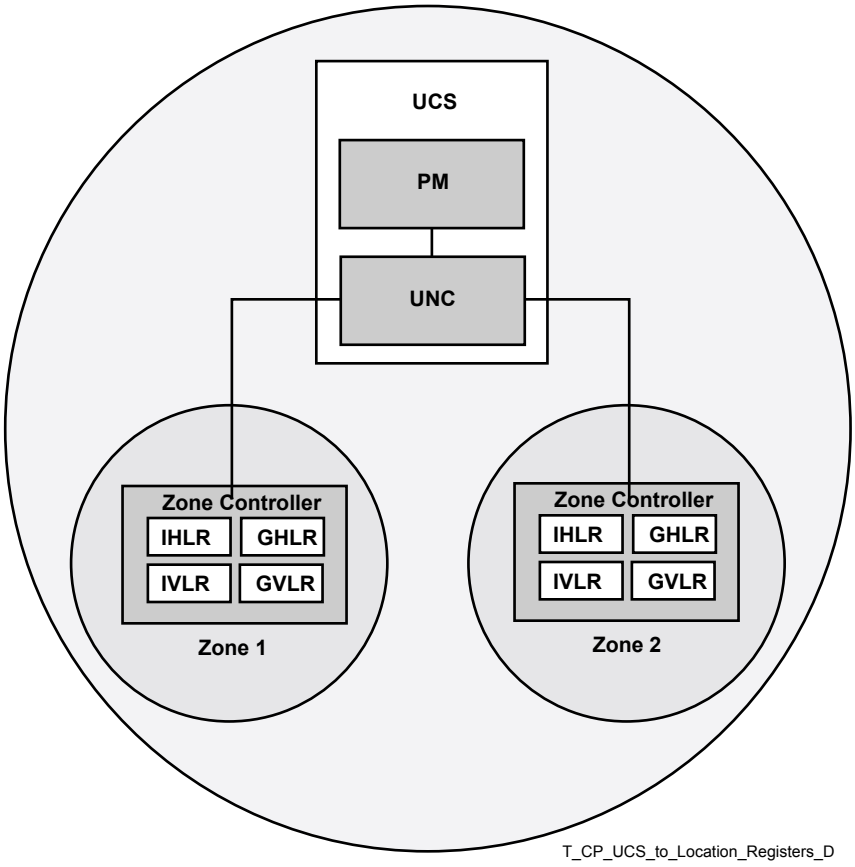
- The Group Home Locations Register (GHLR) stores information about groups.
- The Individual Home Location Register (IHLR) stores information about subscriber radio users.

2.4

Visitor Location Register and Zone Controller

The Visitor Location Register (VLR) is a zone controller database containing information on all subscriber radios currently affiliated to the sites at a zone. The VLR manages a local copy of zone-specific information for individuals and talkgroups, including subscriber radio database information and site location information for both the individual and the talkgroup. Each zone has an Individual VLR (IVLR) and a Group VLR (GVLR).

Figure 7: User Configuration Server to Location Registers Relationship



2.4.1

Creating the Location Registers

The system uses a distributed processing architecture that shares the call processing load between all the zone controllers (ZC) in the system. To enable this process, the responsibility of storing (and using) the configuration information is also spread among the zones in the system. Each individual and group ID is assigned to a zone based on ID ranges in the home zone mapping object in the Provisioning Manager (PM).

The zone assigned to a particular ID is said to be that ID's home zone. The home zone to which an ID is assigned impacts system operation in the following ways:

- Configuration information is distributed throughout the system based on the ID's home zone assignment. The ZC stores the entire database.
- For group call services, the home zone of the group is always the controlling zone for the call, regardless of the zone where the group member is registered. Depending on system configuration, this can impact the number of interzone calls versus the number of single-zone calls that take place in the system. This impact, in turn, can affect the number of interzone resources needed between any two pairs of zones.

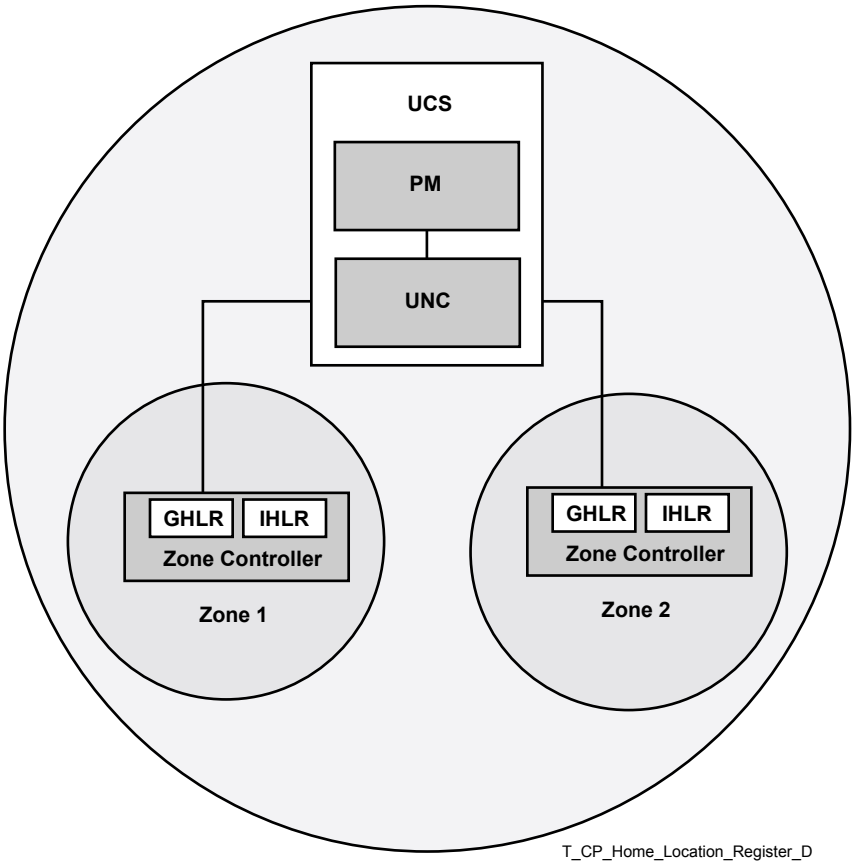
User configuration information is sent through a bulk distribution of data between the PM and the ZC through the Unified Network Configurator (UNC). The PM builds a file for the ZC. The PM maintains a persistent store of the pending updates in this file. The UNC sends updated configuration data to the PM when an update to the data needed by the PM is made. When the PM receives updated configuration data from the UNC, it updates the relevant views automatically. User data shared between the UNC and the PM is managed by the UNC. When users initiate a PM database synchronization from the UNC, the UNC sends the common UNC/PM parameters to the PM (for

example, WACN ID, SYSTEM ID, Default Access Permission, Site Access Denial). Then, the PM shares the information with the ZC (and other devices).

To determine the status of the active home zone map in the system, use the UNC view of **Home Zone Map** status. See the *Unified Network Configurator* manual for more information.

Whenever any individual or group configuration information is needed by any zone, it gets that information from the Home Location Register (HLR) in the individual's or group's home zone.

Figure 8: Home Location Register

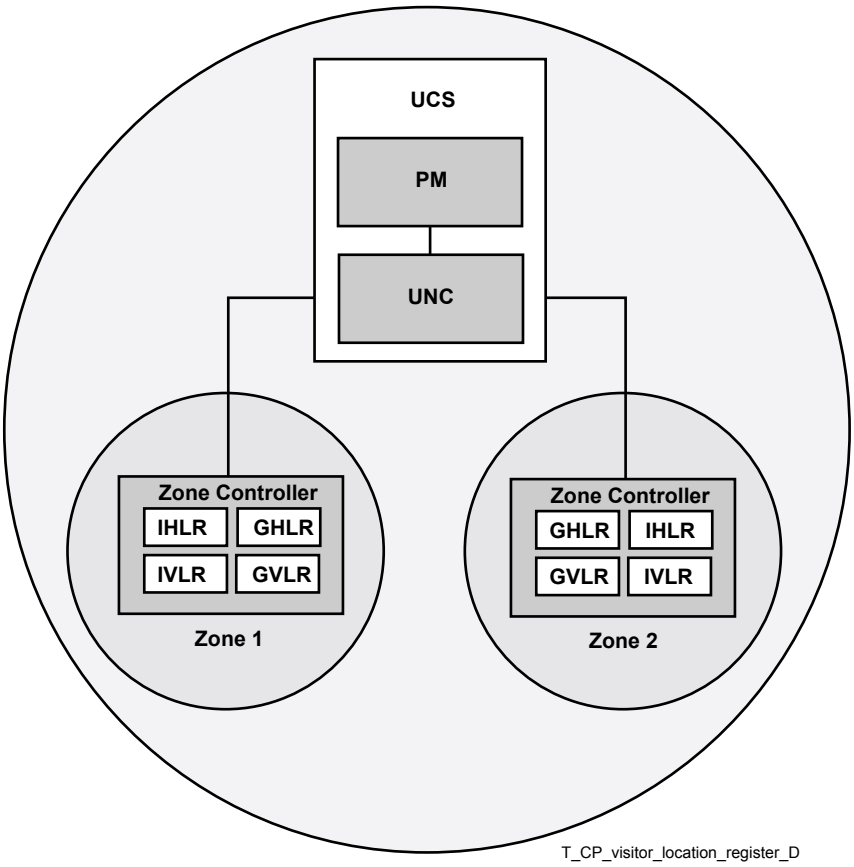


When the HLR receives its information from the PM and HLRs from other zones, the system uses a specialized database, called the Visitor Location Registers (VLR), in each ZC to track the activity of subscriber radios currently active. A VLR stores access configuration information for both individuals and groups along with the current site location of the individual or group member.

NOTICE: The two types of VLRs are:

- Individual VLRs store access configuration information and current site location for each registered individual subscriber radio in the zone.
- Group VLRs store access configuration information for a group that has affiliated members in the zone along with the site location of each affiliated member.

Figure 9: Home Location Register - Visitor Location Register



NOTICE: All operator positions monitoring a talkgroup and the logging recorders are assigned to a talkgroup affiliated with the system. Thus, operator positions and logging recorders have entries in a zone's VLR.

2.4.2
Tracking Location

Location information is kept in two parts in two places:

- The Home Location Register (HLR) in the home zone tracks the individual/group's current zone location. For groups, the group HLR tracks which zones have affiliated members.
- The Visitor Location Register (VLR) in the local zone tracks the individual/group's current site location. For groups, the group VLR tracks which sites have affiliated group members.

When a subscriber radio roams to a new site within the current zone, only the VLRs in that zone are updated with the new site location. When the subscriber radio roams to a site in a new zone, the individual VLR in the new zone requests the individual access control record from the appropriate individual HLR. If no other affiliated group members are in the new zone, the group VLR in the new zone also requests the group access configuration information from the appropriate group HLR. If no other affiliated group members are in the new zone, the group HLR simply updates its list of sites with the members. The group's HLR already knows that members are in that zone.

When a VLR requests the configuration information from an HLR, the HLR also updates the current zone location for the individual and/or group. The zone location in the HLR is updated before the local zone has serviced the registration/affiliation request. If the request is accepted, the VLR in the zone is updated, and the HLR stays as it is. If the request is denied, the local zone sends a de-affiliation message to the appropriate HLR, which then removes the location tracking information from that

individual. For a group, if the subscriber radio being de-affiliated is the last group member in that zone, the zone is removed from the HLR's list of zones with members.

2.4.2.1
Handling Registration/Affiliation Requests

A number of circumstances can cause a subscriber radio to send in a registration/affiliation request. For example, the user turned on the subscriber radio, or the subscriber radio automatically switched sites. From the Fixed Network Equipment' (FNE) view, it services requests and responds to them based on the access configuration information.

The FNE in the zone that receives a request uses part of the access configuration information from the appropriate Visitor Location Register (VLR) in that zone (either individual or group).

NOTICE: The access configuration information also defines which call services can be used by a subscriber radio once it is registered at a site and affiliated to a talkgroup.

2.4.2.2
Getting the Access Configuration Information

When the Fixed Network Equipment (FNE) in a zone receives a registration/affiliation request, it first checks in the appropriate Visitor Location Register (VLR) (individual or group) to see if an entry exists for that subscriber radio/group. If an entry exists, the FNE services the request. If an entry does not exist, the FNE requests configuration information from the appropriate Home Location Register (HLR) in the individual/group's home zone. (The two HLR types are an individual HLR and group HLR).

The home zone for a particular individual or group is found in a map table distributed to all zones from the User Configuration Server (UCS). The two map types are an individual-to-home zone map and a group-to-home zone map.

Once the VLR has the appropriate access configuration information, the FNE in that zone evaluates the request and sends either an accept or reject reply to the subscriber radio.

A VLR keeps the configuration and location information only as long as a registered subscriber radio/ group member is in the zone. If a subscriber radio roams to a site in a new zone, the VLR in the new zone gets the appropriate configuration information and starts tracking the location. The individual VLR in the previous zone (the one the subscriber radio left) deletes its entry for that subscriber radio. The group VLR in the previous zone deletes the site location for that group member. If the subscriber radio that just roamed was the last affiliated group member in the old zone, the group VLR also deletes the group access configuration information.

2.4.2.3
Checking for Valid Site

For a subscriber radio to be able to operate at a site, the subscriber radio must receive an accepted response from the Fixed Network Equipment (FNE) to a registration or affiliation request. When the FNE receives a registration/affiliation request, the system accepts or denies the request based upon the valid site settings for the individual subscriber radio and/or group, and the settings of the Site Access Denial parameter.

2.5
Dynamic System Resilience and Call Processing

For systems using the Dynamic System Resilience feature, see the *Dynamic System Resilience* manual for the call processing scenarios specific to that feature in the event of a catastrophic system failure.

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Chapter 3

Trunked Call Processing Configuration

This chapter details configuration procedures relating to call processing.

3.1 Call Processing Hierarchy

Separate hardware and software components in the ASTRO® 25 system work together to process calls. Two system perspectives help to understand call processing:

- Physical System Perspective: A hierarchical subsystem and component view of the system focusing on how system components and subsystems physically connect to handle voice, control, and data signals to process a call.
- Logical System Perspective: A functional view of the system focusing on how system hardware and software components work together to handle voice, control, and data signals to process a call. The logical perspective describes how system configuration affects call processing, how the system tracks mobile subscriber radios as they roam throughout the coverage areas, and how the system processes the call requests from Mobile Subscriber Unit (MSU).

NOTICE: This information focuses on a logical perspective of the system. Diagrams supporting the logical view of the system show a functional relationship of system components and subsystems. Do not confuse logical diagrams with physical diagrams designed to support the physical view of the system, showing how system components and subsystems are connected.

From a logical perspective, the Master Site/Zone Core in an ASTRO® 25 system is the center of call processing. The Master Site/Zone Core provides the following functions:

- The Zone Controller (ZC) processes requests for registration, individual dispatch calls, group dispatch calls, and enhanced telephone interconnect calls. The ZC validates the requests and assigns the resources required to set up call services.
- The subsystem is a logical infrastructure subsystem which provides the subscriber radio and user information necessary to coordinate the resources for different types of calls.
- Network transport equipment at the Master Site/Zone Core (routers, switches, and so on) provides the IP connectivity to set up network communication paths to process calls. Network transport equipment makes it possible to send voice through the system as IP packets.

3.2 Call Processing Configuration Information

Configuration information is the foundation upon which all other aspects of call processing are built. Configuration information, from a hierarchical perspective, is established at the system, zone, and site level. Configuration information is included for the subscriber radios, Console Database Manager, servers, and console positions.

The following types of configuration information are identified:

Infrastructure Configuration

Infrastructure configuration information defines how the underlying Fixed Network Equipment (FNE) handles signal flow. For example, this type of configuration determines which site, and zone

resources are assigned to a call. In general, this type of configuration is handled by Motorola personnel before and during system installation.

Infrastructure Configuration
Static user configuration information for call processing support identifies system users and services.

Dynamic User Configuration
Dynamic configuration information for call processing support includes tracking and mobility management information. Tracking and mobility management information, based on user configuration and location information, changes frequently and is handled automatically by the system.

NOTICE: System gateway devices provide an alternative solution to various routers in the system. See the *System Gateways – GGM 8000* manual for details.

3.2.1
Call Processing Configuration for Dynamic Dual Mode Capability

This section provides configuration information for systems using the Dynamic Dual Mode (DDM) (without transcoding) functionality .

NOTICE:
The Dynamic Transcoding feature supports group call and unit-to-unit communication between FDMA subscriber radios on one site with TDMA subscriber radios on a separate TDMA-capable site while preserving the FDMA and TDMA modes of operation at each respective site. The Dynamic Transcoding feature also supports group call and unit-to-unit communication between subscriber radios on an FDMA-only site with TDMA subscriber radios in a TDMA-capable site while preserving the FDMA and TDMA modes of operation at each respective site.

3.2.1.1
Zone Controller Software

The software configuration is modified for Dynamic Dual Mode (DDM) capability:

- The Provisioning Manager (PM) identifies talkgroup, multigroup, and agencygroups in Frequency Division Multiple Access (FDMA)-only, Time Division Multiple Access (TDMA), or DDM access mode.
- Unified Network Configurator (UNC)
- ZoneWatch
- Affiliation Viewer
- Radio Control Manager/Computer Aided Dispatch Interface (RCM/CADI)
- Historical Report
- Dynamic Report

For FDMA-only multigroups, any type of talkgroup (FDMA-only, TDMA-only, and DDM) is allowed to be a part of the multigroup. The Zone Controller (ZC) assigns the multigroup call in FDMA mode. Any type of subscriber radio of the multigroup, regardless of FDMA-only or TDMA-only talkgroup affiliation, receives the FDMA multigroup transmission.

For dynamic multigroups, the FDMA-only, TDMA-only, or dynamic talkgroups are allowed to be a part of the multigroup. The ZC assigns the multigroup call in FDMA or TDMA mode based on affiliated members and sites of talkgroups that are part of the multigroup.

For TDMA-only multigroups, TDMA-only and dynamic talkgroups are allowed to be a part of the multigroup. FDMA-only talkgroups are not allowed as a TDMA-only multigroup is transmitting in TDMA mode.

3.2.1.2
Zone Controller Configuration

The Zone Controller (ZC) is configured to support Dynamic Dual Mode (DDM) (without transcoding) operation that tracks and manages the Frequency Division Multiple Access (FDMA) or Time Division Multiple Access (TDMA) call resource assignments. The ZC determines the talkgroup mode based on the capability and current location of the affiliated subscriber radio or capability of the dispatch console. The ZC determines the signaling mode by using the following:

- Subscriber radio registration information
- Dispatch console registration information
- RF site capability

NOTICE: The ZC does not require a preconfigured IP address for the Unified Event Manager (UEM).

To determine the talkgroup signaling mode, the ZC uses the following information:

- FDMA-only, TDMA-only, or DDM attributes
- Subscriber radio or dispatch console capability
- Subscriber radio location information

The ZC transmission trunks active talkgroup calls when the talkgroup mode must change from TDMA to FDMA during an active call.

NOTICE:
The Dynamic Transcoding feature supports group call and unit-to-unit communication between FDMA subscriber radios on one site with TDMA subscriber radios on a separate TDMA-capable site while preserving the FDMA and TDMA modes of operation at each respective site. The Dynamic Transcoding feature also supports group call and unit-to-unit communication between subscriber radios on an FDMA-only site with TDMA subscriber radios in a TDMA-capable site while preserving the FDMA and TDMA modes of operation at each respective site.

3.2.1.3
Provisioning Manager

The Provisioning Manager (PM) requires updates to talkgroup, multigroup, and agencygroup objects to support the Dynamic Dual Mode (DDM) feature.

3.3
Call Processing Static User Configuration

Static user configuration information for call processing support identifies individual subscriber radios and talkgroups that use the system, and identifies the services the system must provide to those individual subscriber radios or talkgroups. The static user configuration information is referenced by the system each time a subscriber radio attempts to register to a site and/or affiliate with a talkgroup.

Static user configuration information is entered in four places:

- The User Configuration Server (UCS) receives user configuration data through the Provisioning Manager (PM) application where data records are built for subscriber radios, radio users, talkgroups, multigroups, and agencygroups. Parameters affecting the operations of all subscriber radios in the system including site access denial are also entered in the PM application. Updates made in PM are available to the Unified Network Configurator (UNC) before they are active in the system. For more information, see the *Provisioning Manager* manual.
- The subscriber radios information is entered through their specific programming software.
- The UNC receives the user configuration records from the PM. Once the job is approved, the updates are distributed through the UNC upon user request. Before this distribution, the Zone

Controller (ZC) is running on default records. For more information on distributing the records and forced initialization of the ZC, see the *Unified Network Configurator* manual.

Static configuration information may be divided into four parts:

- Home zone assignment for individual subscriber radio and talkgroup IDs
- Identification numbers and aliases for individual subscriber radios and talkgroups
- Call services and system features allowed for an individual subscriber radio or talkgroup
- Valid site settings for each individual subscriber radio and talkgroup

IMPORTANT: Configuration information must be consistent when programming the PM, subscriber radios, and consoles.

NOTICE: Valid site settings, in conjunction with the system-wide **Site Access Denial** setting (see System Information on page 83) play an important role in mobility management when a subscriber radio attempts to register or when a group member attempts to affiliate to a site.

3.3.1
Default Access and Default Records

Normally, system recognition of a subscriber radio attempting to access the system is achieved after a subscriber radio record is configured and established through the Provisioning Manager (PM) application. However, default access is a system condition, configured for a zone using the Unified Network Configurator (UNC) that allows subscriber radios to access the communication system using a default configuration record when no configuration information is available. Under default access, when a subscriber radio attempts to access the system, a default configuration record is automatically assigned to the subscriber radio. This default record provides the subscriber radio with a predefined set of call services and permissions.

NOTICE: Default access allows all subscriber radio users and talkgroups to access the system with a predefined set of permissions. Individual control of default access for a subscriber radio user or talkgroup is not possible. This operating mode is not recommended under normal operating conditions.

The zone configuration option in the UNC configures and manages the attributes relating to a specific zone. The zone controllers use these parameters to allocate resources. The zone configuration information is sent to the PM through the UNC.

Two fields determine whether subscriber radios are allowed to access the system only if they have a record in the PM, or whether they can access the system under default conditions using a default record. These fields are the Individual Default Access Permission and Talkgroup Default Access Permission.

3.3.1.1
Individual Default Access Permission

This parameter can be set to **Yes** or **No**.

- **Yes** indicates that a zone can automatically create a record in the IV&D radio object, located in the Provisioning Manager (PM), using default settings for new subscriber radios that contact the system (affiliations). The new IV&D radio record appears in the database as ZC$RADIO ID.
- **No** indicates that under normal operating conditions, a new subscriber radio cannot access the system until a record is manually entered in IV&D radio or High Performance Data (HPD) radio objects in the PM. Any requests from new subscriber radios are rejected.

3.3.1.2
Talkgroup Default Access Permission

This parameter can be set to **Yes** or **No**.

- **Yes** indicates that a zone can create a talkgroup record in the talkgroup object, located in the Provisioning Manager (PM) using default settings when a subscriber radio request is received on a talkgroup not currently in the talkgroup database. The new talkgroup records appear in the database as **ZC$TALKGROUP ID.**
- **No** indicates that under normal operating conditions, a default talkgroup record cannot be created. Any request on a new talkgroup is rejected.

3.3.2
Identification Numbers

ID numbers are key configuration elements that must be entered into the system. Based on the ID numbers entered, the system determines the following:

- Whether the individual subscriber radio or group is allowed to register at a site.
- Which call services the individual subscriber radio or group can use.
- What system features the individual subscriber radio or group can use.
- Which zone is responsible for controlling the call (for group calls).

3.3.3
Home Zones

The home zone mapping object in the Provisioning Manager (PM) application provides the capability to divide the total number of individual subscriber radio and talkgroup IDs into ranges that can be used in the system, and to assign the ranges to the various zones. All home zone assignments for individual subscriber radios and talkgroups are compiled into Radio Home Zone or Talkgroup Home Zone maps.

The PM allows for modification of the individual Radio Home Zone and Talkgroup Home Zone maps to associate a range of IDs with a particular zone. For example, Zone 1 is assigned an individual ID range that includes IDs 1 - 701, and a talkgroup ID range that can include IDs 1 - 17. Zone 1 then becomes the home zone to any subscriber radio or talkgroup programmed with a corresponding ID from the Zone 1 individual and talkgroup range tables.

For a given range of IDs in a zone, if the ISSI 8000/CSSI 8000 Intersystem Gateway (ISGW) feature is implemented, decide which portion of the ID range is assigned to support the radios native to the ASTRO® 25 system, and which portion of the ID range is assigned to support foreign subscriber radios. See the *ISSI 8000/CSSI 8000 – Intersystem Gateway* manual for more details regarding the support of foreign subscribers in an ASTRO® 25 system.

3.3.4
Radio Identification

Radio records that contain attributes related to the physical subscriber radio, such as its unique identity, serial number, RF band, and interconnect capability, are created through the Provisioning Manager (PM). A radio record is required for each subscriber radio accessing the system. Objects created in an Elite dispatch operator position that needs audio resources when active, such as talkgroup objects, also require a unique identification number.

The identification is programmed in two places:

- The Console Database Manager where the talkgroup resources for the console system are created.
- The PM radio object - if a talkgroup resource is created in multiple console positions, each instance of the resource must be identified with a unique record in the PM database.

Identifying console resources in the same way as subscriber radios allows the system to properly identify the source for requests for service and to forward information to the correct destinations.

3.3.5
Radio Authentication

The Radio Authentication feature is an optional offering to ASTRO® 25 systems. The Radio Authentication feature prevents unwanted (and potentially dangerous) subscribers from accessing the network. Each radio attempting to access the network is authenticated by the system infrastructure to prove it is genuine.

The Radio Authentication feature helps to prevent the use of ASTRO® 25 system channel resources by unauthorized subscriber radios. With the Radio Authentication feature, the zone controller is able to validate the identity of subscriber radios requesting service on the system. Neither the subscriber radio hardware nor the person using the subscriber radio is allowed to access the system until authentication is accomplished by validating the subscription programmed into the subscriber radio. For specific information on this feature and system configuration, see the *Radio Authentication* manual.

3.3.6
Radio User

The Data System object, together with the Radio object and Radio User object, establish a data user in the system. Data-capable subscriber radios and data devices configured and identified with an IP address and associated with a unique subscriber radio ID distinguish these users as data users in the system.

Radio user configuration data needed by the Zone Controller (ZC) is established with Provisioning Manager (PM). The ZC relies on the distribution of configuration data (for example, WACN ID, SYSTEM ID, Default Access Permission, Site Access Denial) through the use of the Unified Network Configurator (UNC).

The system uses the subscriber radio registration, dispatch console service to determine the dynamic capability. The ZC uses the subscriber radio and talkgroup capability to determine when a subscriber radio affiliates to a talkgroup.

The system uses the following methods to determine the dynamic capability:

- The subscriber radio, upon registration, indicates the Frequency Division Multiple Access (FDMA)-only or Time Division Multiple Access (TDMA) capability. The information is provided in the subscriber radio registration and location registration.
- The MCC 7500 dispatch console, upon acquiring service with the ZC, indicates the capability of supporting the AMBE+2. The AMBE+2 indication is provided in the **V2 Application in Service** message.

3.3.6.1
Radio User Profiles

Profiles are available for the following:

- Radio User Capabilities
- Radio User Site Access
- Radio User Interconnect

3.3.6.1.1
Radio Capabilities Profile

The Radio Capabilities Profile object defines access parameters for subscriber radio users such as:

- Group/Private Call Priority Level
- Multigroup Call Enabled
- CallEnabled
- Private Call (PC) Enabled
- Group Call Enabled

A Radio Capabilities Profile object can be used to define a set of parameters common to a specific group of subscriber radio users. Every subscriber radio user is assigned a Radio Capabilities Profile.

3.3.6.1.2
Radio Site Access Profile

The Radio Site Access Profile object is used to define a list of specific sites in the system that the subscriber radio user has permission to access. Every subscriber radio user is assigned a Radio Site Access Profile. A Radio Site Access Profile record is used to define a set of sites common to a specific group of subscriber radio users.

3.3.6.1.3
Radio Interconnect Profile

The Radio Interconnect Profile object defines interconnect call capabilities for subscriber radio users. Every subscriber radio user is assigned a Radio Interconnect Profile. The Radio Interconnect Profile record can be used to define a set of parameters common to a specific group of subscriber radio users.

3.3.7
Data User

The Data Configuration in System object, together with the Radio User Alias configuration in IV&D radio or High Performance Data (HPD) radio object, establish a data user in the system. Data-capable subscriber radios and data devices configured and identified with an IP address, and associated with a unique radio ID, distinguish these users as data users in the system.

3.3.8
Profiles

Profiles are available for the following:

- Radio User Capabilities
- Radio User Site Access
- Radio User Interconnect
- Enhanced Console Telephony

3.3.8.1
Radio User Capabilities Profile

The Radio User Capabilities Profile object defines access parameters for subscriber radio users such as:

- Group/Private Call Priority Level
- Multigroup Call Enabled
- CallEnabled
- Private Call (PC) Enabled
- Group Call Enabled

A Radio User Capabilities Profile object can be used to define a set of parameters common to a specific group of subscriber radio users. Every subscriber radio user is assigned a Radio User Capabilities Profile.

3.3.8.2
Radio User Site Access Profile

The Radio User Site Access Profile object is used to define a list of specific sites in the system that the subscriber radio user has permission to access. Every subscriber radio user is assigned a Radio User Site Access Profile. A Radio User Site Access Profile record can be used to define a set of sites common to a specific group of subscriber radio users.

3.3.8.3
Radio User Interconnect Profile

The Radio User Interconnect Profile object defines interconnect call capabilities for subscriber radio users. Every subscriber radio user is assigned a Radio User Interconnect Profile. The Radio User Interconnect Profile record can be used to define a set of parameters common to a specific group of subscriber radio users.

3.3.9
Configuration Updates

Configuration updates established using Provisioning Manager (PM) are distributed to target devices using the Unified Network Configurator (UNC). The UNC manages the download (distribution) of configuration data (RF sites, call parameters, subscriber data, and Home Zone mapping updates) to the Zone Controller (ZC) where it can be used to populate the ZC Group Home Location Register (GHLR) and Individual Home Location Register (IHLR).

3.3.10
Talkgroup Object

The talkgroup object consists of information identifying a group of subscriber radios that communicate and interact together on the system.

3.3.10.1
Talkgroup/Multigroup Capabilities Profile

The Talkgroup/Multigroup (TG/MG) Capabilities Profile object defines the capabilities for a talkgroup or multigroup. The TG/MG Capabilities Profile record can be used to define a set of parameters common to a specific talkgroup or multigroup.

A partial list of parameters that affect call processing include:

- **Message** or **Transmission** mode operation. Selecting **Message** indicates the system assigns one repeater to the call for the duration of the conversation within the parameters of the Message Trunk Timer. Selecting **Transmission** indicates the system assigns one repeater for the duration of a single transmission by one radio.

  NOTICE: The message mode of operation causes the subscriber radio to return to the control channel to send its individual ID anytime the Push-to-Talk (PTT) button is pressed. This mode of operation provides positive identification of the transmitting subscriber radio and must be programmed in both the subscriber radio and the system. In the subscriber radio programming, the field is identified as PTT-ID and in the TG/MG profile record, the field is identified as message.

- Audio Interrupt Mode **Never**, **Always** or **On Priority**. Selecting **Never** prevents all audio interrupt requests. Selecting **Always** allows the system to automatically grant audio interrupt requests on the same talkgroup. Selecting **On Priority** allows audio interrupt requests on the same group, and the subscriber radio user interrupting must have higher priority level than the subscriber radio currently transmitting for the interrupt request to be granted.

Each TG/MG Capabilities Profile contains capability parameters that can be customized per configured profile. Every talkgroup and multigroup are assigned a TG/MG Capabilities Profile.

3.3.11
Multigroup

The Multigroup object is used to create records that identify a group of talkgroups that are the target of multigroup announcements.

These records include the same parameters as the talkgroup record plus two parameters specific to the multigroup record:

- **Interrupt** or **Wait** mode. **Interrupt** mode requires that all subscriber radios in the designated talkgroups participate in the call whether the subscriber radios are monitoring the control channel or participating in a talkgroup call as receiving subscriber radios. A message sent through the voice channel, as part of the embedded signaling, causes the receiving subscriber radios to return to the control channel to receive the multigroup's voice channel assignment. The only subscriber radios unable to participate in a multigroup call are those subscriber radios currently transmitting. Wait mode allows talkgroup calls in progress to end before a multigroup call begins because the multigroup waits for all talkgroup members to be available.
- **Talkgroup in Multigroup**. This parameter is used to enter the list of talkgroups associated with the specified multigroup ID.

  IMPORTANT: All talkgroups assigned to the multigroup must have the same home zone as the multigroup.

3.3.11.1
Talkgroup/Multigroup Site Access Profile

The Talkgroup/Multigroup (TG/MG) Site Access Profile object defines which sites the talkgroup or multigroup has access permission for in the system. Every talkgroup and multigroup are assigned a Site Access Profile. The TG/MG Site Access Profile record can be used to define a set of sites common to a specific talkgroup or multigroup.

3.3.12
Agencygroup

The agencygroup object contains the information identifying a group of multigroups that periodically must communicate and interact with each other in the system.

Up to 256 multigroups and up to 16 agencygroups can be created in the system. Each agencygroup can contain up to 16 multigroups.

Talkgroup IDs are 8–digit decimal numbers, beginning with 80000001. Talkgroups, multigroups, and agencygroups are created from the same pool of 8–digit decimal numbers. For additional information on reserved agencygroup IDs, see the *Provisioning Manager* manual.

Adding an agencygroup is the same as adding a multigroup, but one or more multigroups must be associated with the agencygroups. An agencygroup comprises several multigroups whose members occasionally must communicate as a group. The groups relationship is strictly hierarchical and thus a multigroup cannot contain an agencygroup.

The agencygroup call provides an additional priority level for group calls in the ASTRO® 25 radio communication system. The following call priorities (listed from high priority to low priority) are available with the addition of the agencygroup call:

- Agencygroup – Highest priority and consists of radio users included in various multigroups where the agencygroup has priority over multigroup calls. The priority level of an agencygroup is configurable.
- Multigroup – Medium priority and consists of radio users included in various talkgroups where the multigroup call has priority over talkgroup calls. The priority level of a multigroup is configurable.
- Talkgroup - Individual priority. A talkgroup consists of a group of radio users where radio users in a talkgroup can be configured to establish individual priority levels. The individual priority level of a radio user in a talkgroup is configurable.

These priority levels determine which radio users have the capability to interrupt other radio users based on the type of group each radio user is assigned to in the system.

NOTICE: In Site Trunking mode, all active group calls in the agency hierarchy are not ended when starting an agencygroup call. However, because the agencygroup call has the highest priority in the scanned talkgroup list, the radio users can still hear the audio during activity on the agencygroup.

Audio from an agencygroup call can be received only if a radio affiliated to the agencygroup, or member group in the agencygroup hierarchy is at the scanning radio site. If no member of the agency hierarchy is at the same site as the radio that is priority-scanning the agencygroup, an agency call grant message is not sent to the site. Therefore, the scanning radio has no way to be notified with the agency call.

When the agencygroup user starts to transmit and active calls on the member groups are in the same agency hierarchy, if the agencygroup is configured to Interrupt, all those calls must be ended to start the agency call. Subscriber radios in the call require time to leave the assigned channels, therefore the agency call can initially be busied due to unavailable channel resources. When a channel becomes available, the agencygroup call can be converted.

IMPORTANT: It is important to ensure that the subscriber radio is programmed to priority scan an agencygroup to which the subscriber radio belongs, or that the scanning radio site is configured as the mandatory site for the agencygroup.

The agencygroup can be set to **Interrupt** or **Wait**.

Interrupt: Indicates that the agencygroup can interrupt a call on a multigroup/talkgroup that is part of the agencygroup. If the agencygroup is configured in interrupt mode and an agencygroup user starts to transmit while active calls are on its member groups, all the active calls end immediately and the agencygroup call starts when a channel is available. In this case, the agencygroup call may get busied.

NOTICE: With interrupt mode, when an agencygroup call starts and a channel resource is available, the agencygroup call transmits immediately. In this case, subscriber radios active in member group calls ended due to the agencygroup call interrupt, enter the agencygroup call late. Therefore, a potential loss of audio could occur because the radios in the member group must leave the active voice channel, go to the control channel, recognize the agencygroup call grant, and return to the voice channel where the agencygroup call has started.

Audio interrupt requests are granted based on one of the audio interrupt modes that can be configured for the call group.

Wait: Indicates that the agencygroup waits for the call on a multigroup that is part of the agencygroup to be completed. If the agencygroup is configured in **Wait** mode, and an agencygroup user starts to transmit while active calls are on its member groups, all the active calls are transmission trunked and the agencygroup call starts when all member group calls end.

Audio interrupt requests are granted based on one of the audio interrupt modes that can be configured for the call group.

Table 4: Audio Interrupt Modes for Agencygroup, Multigroup, and Talkgroups

Audio Interrupt Mode	Description
Never	Prevents all audio interrupt requests
Always	Allows audio interrupt request on the same group
On Priority	Allows audio interrupt on the same group if the interrupting radio has priority higher than the current transmitter

NOTICE: Audio interrupt mode **On Priority** is not supported in site trunking because not all individual priorities are available at the site.

3.3.13
System Information

System Configuration in the Unified Network Configurator (UNC) configures parameters at the system level. These parameters are common for every zone and may affect all subscriber radios in the system. The system record is created when the system is staged for testing at the Motorola facility. Subsequently, the record can be opened to modify the fields that affect operation of the subscriber radios in the system. This record includes the system identification, access control timers such as the duration of the message timer for various types of calls, and maximum call duration for group or private calls.

Another field on the **Basic** configuration tab under **System Level Configuration** in the navigation tree in the UNC is the **Site Access Denial Type**. This field works with the Radio User Site Access Profile and Talkgroup/Multigroup (TG/MG) Site Access Profile records. Site access can be allowed or denied to radio users and TG/MG through the corresponding Site Access Profile record.

The setting chosen for the `Site Access Denial` field has a direct impact on subscriber radio mobility.

As illustrated by the tables, the type of rejection depends on the valid sites set for each subscriber radio and affiliated talkgroups in the corresponding Provisioning Manager (PM) records. For example, with a site access denial setting of both, if a radio user is valid at the site but a talkgroup is not valid, the subscriber radio is allowed to register and stay at the site. The subscriber radio is allowed to make unit-to-unit calls but requests for a talkgroup call are rejected.

Continuing this example, if the subscriber radio user switches to another talkgroup, the subscriber radio sends another affiliation request, which is accepted or denied based upon the valid site setting for that group. If it is a valid group, the system begins to provide both group and individual call services at that site.

Valid site and site access denial are the means by which a system manager can specifically control the operating sites and individual/talkgroup services for each subscriber radio.

3.3.13.1

Site Access Denial Set to Individual Only

The **Individual Only** setting rejects the subscriber radio if it is not valid at the site. Reject means that the subscriber radio is given a `Site Access Denial` message. The subscriber radio leaves the current site and attempts to register at another site based on its adjacent control channel list.

Table 5: Effects of Site Access Denial Set to Individual Only

Service Request at a Site in the TG/MG Site Access Profile Table	Service Request at a Site in the Radio User Site Access Profile Table	Result
Yes	Yes	Group Call Allowed Individual Call Allowed
Yes	No	Group Call Denied Individual Call Denied
No	Yes	Group Call Denied Individual Call Allowed
No	No	Group Call Denied Individual Call Denied

3.3.13.2

Site Access Denial Set to Talkgroup Only

The talkgroup only (**TG Only**) setting rejects a subscriber radio if its affiliated talkgroup is not valid at the site. The setting in the Valid Sites Profile for the radio user has no effect in this case. Reject means that the subscriber radio is given a `Site Access Denial` message. The subscriber radio leaves the current site and attempts to register at another site based on its adjacent control channel list.

Table 6: Effects of Site Access Denial Set to Talkgroup Only

Service Request at a Site in the TG/MG Site Access Profile Table	Service Request at a Site in the Radio User Site Access Profile Table	Result
Yes	Yes	Group Call Allowed Individual Call Allowed
Yes	No	Group Call Allowed Individual Call Denied
No	Yes	Group Call Denied Individual Call Denied
No	No	Group Call Denied Individual Call Denied

3.3.13.3

Site Access Denial Set to Either

The **Either** setting rejects the subscriber radio if either the individual subscriber radio or its affiliated talkgroup is not valid at the site. Reject means that the subscriber radio is given a `Site Access`

`Denial` message. The subscriber radio leaves the current site and attempts to register at another site based on its adjacent control channel list.

Table 7: Effects of Site Access Denial Set to Either

Service Request at a Site in the TG/MG Site Access Profile Table	Service Request at a Site in the Radio User Site Access Profile Table	Result
Yes	Yes	Group Call Allowed Individual Call Allowed
Yes	No	Group Call Denied Individual Call Denied
No	Yes	Group Call Denied Individual Call Denied
No	No	Group Call Denied Individual Call Denied

3.3.13.4
Site Access Denial Set to Both

The **Both** setting rejects the subscriber radio if the talkgroup and the subscriber radio are not valid at the site.

Table 8: Effects of Site Access Denial Set to Both

Service Request at a Site in the TG/MG Site Access Profile Table	Service Request at a Site in the Radio User Site Access Profile Table	Result
Yes	Yes	Group Call Allowed Individual Call Allowed
Yes	No	Group Call Allowed Individual Call Denied
No	Yes	Group Call Denied Individual Call Allowed
No	No	Group Call Denied Individual Call Denied

3.3.13.5
Site Access Denial Setting Summary

The type of rejection depends on the valid sites set for each subscriber radio and affiliated talkgroups in the corresponding Provisioning Manager (PM) records. For example, with a site access denial setting of both, if a radio user is valid at the site with a talkgroup that is not valid, the subscriber radio is allowed to register and stay at the site. The subscriber radio is allowed to make unit-to-unit calls, but requests for a talkgroup call are rejected.

Continuing this example, if the subscriber radio user switches to another talkgroup, the subscriber radio sends another affiliation request, which is accepted or denied based upon the valid site setting for that group. If affiliation request is for a valid group, the system begins to provide both group and individual call services at that site.

Valid site and site access denial are the means by which a system manager can specifically control the operating sites and individual/talkgroup services for each subscriber radio.

3.3.14
Site Access Denial for TDMA Talkgroup User at an FDMA-Only Site

As part of the subscriber radio and location registration processes the system provides an indication of Time Division Multiple Access (TDMA) capability requirements. The subscriber radio and location registration processes indicates Frequency Division Multiple Access (FDMA) or TDMA capability of the subscriber radio.

The site access denial is configured through the Provisioning Manager (PM) with the Radio User Site Access Profile and the Talkgroup/Multigroup Site Access Profile records. When the profile is configured, a Site Access Denial Reject occurs when a subscriber radio affiliated to a TDMA-only talkgroup roams into an FDMA-only capable site.

Site Access Denial is independent or mutually exclusive from FDMA or TDMA use.

NOTICE: Site access denial is used to keep a subscriber radio affiliated to a TDMA talkgroup off an FDMA-only-capable RF site.

3.3.15
Source Site Adjacent Control Channel Object

The Source Site Adjacent Control Channel (ACC) object in the Unified Network Configurator (UNC) provides a means for system administrators to identify a list of sites in close RF proximity to any given site. The site list information is used by the system to provide subscriber radios with an Adjacent Site List (ASL). Subscriber radios use the ASL to rank potential control channel candidates. If the control channel of a subscriber radio becomes too weak for acceptable use, the subscriber radio attempts to find a control channel from one of the adjacent sites in the list based on the control channel ranking.

CAUTION: System engineers create the new Source Site ACC record when they initially configure the system. Subsequent users can only open and modify the existing record. System administrators must consider the ramifications when changing the initial configuration. Selection and programming of the source site adjacent to the control channel object requires a detailed knowledge of the system coverage characteristics. Random selection of sites can severely impact system operation as subscriber radios may experience problems accessing the system.

3.4
Simulcast Site Steering

Simulcast site steering, a functional feature of the ASTRO® 25 communication system, steers a data transmission to a specific site. Even though all messages are physically broadcast to all the base radios connected to a given comparator in all the remote sites of the subsystem, the effect of site steering is achieved because only the specific base radio addressed in the message recognizes the transmission. All other simulcast base radios ignore the message.

NOTICE: Site steering transmits payload data packets only at the most recently recorded transmit site.

When an inbound transmission from a subscriber radio is received from simulcast remote sites, the comparator not only establishes a best-quality signal, but also determines which transmit site to use for the outbound transmission by using the configuration information entered into the **Map to Transmit Subsite** field in the Configuration/Service Software (CSS). This field is used to associate the best transmission site for each simulcast remote site.

Transmissions are still time launched (as in simulcasting packets) to allow the comparator to retain control and keep a common pacing engine in the comparator.

NOTICE: Base radios in a single transmitter/receiver voting subsystem do not use the time launching information sent by the comparator, because it is unnecessary in a subsystem configuration with a single transmitter.

The comparator must know the best remote site for each subscriber radio on the packet data channel. The information is gathered from two areas:

- Inbound messages from the subscriber radio on the control channel
- Inbound data responses on the packet data channel

Use the CSS application to provision the remote site number into the base radio. When the link between the base radio and comparator is established, the comparator records the base radio's remote site number. For simulcast subsystems with simulcast receiver-only remote sites, and for single transmitter/receiver voting subsystem configurations, the comparator is configured with information about which remote sites are transmit remote sites and which remote sites are receiver-only remote sites.

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Chapter 4

Trunked Call Processing Operation

This chapter details tasks that can be performed when the fallback modes and group-based services are installed and operational on your system.

4.1 Motorola Trunked System Operation

The operation of a Motorola trunked system can be divided into three functions or planes of operation:

1. Control – Assignment of system resources is centralized.
   - Subscriber radio access to the system and its features are controlled from a central point.
   - System resource operation is monitored. Resources are removed from the available pool if they are not operating properly and returned to service after the problem is resolved either by the system itself or through technical intervention.
   - Subscriber radio use of voice channels is controlled and monitored through data and subaudible signals. The signals let the controller know if the receiver and transmitter are active, and cause the subscriber radios to return to the control channel at the end of a communication or when the base radio malfunctions. The central controller never has contact with the audio itself.
2. Audio – Base radios provide the audio interface between members of a communication group. Base radios are assigned to one communication group at a time. Interference from other subscriber radios is prevented.
3. Management – A program is included in the central controller's firmware that provides a user with the capability to change some of the system features. Some of the managed features control the operation of all subscriber radios, while others are applied to specific subscriber radios through a subscriber radio control record. The management feature also provides enable and disable features for some system resources.

4.2 Fallback Operating Modes

Fallback operating modes identify system operating modes not typically induced by user intervention.

- InterZone trunking - an operating mode applicable to multizone systems. A system in an InterZone trunking mode provides zone-to-zone communication, and typically wide-area trunking services for the participating zones. See Conditions Necessary for InterZone Trunking on page 127.
- Wide-area trunking - an operating mode applicable to multizone or single-zone systems. A system in wide-area trunking provides trunking communication services to most, if not all, sites in a zone. A system can be in wide-area trunking mode without being in the InterZone trunking mode or operation.
- Site trunking - an operating mode applicable to multizone or single zone systems. A site in Site trunking mode functions as a standalone trunking system and is under the control of the site or subsystem controller.
- Site Failsoft - an operating mode applicable to multizone or single zone systems. A site in Site Failsoft mode functions without the use of a site controller and therefore trunking services are not provided. Base radios function only in conventional mode.

- Local Failsoft at Remote Site - an operating mode applicable to multizone or single zone systems. When the Trunked IP Simulcast Remotes Site is in Local Failsoft, the configured base radio operates in a conventional mode through in-cabinet repeat of audio.

NOTICE: The Site Failsoft operating mode is considered primarily a fallback operating mode because communication resources may function in Site Failsoft mode under conditions not initiated by user intervention. However, the Site Failsoft operating mode can also be user initiated from the diagnostics capability of the Unified Event Manager (UEM).

4.3 Group-Based Services

The ASTRO® 25 system offers several types of group-based services.

NOTICE:
The Dynamic Transcoding feature supports group call and unit-to-unit communication between FDMA subscriber radios on one site with TDMA subscriber radios on a separate TDMA-capable site while preserving the FDMA and TDMA modes of operation at each respective site. The Dynamic Transcoding feature also supports group call and unit-to-unit communication between subscriber radios on an FDMA-only site with TDMA subscriber radios in a TDMA-capable site while preserving the FDMA and TDMA modes of operation at each respective site.

4.3.1 Talkgroup Call

The talkgroup is the primary level of communication in a trunked radio communication system. Most of the conversations a subscriber radio user participates in are talkgroup calls.

The two talkgroup variations are as follows:

- Intrazone call where all resources are within one zone.
- InterZone call where resources are in more than one zone.

For Time Division Multiple Access (TDMA)-capable systems, see DDM User Configuration Server Talkgroup, Multigroup and Agencygroup on page 30 for more information.

4.3.1.1 Intrazone Talkgroup Call

An intrazone talkgroup call is the most common type of ASTRO® 25 call. Home zones are generally assigned to match up to geographic areas where subscriber radios are used most frequently, such as a patrol district or management area. When possible, talkgroups and subscriber radio users should be configured so that the majority of the calls take place within this geographic area, thus reducing the need for InterZone resources.

4.3.1.1.1 Call Request

A talkgroup call begins with a call request. The call request resolution determines whether the call is set up or not. A talkgroup call request is initiated when the caller selects the appropriate mode on the subscriber radio and then presses the Push-to-Talk (PTT) button.

- When the caller presses the PTT button, the call request, in the form of an Inbound Signaling Packet (ISP), is sent over the control channel to the current site. The information is passed to the site controller for processing and routing to the Zone Controller (ZC) through the site router/ gateway.
- The ZC for the zone where the request originates determines if the call request is valid by checking the access configuration information stored in the Visitor Location Register (VLR). If the request is a

valid, the ZC checks its talkgroup-to-home zone map table to see which zone is the talkgroup's home zone. For group calls, the talkgroup's home zone becomes the controlling zone for the call, regardless of which zone the caller is in when the request is made.

- If the zone from where the request originates is the home zone, the ZC coordinates the call setup. If another zone is the home zone, the ZC for the zone from where the request originates forwards the request to the appropriate zone.

4.3.1.1.2

Call Request from an ASTRO 25 Repeater Site or Simulcast Remote Site

If the call request originates at an ASTRO® 25 repeater site or circuit-based or IP-based simulcast remote site, the request is encapsulated as 10Base-T Ethernet packets by the base radio, and is then routed to the corresponding site Ethernet switch. The information is routed from the switch to the site router/gateway, where it is encapsulated in Frame Relay packets for transmission to the Master Site/ Zone Core.

NOTICE: The gateway router performs control and data router functionality.

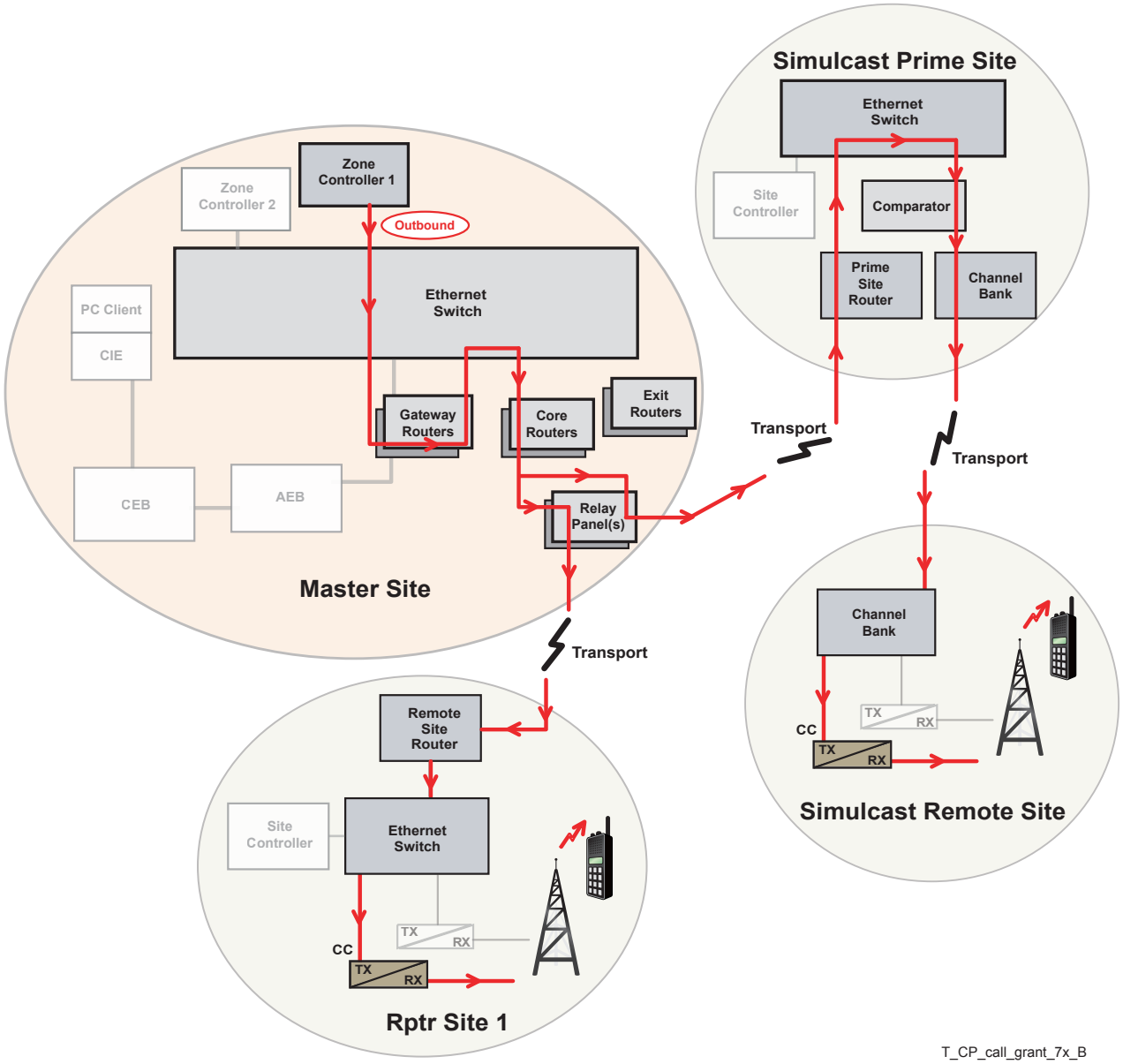
4.3.1.1.3

Call Request from a Simulcast Subsystem

A call request can originate at a circuit-based or IP-based simulcast subsystem. The following is an example of a call request from an IP-based simulcast subsystem:

- The call request originates at an IP simulcast remote site, and the base radio takes the call request from the subscriber radio and routes it through its IP network to the comparator at the IP simulcast prime site.
- The comparator receives the information from the IP network, votes the signal, and sends it to the site controller through the IP network.
- The site controller receives the call request from the IP network, processes the request, and sends it to the zone controller (ZC) through the IP network.
- The receiving ZC checks its Visitor Location Register (VLR) to see if the requesting individual is configured to make talkgroup calls. If the talkgroup is affiliated to the current zone, the ZC checks for site affiliations.

Figure 10: Intrazone Talkgroup Request from Simulcast Subsystem



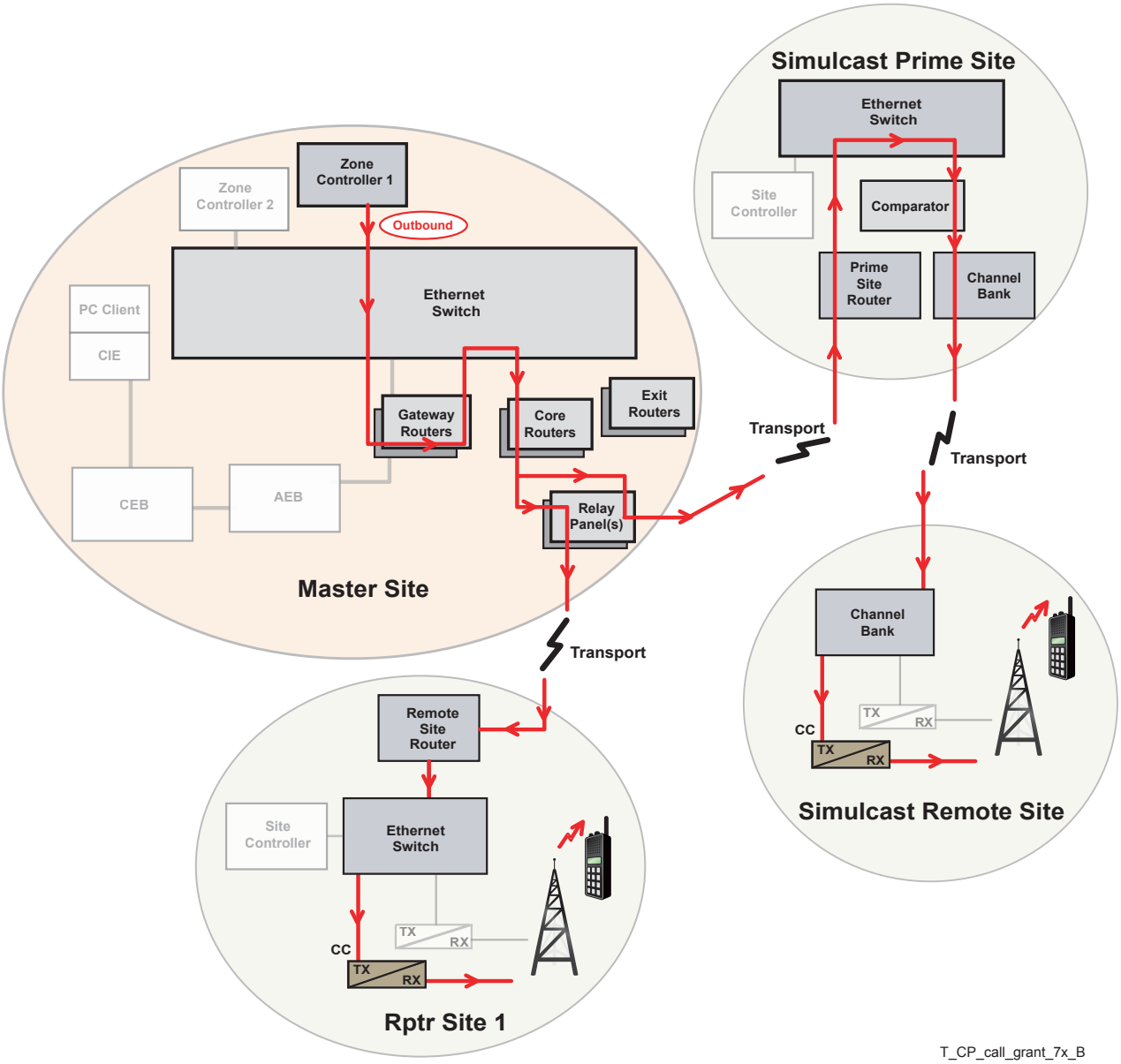
NOTICE: System gateway devices provide an alternative solution to various routers in the system. See the *System Gateways – GGM 8000* manual for details.

4.3.1.1.4

Call Set Up and Call Grant Process

The following describes a call set up and call grant process.

Figure 11: Call Grant



NOTICE: System gateway devices provide an alternative solution to various routers in the system. See the *System Gateways – GGM 8000* manual for details.

Process:

1. Routing information is sent to the appropriate Master Site/Zone Core and remote site routing equipment.
2. The Home Zone for the call request sets up a core router as the distribution point for the audio information. This audio focal point is known as the Rendezvous Point (RP), and its router becomes the RP router. The RP for intrazone audio is the core router.
3. The Zone Controller (ZC) checks the Visitor Location Register (VLR) to determine talkgroup affiliations and subscriber radio location. This information indicates which sites participate in the call.

4 The ZC checks that all needed resources, such as channels at sites, consoles are available to make the call. The ZC sends the multicast information if the needed resources are available.

5 Channel assignments are sent to the needed sites.

6 The site controllers broadcast the channel assignment through the control channel to the radios, and send the activation message to the assigned voice channels.

7 The assigned voice channels send a join message back to the RP router.

8 The comparator for the designated channel sends a join message if the call involves a simulcast subsystem.

9 MCC 7500 Dispatch Consoles participating in a call send their own join messages.

10 The sites cause the activation of the receive and transmit circuits in the designated voice channels.

11 The receiving subscriber radios tune to the assigned voice channel at their respective sites.

12 The requesting subscriber radio electronically activates its transmitter.

NOTICE: If a required resource is not available, the ZC sends a busy signal to the subscriber radio requesting the call. See Busy Call Handling on page 109 for details.

4.3.1.1.5
Call Setup

Once a valid call request is received, the Zone Controller (ZC) starts to set up the call:

- The ZC checks the Visitor Location Register (VLR) to determine talkgroup affiliations and subscriber radio location. This information indicates which sites participate in the call.
- The ZC checks that all needed resources, such as channels at sites, consoles are available to make the call. The ZC sends the multicast information if the needed resources are available. If some resource is not available, the ZC sends a busy signal to the radio requesting the call. See Busy Call Handling on page 109 for details.

4.3.1.1.6
Call Grant

When the call is granted, the following occurs:

1 Routing information is sent to the appropriate Master Site/Zone Core and remote site routing equipment.

2 The Home Zone for the call request sets up a core router as the distribution point for the audio information. This audio focal point is known as the Rendezvous Point (RP) and its router becomes the RP router. The RP for intrazone audio is the core router.

3 Channel assignments are sent to the needed sites.

4 The site controllers broadcast the channel assignment through the control channel to the subscriber radios, and send the activation message to the assigned voice channels. The assigned voice channels send a join message back to the Master Site/Zone Core.

5 The comparator for the designated channel sends a join message if the call involves an IP simulcast subsystem.

6 The sites cause the activation of the receive and transmit circuits in the designated voice channels.

7 The receiving subscriber radios tune to the assigned voice channel at their respective sites.

8 The requesting subscriber radio electronically activates its transmitter.

NOTICE: The gateway router performs control and data router functionality.

4.3.1.1.7
Intrazone Talkgroup Call Audio Routing

When the call is set up, voice communications begins by the following process:

1. When the subscriber radio user speaks into the microphone, the subscriber radio converts the speaker's analog audio into ASTRO® 25 and transmits the signal to the assigned voice channel.
2. The audio signal is transmitted by the subscriber radio over the assigned frequency to the caller's site and received by the assigned voice channel.
3. The voice channel places the audio into the site's Ethernet LAN as IP packets and routes the audio signal through the site router/gateway to the assigned Rendezvous Point (RP) router (core router) at the Master Site/Zone Core.
4. The talkgroup members already locked on to the voice channel receive the audio.

4.3.1.1.8
Talkgroup Call Continuation and Teardown

When the original speaker releases the Push-To-Talk (PTT) button, a control message is sent over the voice channel. This message is extracted from the audio stream by the remote site and forwarded to the Zone Controller (ZC).

NOTICE: Control information flows continually during a call, over the control channel during call setup, and embedded in the digital audio signal during the active call phases.

1. When the speaker releases the PTT button, a message is sent to the controlling ZC. If the call is message trunked, a message hangtime timer starts when the message is received. All system resources previously assigned to the call are held available during the timer's hangtime period.
2. If a person responds to the initial caller by pressing the PTT button within the hang timer period, the call continues. The message hang timer is reset and the new speaker's audio is routed as the source audio using the voice channels and router assignments already allotted for this call.

4.3.1.2
InterZone Talkgroup Call

The difference between an InterZone call and an intrazone call is the other zone controllers that must be included in the call control process. In an InterZone call, each zone controls its local resources in a similar manner to the previously described intrazone call. However, because the controlling zone must coordinate with the needed participating zones prior to granting the call, much more activity takes place during the call request and setup phases.

4.3.1.2.1
InterZone Talkgroup Call Request

The call request is sent by the subscriber radio over the control channel at the local zone and site when the subscriber radio user presses the Push-To-Talk (PTT) button. This request is relayed through the remote site to the local Zone Controller (ZC).

Based on the talkgroup ID information in the call request, the ZC receiving the request checks its Visitor Location Register (VLR) and determines if the requester is able to make the call. The ZC then checks the talkgroup-to-home zone map and determines if it is the home zone, and thus the controlling ZC, for the call.

If it is the home zone, the local ZC becomes the controlling ZC and takes responsibility for the call. The call request is acknowledged, and the controlling ZC begins to set up the call. If the receiving zone is not the home zone, the call request is passed on to the appropriate ZC, which accepts control of the call and becomes the controlling ZC for the call.

4.3.1.2.2
InterZone Talkgroup Call Setup

The controlling Zone Controller (ZC) determines which zones must be included in the call and sends a message to the appropriate ZCs requesting their participation in the call. All InterZone call control messages between any pair of ZCs go over the InterZone Control Path between those two zones. An active InterZone Control Path exists between any two zones in the system.

Each ZC checks its Visitor Location Register (VLR) to determine which sites, along with which fixed resources, should be included in the call, and if all the resources are available to set up the call. The call is busied if any zone cannot participate due to lack of resources. If all the resources are available, the participating ZCs acknowledge their participation back to the controlling zone.

When all participating zones acknowledge the call request, the controlling ZC grants the call. The grant message is sent to each participating zone through its active InterZone Control Path with the controlling zone. At this point, each zone is responsible for setting up the resources within its zone.

Within each zone, the ZC accomplishes the following:

- Assigns voice channels at the appropriate sites within its zone.
- Assigns the necessary audio resources and sends multicast addresses.
- Notifies the consoles of the talkgroup call and its audio source, if needed. The ZC relays the audio assignments to the Embassy switch through the Zone Ambassador Interface Board (ZAMBI) link and the channel assignments to the appropriate remote sites through their site control paths.
- When the resources are assigned, the Rendezvous Point (RP) router becomes the center of control for audio distribution.

The site control function at each site performs the following:

- Activates the base radio assigned as the voice channel.
- Sends the voice channel assignment to the affiliated subscriber radios over the control channel.

The assigned voice channel at ASTRO® 25 repeater sites, the appropriate comparator at a digital circuit-based or IP-based simulcast subsystem send a join message to the RP after they receive the multicast address.

As resources are set up in each zone, the subscriber radios in the talkgroup in each zone switch to the assigned voice channel. The initiating user's subscriber radio activates the transmit circuitry and begins sending the audio to the receiver at the assigned voice channel.

4.3.1.2.3
InterZone Talkgroup Call Audio Routing

When the transmitting user speaks into the microphone, the audio signal is transmitted on the assigned voice channel frequency and received by the base radio at its site, which routes the audio stream to the core router at the local zone Master Site/Zone Core. The exit routers in the participating zones then route the audio to the LAN switch, the core router, consoles in their respective zones, and the assigned sites. The sites transmit the signal to the members of the target talkgroup.

4.3.1.2.4
InterZone Talkgroup Call Continuation and Teardown

When the original speaker releases the Push-To-Talk (PTT) button, a control message is sent over the voice channel. This message is extracted from the audio stream by the remote site and forwarded to the controlling Zone Controller (ZC). In transmission trunking mode, the call is ended after the PTT-released message is received. In message trunking mode, however, the controlling ZC starts the message hangtime timer upon reception of the PTT-released message. If another user in the talkgroup responds to the call within the hangtime period, the controlling ZC receives the new call request, either from a site in its zone or from a participating ZC, sees that it is for a talkgroup that has an active call,

and continues the call using the resources currently assigned to the talkgroup. The audio source is the only resource change in this instance.

The call is ended when no one from the talkgroup keys-up within the message hangtime period. The controlling ZC sends a message to each participating zone to tear down the call. Each zone goes through the teardown process, disabling the audio, and marking the resources used in the call as available for other call assignment.

4.3.1.2.5
Roaming During a Talkgroup Call

When a call by a receiving subscriber radio user in an active talkgroup roams into a new zone, the call is continued automatically. Depending upon whether resources, such as a voice channel, are available to set up the call at the new site, the roaming user experiences the following conditions:

- If resources are available at the new site and the talkgroup call is already active in the new zone (talkgroup members are at sites within the zone), the roaming user experiences a short loss of audio while the call is set up at the new site.
- If resources are available in the zone to set up the call, but the talkgroup call is not active (no affiliated talkgroup members are in that zone), the roaming user experiences a longer loss of audio while the InterZone call setup process takes place. The access control information needs to be transferred from the home zone Home Location Register (HLR) to the HLR in the new zone, and from there to its Visitor Location Register (VLR). The call request must be validated in the new zone, and a channel assigned and activated at the new site.
- If resources are not available at the site or in the zone, the call continuation request to the new zone is placed in its busy queue. When the needed resources become available, the roaming user rejoins the call in process. A longer loss of audio occurs in this case.

4.3.2
Talkgroup Calls Registration

During a talkgroup call, a subscriber radio of an active talkgroup is allowed to roam into a trunked RF site that does not have participating members. After a subscriber radio registers to a site that does not have affiliated members for the call, the site is added to the call to provide continuity of the talkgroup.

The systems receive the mobility information of a roaming subscriber radio when it roams into the trunked site. The subscriber radio sends the new registration update to the Zone Controller (ZC). It then grants a voice channel to the RF site. When the roaming subscriber radio roams to a Frequency Division Multiple Access (FDMA)-only capable site during an active Time Division Multiple Access (TDMA) call on a talkgroup configured as dynamic, the call is not started at the new site. The dynamic operation mode of the talkgroup changes to FDMA. The dynamic mode of the active call does not change until the call ends and a new call is started, and the roaming subscriber radio does not hear the audio of the current call. The ZC attempts to transmission trunk the TDMA call in an effort to speed up the process of ending the call.

When a dynamic talkgroup call does not have initial console positions, the first console operator in a console site affiliates in the talkgroup. This process triggers a console site to add the talkgroup call. The ZC evaluates the dynamic operation mode of the talkgroup. With no changes to the mode, the ZC assigns the audio resources to route audio to the newly affiliated console position. With a console type change from TDMA to FDMA, the console site is not added to the call until the original call type ends and a new call is started.

4.3.3
Unit-to-Unit Calls Registration

During a unit-to-unit call, a participating subscriber radio roams into a different RF site and sends the mobility information. The Zone Controller (ZC) adds a new RF site to the call to support the call continuity. A grant message is issued to a unit-to-unit call to the newly joined trunked RF site where the subscriber radio is roaming into. The ZC determines whether the active subscriber radio in a unit-to-unit call registered at a fixed site subsystem has the RF resource capability to support the active unit-to-unit call.

NOTICE: The call is transmission trunked when the initial Time Division Multiple Access (TDMA) call roams into a Frequency Division Multiple Access (FDMA) site.

The ZC issues a `Group Grant` message to the joined trunked RF site. This message includes the assigned multicast ID, both source RF sites, and destination field information to route the audio.

The ZC determines the access method type for each unit-to-unit call request in a dual-phase system. The ZC determines the FDMA-only or TDMA capability of a subscriber radio based on the signaling information in the location registration message from the fixed radio subsystem provided by the subscriber radio. Unit-to-unit calls occur between any two users in the system. The following factors determine whether the call occurs as an FDMA or TDMA call:

- Type of site
- Type of subscriber radio

Based on the two variables, multiple combinations occur.

Table 9: Call Types in Unit-to-Unit Call Combinations

Combination	Result
FDMA subscriber radio at FDMA-only capable RF site to FDMA subscriber radio at FDMA-only capable RF site	FDMA call
FDMA subscriber radio at TDMA-capable site to FDMA subscriber radio at FDMA-only capable RF site	FDMA call
TDMA capable subscriber radio at TDMA-capable site to TDMA-capable subscriber radio at TDMA capable site	TDMA call
MCC 7500 dispatch console with Improved Multi-Band Excitation (IMBE) vocoder to TDMA-capable subscriber radio at TDMA-capable site	FDMA call
MCC 7500 dispatch console with AMBE+2 vocoder to TDMA-capable subscriber radio at TDMA-capable site	TDMA call

The ZC allocates the multicast group for voice services. The unit-to-unit call grants two multicast addresses allocated to support the full duplex audio connection where two endpoint devices are in the call. Because the multicast addresses are from the same RF, the impact of an RF site failure on unit-to-unit calls is reduced. Each device uses one of the multicast addresses to source audio on and the other to receive. The ZC indicates which address is used to source or receive in the grant message sent to the devices.

4.3.4
Multigroup Call

A multigroup is a collection of talkgroups. A message can be transmitted to two or more talkgroups simultaneously by selecting a multigroup. Any user affiliated to any of the talkgroups in the multigroup, or to the multigroup itself, hears the call.

IMPORTANT: The multigroup and all talkgroups in the multigroup must have the same home zone assignment.

A multigroup call can be set to wait or interrupt mode.

- Wait allows talkgroup calls in progress to end before a multigroup call begins, so the multigroup waits for all talkgroup members to be available. This mode allows all subscriber radios in the multigroup to hear the call.
- Alternatively, a multigroup call can be set to interrupt existing talkgroup communications, not waiting for transmitting users in the talkgroups to stop keying their subscriber radios. Those users join the call in progress when they release their Push-To-Talk (PTT) buttons.

Multigroup calls use message trunking, allowing those who receive the call to talk back to the multigroup. A multigroup call is processed in a similar manner as a talkgroup call. Audio for a multigroup call is routed through the Fixed Network Equipment (FNE) in the same manner as a talkgroup call.

NOTICE: The talkgroup call requests (of the multigroup) in the busy queue for the affected subscriber radios are dropped.

Multigroup information is programmed in two places:

- One multigroup per personality can be programmed in the subscriber radios.
- Multigroup records must be created in the Provisioning Manager (PM) database identifying the multigroup itself and the individual talkgroups associated with that multigroup.

A subscriber radio with the selector in the multigroup mode position can monitor talkgroup activity for talkgroups associated with the selected multigroup only if the monitored talkgroups have an affiliated member in the same zone as the monitoring subscriber radio. The system does not pass audio between zones exclusively for a subscriber radio scanning talkgroup activity while in multigroup mode.

The Zone Controller (ZC) evaluates dynamic multigroup to be in Frequency Division Multiple Access (FDMA) operation mode when any of the following conditions is satisfied:

- One talkgroup part of the multigroup is flagged as FDMA-only -or-
- One dynamic talkgroup part of the multigroup is currently evaluated to be in FDMA mode. -or-
- The multigroup is currently evaluated to be in FDMA mode.

The ZC evaluates the dynamic multigroups in Time Division Multiple Access (TDMA) operation mode when the following conditions are satisfied:

- All the non-dynamic talkgroups part of the multigroup is flagged as TDMA-only.
- All the dynamic talkgroups part of the multigroup is currently evaluated to be in TDMA mode.
- The multigroup itself is currently evaluated to be in TDMA mode.

Multigroups operating in the dynamic mode provide the highest level of interoperability with the talkgroup in the multigroup.

When network management adds or deletes a talkgroup in a multigroup, the ZC evaluates the FDMA/TDMA mode of the dynamic multigroup.

4.3.5
Agencygroup Call

An agencygroup is a collection of multigroups. A message can be transmit to multiple multigroups simultaneously by selecting the agencygroup. Subscriber radios affiliated to talkgroups in the members' multigroup also hear the agencygroup audio.

The agencygroup can be configured to support up to 16 multigroups. In the Provisioning Manager (PM), the multigroup in the agencygroup list shows which multigroups are part of the agencygroup. An

agencygroup must be created with multigroups from the same home zone, and a multigroup must be associated with at most one agencygroup.

The Frequency Division Multiple Access (FDMA) or Time Division Multiple Access (TDMA) signaling is determined based on the talkgroups and multigroups associated with an agencygroup. The following combination of signaling (access types) are allowed:

- FDMA-only
- TDMA-only
- Dynamic Dual Mode (DDM)

When a subscriber radio transmits an agencygroup call with all the radios located at the same sites, any radio that is part of the agencygroup hierarchy can priority-scan the agencygroup to ensure they hear the agencygroup call audio. The radio affiliating to the agencygroup itself can hear the agency call audio.

Dispatch consoles receive the agencygroup call audio if they are affiliated to the agencygroup itself.

If the subscriber radio is affiliating to an agencygroup, it receives audio from the agencygroup and can scan for additional group call audio.

NOTICE: Subscriber radios affiliated to an agencygroup do not scan the audio from their member groups as they do when affiliated to a multigroup.

4.3.5.1
Agencygroup Emergency Calls

Emergency agencygroup calls are allowed and are treated in a way similar to the emergency multigroup call. Emergency calls on the member talkgroups/multigroups are not ended when the agency call is started. However, the subscriber radios in those active emergency calls can scan to the agencygroup call as accomplished by using priority monitor.

If an emergency call on a member group is in an agency hierarchy, the emergency call is not ended to start the agencygroup call. However, the radios in the emergency call leave the emergency call and start to listen to the agency call audio as along as the agencygroup is configured with the highest priority.

4.3.5.2
Agencygroup Priority Configuration

The agencygroup should always be configured as highest priority. If the agencygroup is not configured as highest priority, the agencygroup call might not be started as quickly as expected.

Unless the agencygroup is configured as highest priority, if a channel is not available when the agencygroup call is started, the agency call is busy. Even when a channel becomes available, the agency call may or may not have the busy converted based on how the agencygroup priority is configured. When the agencygroup is configured with a higher priority, a busy agency call has the best chance to be converted as soon as possible.

If a member talkgroup (TG 1) in an agency hierarchy is patched to a supergroup (SG 1) with an active supergroup call, the supergroup call is not ended when the agencygroup (AG 4) call is started. However, the radio affiliating to the member talkgroup (TG 1) leaves the supergroup call and starts to listen to the agencygroup call audio as long as the agencygroup is configured with the highest priority.

4.3.6
Zone Controller Supergroups

See Call Services Supergroup Operation on page 42 for more information.

4.3.7

Zone Controller Service Mode Group Call

The system operating in Dynamic Dual Mode (Frequency Division Multiple Access/Time Division Multiple Access) supports service mode group calls. The user is able to specify a channel but not the slot level.

4.3.8

Emergency Services Operation

This section describes the following topics:

- Emergency Calls
- Emergency Alarm

4.3.8.1

Emergency Calls

An emergency call is a specialized, high-priority version of a talkgroup or multigroup call. Emergency calls always have the highest priority in the system. When an emergency call request is made during a period of time when all voice channels are busy, the request takes a priority over any other type of call request. The emergency call is transmitted on each subscriber radio's selected talkgroup or multigroup.

NOTICE: When an emergency call is set up by a console and is initially assigned in Time Division Multiple Access (TDMA) mode, a Frequency Division Multiple Access (FDMA) affiliation causes the call to be transmission trunked. The FDMA-only user is allowed to participate in the call. FDMA-only or TDMA-only talkgroups are used to assure the emergency setups are indefinite, and to assure the emergency setups remain active until the dispatch console “knocks down” the setup.

All call types including an emergency call are transmission trunked when an FDMA-only subscriber radio or dispatch console affiliates to a dynamic talkgroup active in a TDMA talkgroup call, or when a TDMA subscriber radio roams to an FDMA-only capable site. When an emergency call is active, the current transmitter (subscriber radio or dispatch console) dekeys, and the emergency call is ended and re-established to restart the call. The restart allows all members of the talkgroup to receive audio on the talkgroup. The ending of an emergency call applies to both a subscriber radio and a dispatch console-initiated emergency call. When an emergency call is granted, it is handled by the system as a talkgroup call although emergency calls are message trunked with their own longer hangtime timer setting. The range for this timer is 0 to 3660 seconds, and the default message hangtime for an emergency call is 30 seconds. A console operator can initiate an emergency call on any talkgroup or multigroup being monitored. The system handles a console emergency call request the same as a radio-generated request, with one exception: a console-generated emergency call has an unlimited hangtime, so the call stays active until the operator “knocks down” the emergency call at the operator position.

IMPORTANT: FDMA-only or TDMA talkgroups are used to set up the emergency call to ensure indefinite user participation. To ensure that an emergency call setup by a console dispatcher remains up indefinitely, a Dynamic Dual Mode (DDM) group should not be used.

Subscriber units are allowed to attempt to register at a site if the subscribers have a valid ID at power-up registration. The subscriber unit's request is either accepted or denied, depending on the configuration of the valid site flag and the site access denial flag. These responses allow the subscriber to stay at the site or leave the site, respectively. The unit registration procedures are responsible for making the subscriber's presence known at the site during power up.

The **Emergency Allowed at Not Valid Sites** flag may be used, in addition to the **Valid Site Flag** and **Site Access Denial** flag, to determine whether the registration or affiliation request or affiliation query response is accepted while the subscriber unit is in emergency mode. When the inbound registration

request indicates that an emergency bit is set and the **Emergency Allowed at Not Valid Site** parameter is set in the Unified Network Configurator (UNC), the subscriber is permitted access.

This feature is available on APX, XTS1500/2500 B versions or later, XTS5000, XTL 5000/2500/1500, XTL/XTS, and is supported by both the PSC 9600 site controller and the GCP 8000 site controller. This feature is supported on mobile radios used as part of Digital Vehicular Repeater System (DVRS) mobile installation, but not by DVRS portable radios operating into a DVRS.

This feature does not change any configuration procedures including Radio Authentication. It is a change to the registration messages which are transparent to administration and user operation.

Emergency calls are processed by the system. Calls continue to be supported in the following method:

- Top of Queue.
  During the top-of-queue processing, the controller places the incoming emergency call request at the top of the busy queue. In addition, the central controller monitors the voice channels for a disconnect signal. Upon detection of a disconnect signal on one of the voice channels, the controller assigns that channel to the subscriber radio in emergency mode.
- Ruthless Preemption.
  This mode of operation causes the controller to look at the priority of the talkgroups assigned to the voice channels and preempt the group with the lowest priority so the channel can be assigned to the emergency caller.

The system supports top-of-queue mode for emergency calls at the requesting site. In top-of-queue emergency mode, the emergency call request does not obtain an RF resource at the subscriber radio's RF site. It is queued at the top of the priority. All non-emergency calls at the RF site are transmission trunked. The Zone Controller (ZC) preempts lower priority calls at the non-initiators site when a resource is not available regardless of the top-of-queue setting.

An emergency call is routed to all affiliated talkgroup or multigroup members, including all console positions and logging recorders affiliated to talkgroup or multigroup. All needed resources for receiving sites are ruthlessly preempted.

NOTICE: A value of 3660 disables the message timer for emergency calls. Radio users have unlimited time between Push-To-Talks (PTT).

A console operator can initiate an emergency call on any talkgroup or multigroup being monitored. The system handles a console emergency call request the same as a radio-generated request, with one exception: a console-generated emergency call has an unlimited hangtime, so the call stays active until the operator "knocks down" the emergency call at the operator position.

NOTICE: Emergency calls initiated from the console are always processed in Ruthless Preemption mode when resources are not available to grant the call immediately.

For an FDMA emergency call initiated at a busy dual-phase RF site set for top-of-the-queue mode, the ZC completes transmission trunk both FDMA and TDMA calls to free resources. Two possible FDMA emergency call situations can occur:

- When a TDMA channel has one TDMA call active while the emergency call is waiting for the active TDMA call to end, another TDMA call is assigned to the free slot. The second TDMA call does not complete transmission trunked causing the emergency call to be delayed.
- When a TDMA channel has two TDMA calls active on the channel and one of the TDMA calls ends before the other, the free TDMA slot is assigned to a lower priority TDMA busy call causing the emergency call to be delayed.

When the ZC transmission trunked calls receive an FDMA emergency call and does not reserve resources to convert an FDMA busy, the result is a potential wait time for a busy FDMA emergency call at a dual-phase RF site.

4.3.8.2

Emergency Alarm

The emergency service allows a subscriber radio to send an emergency alarm to both the dispatch system and the Radio Control Manager (RCM) application. Only subscriber radios can send an emergency alarm. Only dispatch consoles and RCM can receive an emergency alarm.

When the emergency button on a subscriber radio is pressed, an emergency alarm is transmitted through the control channel. This alarm is forwarded to any consoles monitoring the subscriber radio's currently selected talkgroup or multigroup. Any RCM positions that are active, and have the currently selected talkgroup or multigroup as part of their list of attachments, also receive and display the emergency signal. The subscriber radio can be configured to enter emergency call mode automatically when the emergency button is pressed.

The emergency is delivered to all dispatch consoles that have the affiliated talkgroup or multigroup of the subscriber radio assigned.

When an emergency is received at the console, the following occurs:

- The emergency tone sounds in the select speaker.
- The border of the resource window that receives the emergency flashes red.
- The status line of the resource window displays `Emerg`. It displays or `Emerg Call` if the transmit button was pressed on the subscriber radio initiating the call.
- The subscriber radio ID and emergency type are also shown in red in the stack and activity log if displayed.
- The volume for the resource is automatically set to the maximum level.

The zone controller generates an acknowledgment returned to the originating subscriber radio to indicate that the emergency is received.

NOTICE: The emergency at invalid sites rules applies to emergency alarm. Rules for registration and affiliation at invalid sites apply for emergency alarms the same as for emergency calls.

4.3.9

Channel Marker

A Channel Marker is a distinct, short-duration audible tone played over subscriber radio and console speakers. The Channel Marker feature provides the ability for dispatch console users to send a periodic, short-duration audible tone (a 700-Hz sine wave) through a conventional channel or trunked channel (talkgroup) resource to subscriber radios.

The primary use of the Channel Marker feature is to inform radio users that the conventional channel or the trunked talkgroup is currently involved in a high-priority situation, and radio users should stay off the channel unless they are involved in the high-priority situation. The tone also informs users that a console operator is monitoring the talkgroup.

The MCC 7500 console operator has a Channel Marker button on each resource configured with the Channel Marker capability so that an audible Channel Marker tone can be generated periodically through channel resources where the Channel feature is enabled only when there is no voice activity on the channel. The console operator is able to activate or deactivate the Channel Marker feature on any resource that has the Channel Marker capability, regardless of the current selected resource on the console.

All MCC 7500 consoles share the status and control of the Channel Marker, so when one dispatcher activates Channel Marker on a resource, all parallel consoles see that the Channel Marker is activated and the parallel operator positions are able to deactivate the Channel Marker.

In Provisioning Manger (PM), the console Talkgroup/Multigroup (TG/MG) Capabilities Profile is used to enable/disable the Channel Marker feature for a TG/MG. The Console User Capabilities Profile is used

to configure the Channel Marker Repeat Interval (seconds). The Analog Conventional Channel or Digital Conventional Channel objects are used to enable/disable the Channel Marker feature on a conventional channel resource. The Channel Marker tone duration is set at 0.5 seconds. While the Channel Marker tone recurrence rate (Repeat Interval in seconds) is set by default at once every 10 seconds, and is configurable from 5 to 255 seconds, the recommendation is to set it no lower than 8 to 10 seconds to avoid an unnecessary increase in communication traffic.

NOTICE: The tone of a channel marker on a Priority talkgroup does not interrupt a subscriber radio on a voice channel involved in another talkgroup call.

4.3.9.1
Channel Marker Configuration Files

Configure the Channel Marker feature in the Provisioning Manager (PM) using the objects and fields.

Table 10: Channel Marker Configuration Files

Application	Object	Tab/Field
PM	Console TG/MG Capabilities Profile	Configuration Channel Marker Enabled
PM	Console User Capabilities Profile	Configuration Channel Marker Repeat Interval (sec)
PM	• Analog Conventional Channel • Digital Conventional Channel • MDC Channels • Mixed Mode Channels	Configuration Channel Marker Enabled

4.4
Individual Call Services

Individual, unit-to-unit call services are available with an ASTRO® 25 system. Controlling zones are determined in a manner different from that used for group-based calls for this type of call service. In an individual call, the controlling zone is determined by the home zone of the subscriber requesting the unit-to-unit call.

NOTICE: In unit-to-unit calls, the initial call request goes over the control channel. An audio channel is not assigned until the target subscriber radio responds to the initial request. Audio channel resources are assigned when the target subscriber radio responds to the call request.

4.4.1
Calling Unit-to-Unit

When and where to use: A unit-to-unit call begins with a call request. The call request resolution determines whether the call is set up. Requests are rejected if the target radio does not respond to the request or if the target radio is not registered with the system. Other reasons for a call to be rejected include configuration-related where one of the radios is blocked from private calls, site not allowed, and so on. The following explains the sequence of unit-to-unit call request from an IP simulcast subsystem.

Procedure:

1 A private or unit-to-unit call request is initiated when the caller selects the appropriate mode on the subscriber radio and then enters the target subscriber radio's ID or selects it from a list.

2 When the caller presses the Push-To Talk (PTT) button, the call request is sent over the control channel to the current site.

3 The base radio takes the call request from the subscriber radio and routes it through the IP network.

4 The site controller receives the call request through the Ethernet switch, processes the request and routes it to the Zone Controller (ZC) through the IP network.

5 The receiving ZC checks its Visitor Location Register (VLR) to see if the requesting individual is configured to make unit-to-unit calls.

6 If the call is allowed, the ZC checks its individual VLR to see if the target subscriber radio is currently affiliated in the zone, and if it is, at which site.

7 The ZC does one of the following:

If…	Then…
The target subscriber radio is active (registered) in the zone,	the ZC sends it a unit-to-unit call request over the control channel at its current site.
The target subscriber radio is not in the current zone,	the caller's ZC determines the target subscriber radio's home zone by checking its individual-to-home zone map.

8 The caller's ZC sends a message to the target subscriber radio's home ZC requesting the current location of the target subscriber radio, which the home ZC gets from its individual Home Location Register (HLR).

9 When the target subscriber radio's current zone is known, the receiving ZC sends the call request to the ZC in that zone.

10 The target subscriber radio's ZC checks its individual VLR for the target's site location and sends the call request to the target subscriber radio through the control channel at its current site.

11 The call request response depends on the situation:

If…	Then…
The target subscriber radio is not registered with the system,	the requester receives a call reject.
The target subscriber radio is registered with the system,	the requester hears a ringing tone.
The target subscriber radio does not respond within the time-out period,	the call request is ended.
The target subscriber radio responds to the call request,	the unit-to-unit call is set up.

4.4.1.1 Unit-to-Unit Call Diagrams

Individual, unit-to-unit call services for the ASTRO® 25 system are shown for inbound calls, outbound calls and audio flow.

Figure 12: Unit-to-Unit Call Inbound Call

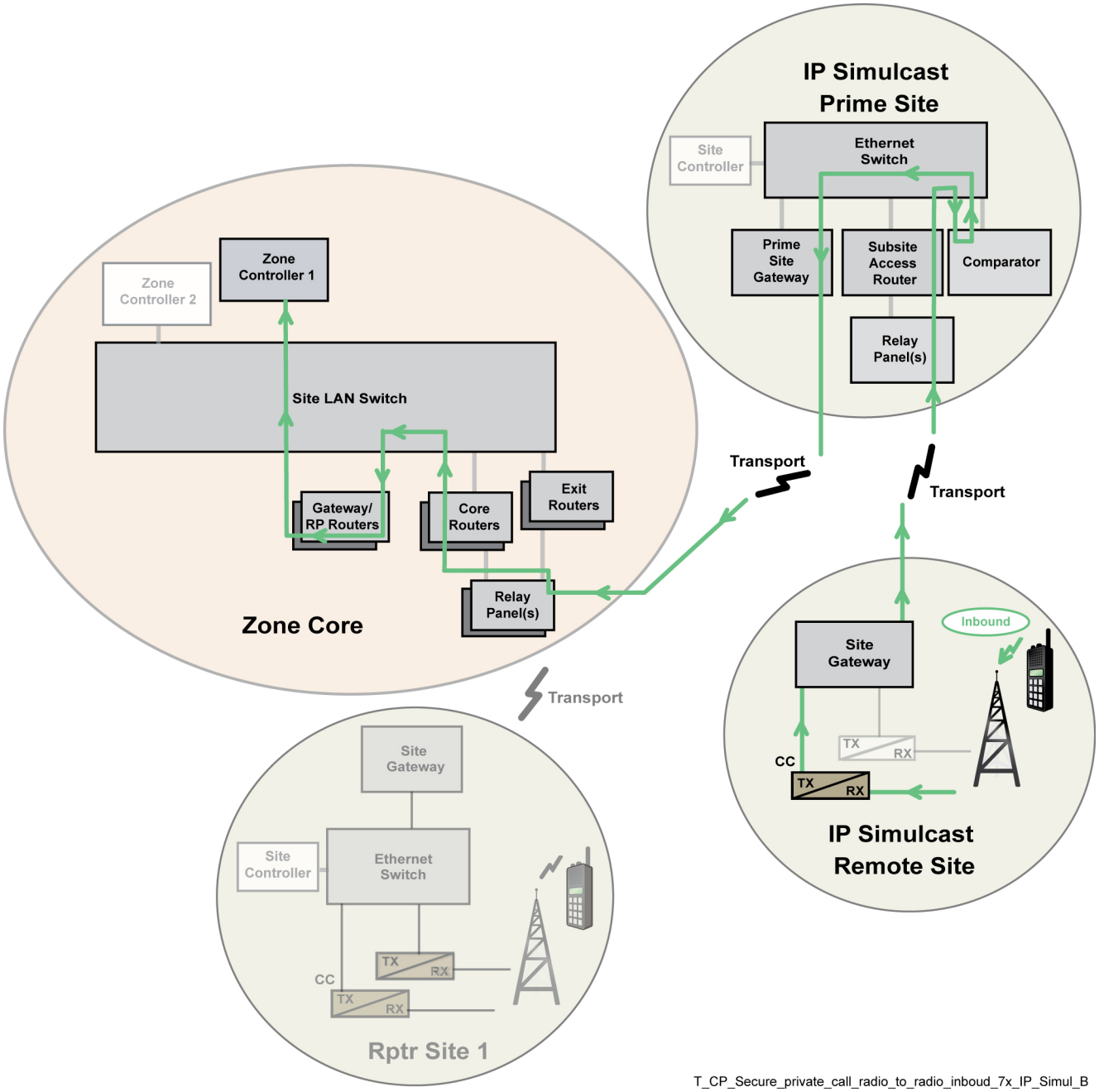


Figure 13: Unit-to-Unit Call Outbound Call Grant

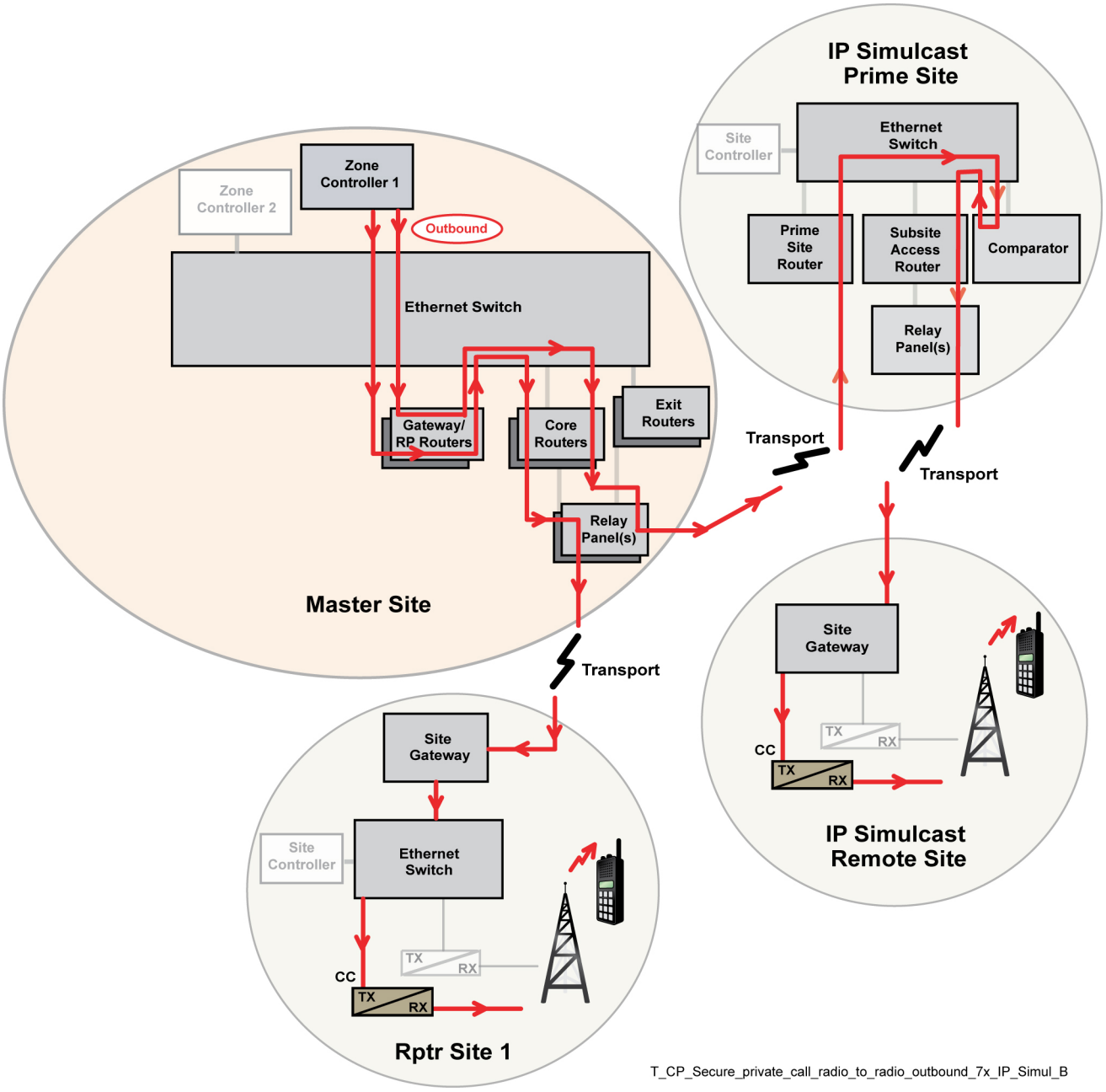
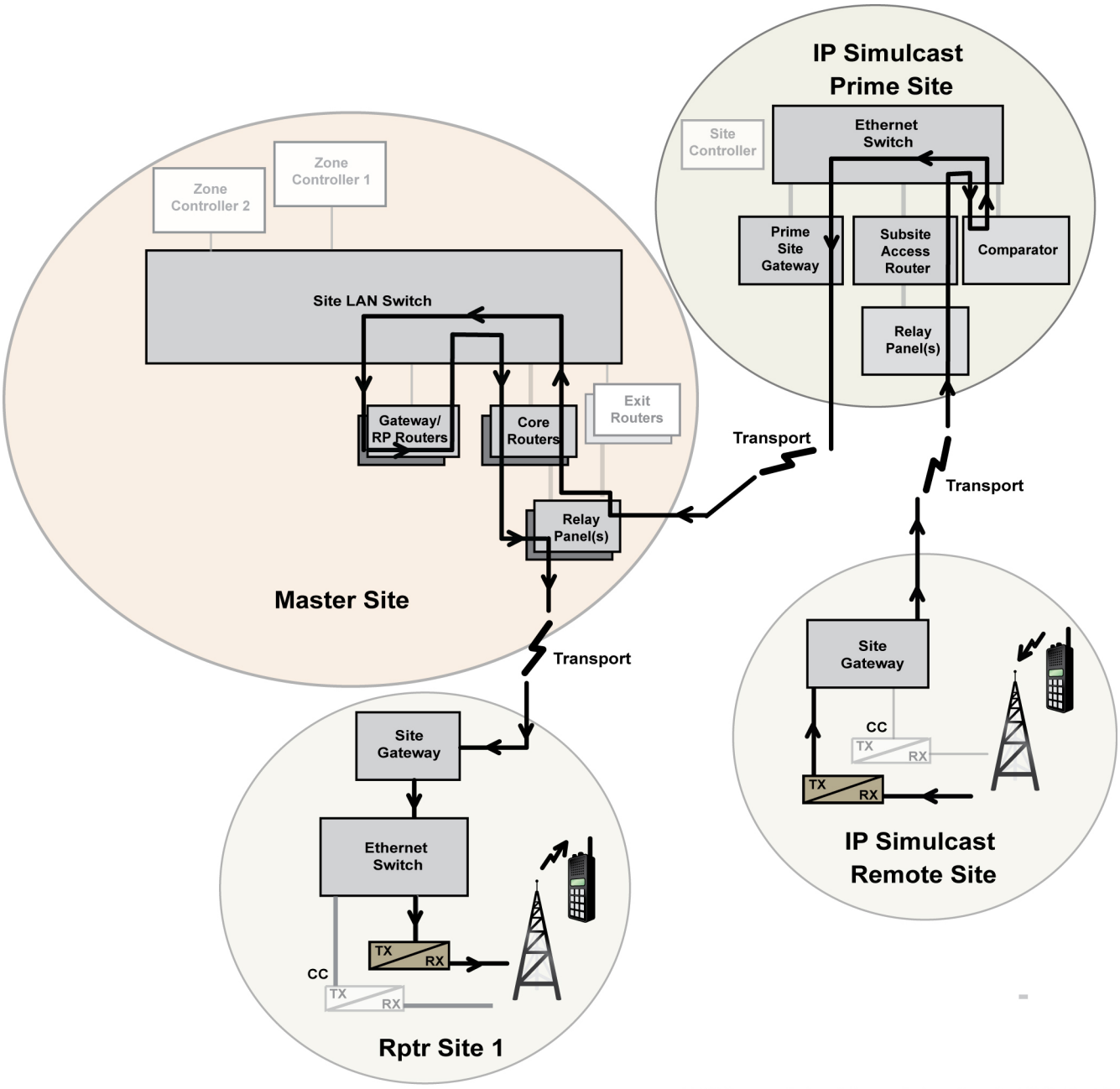


Figure 14: Unit-to-Unit Call Audio Flow



T_CP_Secure_private_call_from_radio_to_radio_audio_7X_IP_Simul_B

4.4.2

InterZone Unit-to-Unit Audio Flow, Call Continuation, and Teardown

The following is a description of InterZone unit-to-unit audio flow, call continuation, and call teardown:

1. When the initiating user presses the Push-To-Talk (PTT) button on the subscriber radio, the audio signal is received by the assigned voice channel at the local site and is routed to the Rendezvous Point (RP) at the controlling zone.
2. The core router at the transmitting subscriber radio's zone sends the audio to the exit router through the LAN switch. The exit router transmits the audio to the participating zone(s).

3 When the target user responds, the same path is used, but the source and destination of the audio are swapped.

4 When neither party responds to the call within the message hangtime, the call is ended.

NOTICE: If either user keys up to respond after the hang timer has expired, but while still in unit-to-unit call mode, a new unit-to-unit call is established.

4.4.3
Roaming During a Unit-to-Unit Call

The ASTRO® 25 system supports call continuation during roaming for unit-to-unit call. When a non-transmitting subscriber radio user roams to a new site during a call, the audio is redirected automatically to the new site. The subscriber radio user experiences a brief interruption of the audio when moving to another site within the same zone. The audio interruption when moving to a site in a new zone may be slightly longer.

NOTICE: A transmitting subscriber radio user in an active unit-to-unit call cannot roam automatically. When a transmitting subscriber radio fades out, due to moving away from the current site, the system detects the loss and begins the call termination process.

4.5
Busy Call Handling

A call request that cannot be granted the necessary resources when the call request is made is placed in the busy queue of the controlling zone controller.

Calls are placed in the busy queue in the order in which they are received. However, priority setting of each call type influences the order in which calls in the busy queue are evaluated. Higher-priority calls are evaluated before lower-priority calls. Calls of equal priority are evaluated on the basis of the order in which they were placed in the queue.

In Dynamic Dual Mode (DDM), the system converts the first busy in the busy queue whenever possible. When the first busy in the busy queue does not use the resources that are free, the system converts the next busy in the busy queue or grants the next call request.

4.5.1
Priority Levels

The system uses priority levels determine the assignment of system resources when multiple calls are competing for system resources. Emergency calls always have the highest priority level. For details, see Agencygroup on page 81. The system has 10 priority levels:

- Priority level 1 – the highest priority reserved for emergency calls. Priority level 1 calls cannot be assigned to any other call types.
- Priority levels 2-10 – assigned to talkgroup, individual, or telephone interconnect calls. Priority level 2 is the highest assignable priority, while priority level 10 is the default priority setting.

4.5.2
Group Call Busies

Two calling features determine when group, talkgroup, and multigroup, calls are busied:

- AllStart™
- FastStart™

These calling features are assigned to the groups in the Provisioning Manager (PM) application.

4.5.2.1
Group Call Busies AllStart

An AllStart™ setting for a group indicates that all the available resources for the call must be present for the call to start. An AllStart™ call requires the following resources before a call is granted:

If any of the following conditions are not met, the call is placed in the busy queue:

- A voice channel at all sites that have affiliated group members.
- All affiliated consoles and logging recorders, including all resources to support console calls.
- A voice channel at all critical sites. Critical sites for a talkgroup are designated in the Talkgroup/ Multigroup (TG/MG) Site Access Profile record available in the Provisioning Manager (PM).

4.5.2.2
Group Call Busies FastStart

A FastStart™ setting for a group call indicates that only mandatory resources, that is critical sites, critical resources, and requested sites, are required to grant a call. Any other resources available at the time the call is set up are also included in the call. In FastStart™, not all affiliated members in a talkgroup must have a channel available for a call to start. FastStart™ requires the following resources before a call is granted:

- A voice channel at the requestor's site.
- All affiliated consoles and logging recorders, including all resources to support console calls.
- A voice channel at all critical sites.

If any of the above conditions are not met, the call is placed in the busy queue.

NOTICE: When a group call is busied, the priority assigned to the call in the queue is determined by the higher of the talkgroup's or requestor's individual priority. For example, if the talkgroup is priority 8 and the requestor is priority 5, the call is queued with priority 5.

4.5.3
Unit-to-Unit Call Busies

Unit-to-unit calls are placed in the busy queue if the required resources for the call, including encryption, are not available at the time of the request.

Unit-to-unit calls can have a priority level assigned that determines how the call request is serviced in the busy queue. The higher the priority, the sooner the call is serviced.

For more information on priority level assignment, refer to Talkgroup Object on page 80, Multigroup on page 81, or Agencygroup on page 81.

NOTICE: When a unit-to-unit call is busied, the priority assigned to the call in the queue is determined by the higher of the target or requestor's individual priority. For example, if the target's priority is 8 and the requestor's priority is 5, the call is queued with priority 5.

4.5.4
Using Call Alert

This section provides information for the Call Alert feature. The following topics are included:

- Using Call Alert in Site Trunking
- Talkgroup Muting
- Configuring Call
- Using In-Call User

Call Alert is a functionality that allows an authorized caller to leave a notification in an unattended subscriber radio to indicate that a system user wishes to communicate with the user of the alerted subscriber radio. The initiator may be a dispatcher or another subscriber radio user. No voice communication is involved in Call Alert. This paging feature provides benefits in following situations:

- If a user is temporarily away from the subscriber radio, a Call Alert page can be sent to the subscriber radio. The subscriber radio continues to emit call-received tones, four tones every 15 seconds, until acknowledged manually by the target subscriber radio user.
- If a user operates in a noisy environment, a Call Alert can be sent to the subscriber radio. When the user leaves the high-noise area, the tones inform the user a call has been missed while in the high-noise environment.
- If verifying user's activeness on the system is needed, a successful Call Alert emits four beeps at the initiating subscriber radio or dispatcher, informing the caller that the target subscriber radio is active on the system and has received the page.

The Call Alert feature encompasses the ability to encode and send a Call Alert page, or to decode an incoming page.

Calls can be initiated from and received by consoles and subscriber radios.

The console sends the Call Alert to its local zone controller, which processes the Call Alert. This includes the case where the destination is in another zone. The zone controller of the destination zone sends the Call to the site where the subscriber radio is located.

A call alert also has both an audible and visual alerting indication to the target radio. The visual alert can be seen if the target radio is attended. The initiator of the call alert is informed of the success or failure of the alert attempt.

4.5.4.1
Call Alert Processing

When and where to use: The following is a description of the Call Alert process.

Process:

1. A Call Alert destined for a subscriber radio is initiated by a user at a dispatch console position. An alternative scenario is that the Call Alert is initiated by a subscriber radio user.
2. The Call Alert is sent from the console to the local Zone Controller (ZC).
3. The ZC subsystem determines the destination zone and destination site for the Call Alert based on the current location of the target subscriber radio.
4. The ZC subsystem sends the Call Alert to the destination site, and sends a response back to the console indicating that the Call Alert is sent to the site.
5. The site controller at the destination site receives the Call Alert from the ZC and sends the Call Alert to the control channel, and to voice channels and data channels if In-Call User is enabled, for transmission over the air. The channel transmits the Call Alert to the subscriber radio using APCO standard messaging.
6. Upon receipt of the Call Alert, the subscriber radio alerts the user both visually and audibly of the receipt of the Call Alert. The visual and audible notifications persist until the user responds to the Call Alert. Any key or button press, channel or switch change with the exception of the light key/dim button and the volume knob, responds to the Call Alert and stops the visual and audibles.
7. When the user responds to the Call Alert, the subscriber radio sends an acknowledgment on the control channel to the site.
8. The site controller receives the Call Alert acknowledgment from the control channel and forwards it to the ZC.

9 The ZC subsystem sends the Call Alert acknowledgment to the originating console or subscriber radio.

10 The console then displays the success/failure of the Call Alert to the console dispatcher or subscriber radio.

4.5.4.2
Using Call Alert in Site Trunking

Site Trunking mode of operation occurs when the link to the zone controller fails, and the site controller operates the site as if it were an independent single-site system. When operating in Site Trunking mode, the site performs the same Call Alert functionality as in Wide Trunking mode, but the Call Alerts are processed within one site.

4.5.4.3
Talkgroup Muting

Talkgroup muting is a functionality which allows the subscriber radio user to mute all voice traffic for the currently selected talkgroup. The subscriber radio allows the user to enable and disable talkgroup muting using the Push-To-Talk (PTT) button or menu option. While talkgroup muting is enabled, the subscriber radio mutes all talkgroup voice for the talkgroup the subscriber radio is currently affiliated to, including emergency voice received. When talkgroup muting is disabled, the subscriber radio returns to standard talkgroup audio processing.

Several circumstances when talkgroup muting is disabled automatically without any action by the subscriber radio user include:

- Entering Site Trunking mode
- Receiving Call
- Entering Site Failsoft mode
- Radio Inhibiting/Uninhibiting
- Dynamic Regrouping

Talkgroup muting by the subscriber radio is configured through the Customer Programming Software (CPS).

4.5.4.4
Configuring Call Alert

See the *Configuring Call Alert* section in *Provisioning Manager* manual for Call Alert configuration details.

NOTICE: Regardless of the infrastructure configuration, user limitations, or channel availability, Customer Programming Software (CPS) programming of the subscriber radio can prevent Call Alerts from being supported by the subscriber radio.

4.5.4.5
Using In-Call User Alert

In-Call User Alert is a functionality that provides the ability to send a Call Alert signal from a console or subscriber radio to a target subscriber radio regardless of which service the subscriber radios may be in when the signal is sent.

In-Call User Alert relies heavily on the existing Call Alert feature of the ASTRO® 25 system.

The system is configured through the Provisioning Manager (PM) to enable the In-Call User Alert feature. When this feature is enabled, the system transmits all Call Alerts on the Control Channel, Voice Channels, and Packet Data Channels. This transmission allows the target subscriber radios to

receive the Call Alert even when they are involved in voice or data calls. The system performs this functionality for all Call Alerts regardless of whether they are sourced from a console or subscriber radio.

NOTICE: Even with the In-Call User Alert feature enabled, if the subscriber radio is transmitting at the time the Call Alert is initiated, the subscriber radio does not receive the call since the subscriber radio is half-duplex.

When the In-Call User Alert feature is disabled, the site transmits Call Alerts only on the Control Channel. In this case, the target subscriber radio does not receive the Call Alert if it is involved in a voice or data call.

From a Radio and Radio User Management perspective, no additional parameters requiring configuration apart from those set through PM software are required. See the *Provisioning Manager* manual for more information.

4.5.4.5.1
Configuring In-Call User Alert

When In-Call User Alert is enabled, the site controller at the destination site receives the call alert from the Zone Controller (ZC) and sends the call alert to the control channel, the voice channels, and data channels. In-Call User Alert is configured using Provisioning Manager (PM). See the Console User Capabilities Profile, Radio Capabilities Profile, and Call Alert Receive/Transmit Enabled parameters, channel objects, ASTRO Control Interface Module (ACIM) Conventional Channel, Mixed Mode Conventional Channel, or Digital Conventional Channel, and the Inbound and Outbound Call Alert parameters in the *Provisioning Manager* manual for details to configure for Call Alert.

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Chapter 5

Trunked Call Processing Troubleshooting

This chapter provides fault management and troubleshooting information relating to Call Processing and Mobility Management failures. For troubleshooting call processing associated with the Dynamic Transcoding feature, see the *Dynamic Transcoder User Guide* manual.

NOTICE:
The Dynamic Transcoding feature supports group call and unit-to-unit communication between FDMA subscriber radios on one site with TDMA subscriber radios on a separate TDMA-capable site while preserving the FDMA and TDMA modes of operation at each respective site. The Dynamic Transcoding feature also supports group call and unit-to-unit communication between subscriber radios on an FDMA-only site with TDMA subscriber radios in a TDMA-capable site while preserving the FDMA and TDMA modes of operation at each respective site.

5.1 Control Plane Failure

Troubleshooting control plane failure comprises the following:

- Call Processing Failure
- Call Management Failure
- Mobility Management Failure
- Interzone Communications Failure
- Enhanced Console Telephony Failure

5.1.1 Troubleshooting Call Processing Failure

The zone controller is responsible for all registration, individual call, and group call processing in its zone. A failed zone controller results in the loss of system and zone trunking for that particular zone. All call requests, registration requests, and calls in progress are dropped. The zone also drops out of participation in all InterZone calls.

5.1.2 Call Management Failure

The zone controller is responsible for managing sites, telephone interconnect services, and other equipment in the zone to arrange calls. With the zone in site trunking, services such as telephone interconnect and console operations are not available.

5.1.3 Mobility Management Failure

The zone controller maintains mobility information for its zone including a Visitor Location Register (VLR) of all subscriber radio users located in the zone, and a Home Location Register (HLR) of all subscriber radio users mapped to the zone. A failed zone controller loses all mobility management information. Site location information for all subscriber radio users is maintained at the sites. If any

roaming subscriber radio users are mapped to another zone, their home zones are not able to track their location until the zone is operating normally again.

5.1.4
Modes of Operation

The ASTRO® 25 communication system functions in various operating modes. Standard operating modes identify system operating modes not typically induced by user intervention. User-initiated operating modes identify system operating modes typically induced by intentional user intervention.

5.1.4.1
User Initiated Operating Modes

User-initiated operating modes identify system operating modes typically induced by intentional user intervention.

- Site Off - This is a Unified Event Manager (UEM) function for taking a site off the air (dekeys all channels). Site Off may be useful if channel interference is occurring in the service area. This command causes subscriber radios locked to the site to scan for other sites in the system.
- Site Test - This command resets an ASTRO® 25 site. Using this command causes any subscriber radio locked to the site to scan for other sites in the system.

IMPORTANT: Use the Site Off command with the utmost discretion. Resetting a site causes the site to attempt to go back into a trunking state. Therefore, the Site Off mode is considered to be a temporary operating state.

NOTICE: The Site Failsoft operating mode can also be user initiated from the diagnostics capability of the UEM. However, the Site Failsoft operating mode is considered primarily as a fallback operating mode because communication resources may function in Site Failsoft mode under conditions not initiated by user intervention.

Two gateway routers exist at the Master Site/Zone Core. The gateway routers provide the control Rendezvous Point (RP) function for zone controller RF Site Control Paths (ZC-RF SCPs) that service each site. Failure of one gateway router does not take RF sites out of wide area trunking mode. The gateway routers also provide the RP function for InterZone Control Paths (IZCPs) that service each zone.

Each RF site interfaces to two core routers (the audio RP) at the Master Site/Zone Core. This interface allows the system to stay in wide-area trunking mode if a single core router fails.

Redundancy for InterZone communications is supported through the exit routers. Each Master Site/Zone Core has two exit routers that interface to other zones. This interface allows the system to maintain InterZone connectivity if a single exit router failure occurs.

NOTICE: The failure of an exit router temporarily takes a zone out of InterZone trunking with other zones until the network can converge to the remaining exit router. This convergence takes approximately 10-20 seconds in an ASTRO® 25 multizone system.

In an ASTRO® 25 system, voice control and network management traffic flow over the same physical bandwidth between the Master Sites/Zone Cores. Traffic is sent through network links between the zones. The exit routers prioritize voice and voice control over other system traffic. Due to manner in which routing works between zones, only one exit router in each zone carries InterZone traffic between zones at a time.

5.1.4.2
ASTRO 25 Repeater Site Modes of Operation

The following are the operational modes for an ASTRO® 25 repeater site:

Wide Area Trunking

An ASTRO® 25 repeater site can remain in wide-area trunking if the following resources are available:

- One voice channel
- One control channel
- A site controller
- Connectivity through the Ethernet switch or switches
- A site router/gateway
- A physical link between the subsystem and the Master Site/Zone Core
- A logical path between the site router/gateway and the Master Site/Zone Core IP equipment

Site Trunking

Site trunking operation takes place when no physical or logical link is between the site routers/gateways and the Master Site/Zone Core. It can also be initiated from the diagnostic capability in the Unified Event Manager (UEM). If a site controller switchover occurs while the site is in the site trunking state, all active calls at the site are transmission trunked.

Site Failsoft

Site Failsoft mode of operation at an ASTRO® 25 repeater site takes place only when both site controllers fail, the Ethernet switch fails (or both fail in a dual-switch configuration), no base radios are operational control channel capable, or all voice channels are inoperative. Site Failsoft can also be initiated from the diagnostic capability in the UEM. When an ASTRO® 25 Repeater Site enters Site Failsoft, the channels configured for Failsoft operation begin using their "In-cabinet Repeat" mode. Subscriber radios configured for Failsoft operation can only place calls to other subscriber radios on the same Failsoft channel.

Site Off

Site Off is an operational mode that can be initiated from the diagnostic capability in the UEM. In this state, the subsystem is not available to the subscriber radios.

NOTICE: Site Failsoft is only supported in FDMA mode.

If a site controller switchover occurs while the subsystem is in wide-area trunking state, all active voice calls at the site continue without any interruption in service. No "in progress" voice calls are lost on a site controller switchover. This stability is possible because the active voice call states and databases of the active and standby site controllers are synchronized.

If one site controller fails, the other maintains the system in wide-area trunking. If the site is in site trunking mode, however, the site controller manages all site functions and call processing.

For ASTRO® 25 repeater sites using dual site routers/gateways, a Master Site/Zone Core interface link failure or a site router/gateway failure has no effect on wide-area operations because the remaining site router/gateway maintains the links. With a single router configuration, however, the subsystem enters site trunking mode if a Master Site/Zone Core interface link failure or a site router/gateway failure occurs.

5.1.4.3

Simulcast Subsystem Modes of Operation

Many of the modes of operation available in a Simulcast Subsystem are similar in name to the modes of operation available in an ASTRO® 25 Repeater Site. But there are operational differences between

an ASTRO® 25 Repeater Site and a Simulcast (Multi-Site) Subsystem. These differences and some similarities are described in the following sections.

NOTICE: Simulcast subsystem with Receive only subsites and Single Transmitter, Receiver Voting (STRV) subsystems, are both types of Multi-Site subsystems and have the same modes of operation as a simulcast subsystem.

The operational modes for both circuit-based and IP-based simulcast subsystems include the following:

- Wide-area trunking
- Site Trunking
- Site Failsoft: Site (Subsystem) Failsoft and Local Failsoft
- Local Failsoft at remote site
- Site Off

Simulcast Channels States of Operation

The operational modes for both circuit-based and IP simulcast subsystems include the following:

- Enabled
- Malfunctioned
- Impaired
- User Disabled
- Unconfigured state

Simulcast Subsites States of Operation

The operational modes for both circuit-based and IP simulcast subsites include the following:

- Enabled
- Malfunctioned
- User Ignored
- Unconfigured

Simulcast Subsystem Resource Voting

Resource Voting impacts the criteria to enter, or not to enter failsoft. For details, see Simulcast Subsystem – Resource Voting on page 122.

5.1.4.3.1 Simulcast Subsystem Wide Area Trunking Mode

Both circuit-based and IP simulcast subsystems remain in wide-area trunking as long as the following resources are available and functioning properly:

- The site control path (transport link, zone controller, gateway router, LAN switches, and core router at the Master Site/Zone Core)
- One site router/gateway
- One prime site controller
- One site switch
- At least one voice channel and associated comparator
- At least one control channel
- The resource Voting rules given in section Simulcast Subsystem – Resource Voting on page 122 dictate that the sub-system should NOT enter failsoft mode.

NOTICE: The site control path includes any transport link between the subsystem and Master Site/Zone Core, zone controller, gateway router, WAN and LAN switch, and core router equipment.A functioning site control path results from good communications between the prime site controller and the zone controller.

NOTICE: For an IP simulcast subsystem, with a redundant configuration, the LAN maintains wide-area trunking performance if a single switch fails. In a geographically redundant configuration, an outage could occur briefly before restoration of wide-area trunking.

5.1.4.3.2
Simulcast Subsystem Site Trunking Mode

When a simulcast subsystem loses the site control path due to a failure in the transport link or site control path equipment, and the subsystem enters site subsystem trunking mode. The subsystem continues to provide trunked voting/simulcast operations. In site trunking mode, subscriber radios can continue to communicate with members of their talkgroup registered at the site subsystem.

NOTICE: Communication outside the subsystem, communication with console operators, and centralized telephone interconnect are not available when the subsystem is in site trunking mode.
Any subsite designated as an essential subsite must have the required resources to provide trunking services. For details, see the description of an essential subsite in Simulcast Subsystem – Resource Voting on page 122.

5.1.4.3.3
Simulcast Subsystem Failsoft Mode

There are two types of Failsoft available depending on the type of site/subsystem:

- Site Subsystem Failsoft is available for both Circuit-based and IP-based Simulcast subsystems.
- Local Failsoft is only available for IP Simulcast Subsites which are part of M1, M2, M3, or L core system configurations. Local Failsoft is a configurable item on each base radio.

NOTICE: An ISR site enters an in-cabinet repeat mode for failsoft. A Simulcast or STRV type system enter sub-system wide failsoft with repeat happening through comparator voting.

Site Subsystem Failsoft
can be used when a major failure such as the loss of all Site Controllers at an ASTRO® 25 Repeater Site or a Simulcast Subsystem Prime Site occurs. When this type of major failure occurs, the subsystem can no longer maintain a control channel for use by the subscriber radios operating within the site/subsystem. When this happens, the subscriber radios try to locate another control channel at another repeater site or simulcast subsystem. If the subscriber radios cannot locate another control channel on which to operate and if the following conditions are met, the subscriber radios operate in Site Failsoft:

- One or more channels within the site/subsystem have been configured for Site Failsoft.
- The subscriber radios are configured for Failsoft operation.

With these conditions met, the subscriber radio enter a two-way conventional mode of operation on a given Failsoft channel. While in Failsoft, subscriber radio is limited to communicating only with other subscriber radio on the same Failsoft channel. The channel transmits a beep tone used for Failsoft to notify the radio user that the subscriber radio is operating on a Failsoft channel.

NOTICE: Failsoft call traffic is still being voted and simulcasted by the available channel resources.

The subscriber radios can be configured for the following modes of Failsoft operations:

- Failsoft by last known control channel – all talkgroups at a site/subsystem use the last known control channel transmit/receive frequency pair in a conventional mode

- Failsoft by Personality – subscriber radio uses a predefined channel transmit/receive frequency pair in a conventional mode for all talkgroups configured under a given personality in the subscriber radio.
- Failsoft by Talkgroup – subscriber radio uses a predefined channel transmit/receive frequency pair in a conventional mode for a specific talkgroup
- Failsoft Disabled – subscriber radio displays an “Out of Range” indication and no site-based RF communications are possible

Subscriber radios automatically exit Failsoft operation when a control channel is detected and the subscriber radio has synchronized with the site/subsystem.

Local Failsoft can be used when a critical failure occurs involving the IP Simulcast Prime Site, or the links between the IP Simulcast Primary Site and an IP Simulcast Subsite are not functioning. Critical failures can be caused by either of the following:

- The comparators at the Simulcast Prime Site are inoperable
- An IP Simulcast Subsite has lost its links to the comparators at the IP Simulcast Prime Site

Under this type of failure, and if one or more of the Multi-Site Base Radio (MsBR) at a subsite have been configured for Local Failsoft, the MsBR enters Local Failsoft mode based on its configuration. MsBRs configured for Local Failsoft transmit a special Failsoft message indicating Local Failsoft.

The timing of the Local Failsoft alarm tone is different than the Site Failsoft beep tone, so that the radio user is able to distinguish between Local Failsoft and Site (subsystem) Failsoft.

The base radio automatically exits Local Failsoft operation, after detecting that the link to the comparator has been reestablished, or when the Local Failsoft configuration has been disabled on the base radios. The subscriber radios automatically exit Failsoft operation when a control channel is detected and subscriber radio has synchronized with the control channel.

NOTICE: Any channels frequencies in use for Local Failsoft must be disabled at all other subsites, while Local Failsoft base radios are transmitting to avoid RF interference between the base radios at the different subsites. Use caution when configuring MsBRs for Local Failsoft. As the MsBR in Local Failsoft mode key locally on a simulcast frequency, destructive interference occurs on the same channel if other sub-sites of the simulcast sub-system transmit on the channel and are within the RF coverage range of the MsBR.

5.1.4.3.4
Simulcast Subsystem Site Off Mode

Site Off is a mode of operation initiated from the diagnostics capability of the Unified Event Manager (UEM). In this state, the subsystem is not available to the subscriber radios. Site Off de-keys the control channel, making it unavailable for subscriber radios to lock to.

Within the operational boundaries of the subsystem states, the remote sites may be found in one of the four states:

- Enabled
- Malfunctioned
- User ignored
- Unconfigured (unused)

5.1.4.3.5
Simulcast Channel States of Operation

IP Simulcast subsystem channels may be in any of the following states:

- Enabled

- Malfunctioned
- Impaired
- User Disabled
- Unconfigured state

Enabled State
When a channel is in the Enabled state, the channel is eligible for assignment in the Multi-Site subsystem.

Malfunctioned State
When a channel is in the Malfunctioned state, a resource fault somewhere on the channel has caused the channel to be marked as unusable for call processing. Testing may still be done on the channel. The channel is not precluded from being a Failsoft channel.

Impaired State
When a channel is in the Impaired state, a resource fault has occurred somewhere on the channel, but the resource in the malfunctioned state is located in a Malfunctioned or User Ignored subsite. The channel is still used for call processing, but reduced system coverage may result.

User Disabled State
When a channel is in the User Disabled state, the user has requested that the channel is not to be used for call processing. User Disabled channels may be tested, and may be used for Failsoft channels.

Unconfigured State
If a channel number is unused, the channel is reported to be in the Unconfigured state.

5.1.4.3.6
Simulcast Subsystem Subsite States

Each subsite may be in one of the following states:

- Enabled
- Malfunctioned
- User Ignored
- Unconfigured

Enabled State
When the subsite is in the Enabled state, the subsite operates as a fully functional part of the Simulcast or STRV subsystem.

Malfunctioned State
When individual resource faults degrade the capabilities of the subsite below a defined threshold, the system places the subsite in the Malfunctioned state. When a subsite is in the Malfunctioned state, the system disregards the state of the individual resources at the subsite so that they do not affect the channel states in the rest of the subsystem. The subsite continues to participate in the operation of the subsystem where it cans.

User Ignored State
When the user does not want the state of the individual resources at a subsite to affect the channel states in the rest of the subsystem, the user may request to put the subsite in the User Ignored state. Operationally, the User Ignored state is equivalent to the Malfunctioned state.

Unconfigured State
If a subsite number is unused, the subsite is reported to be in the Unconfigured state.

5.1.4.3.7

Simulcast Subsystem – Resource Voting

When a simulcast subsystem experiences malfunctions, the use of resource voting is the method the simulcast subsystem uses to maximize the number of channels and subsites available for use.

The simulcast subsystem implements “resource voting” to manage the simulcast subsystem resources (channels). The resource voting algorithm collects resource capabilities for the simulcast subsystem and either enables or disables resources based on the current capabilities in the subsystem. Having multiple subsites becomes an asset instead of a liability since the subsites can be removed from the resource voting pool when they are experiencing significant difficulties. The simulcast subsystem degrades gracefully to provide a continuum of available services.

Each simulcast subsite (remote site) is assigned an availability number. The availability number is a parameter that the customer can configure via Unified Network Configurator (UNC) or Configuration/ Service Software (CSS). It specifies the percentage of subsite channels that must experience malfunctions before the subsite is removed from service (placed in the malfunctioned state). Since subsite channel malfunctions affect the status of the channel across the entire IP simulcast subsystem, it is important to have a mechanism that prevents significant problems at a single remote site from bringing down the entire subsystem.

The availability number can have a value from 1 to 100. The default value is 50. For example, for a 10-channel subsystem, a subsite with an availability number of 50 is put in the malfunctioned state if 5 subsite channels at that subsite are in a failed state.

The availability number 100 has special meaning. A subsite with an availability number of 100 is called an essential subsite. Customers assign an availability number of 100 to subsites that provide critical RF coverage. Critical subsites need to be on the air at all costs, even if it means that the entire IP simulcast subsystem is in Failsoft mode. Essential subsites are in the failed state if all of their subsite channels are unavailable (for example, from a link failure). However, if the essential subsite is capable of supporting a wide area Failsoft channel, then the rest of the simulcast subsystem channels follow the capability of the essential subsite’s channels.

A subsite can be put in the malfunctioned state even if its availability threshold is not reached. If all non-essential subsite’s control channels experience malfunctions, then the subsite is put in the malfunctioned state, so that the rest of the IP simulcast subsystem can establish a control channel. If channels 1-4 at a non-essential subsite malfunction, the subsite is put in the malfunctioned state even though its availability number is 50 or higher.

Once a subsite is in the malfunctioned state, all IP simulcast subsystem channels that are out of service due to problems at the subsite in the failed state are returned to service. The subsite in the malfunctioned state is included in all call activity; it participates to the best of its ability. The IP simulcast subsystem channels that are returned to service are in the impaired state; the channels are in use, but not all channel’s resources are functioning properly.

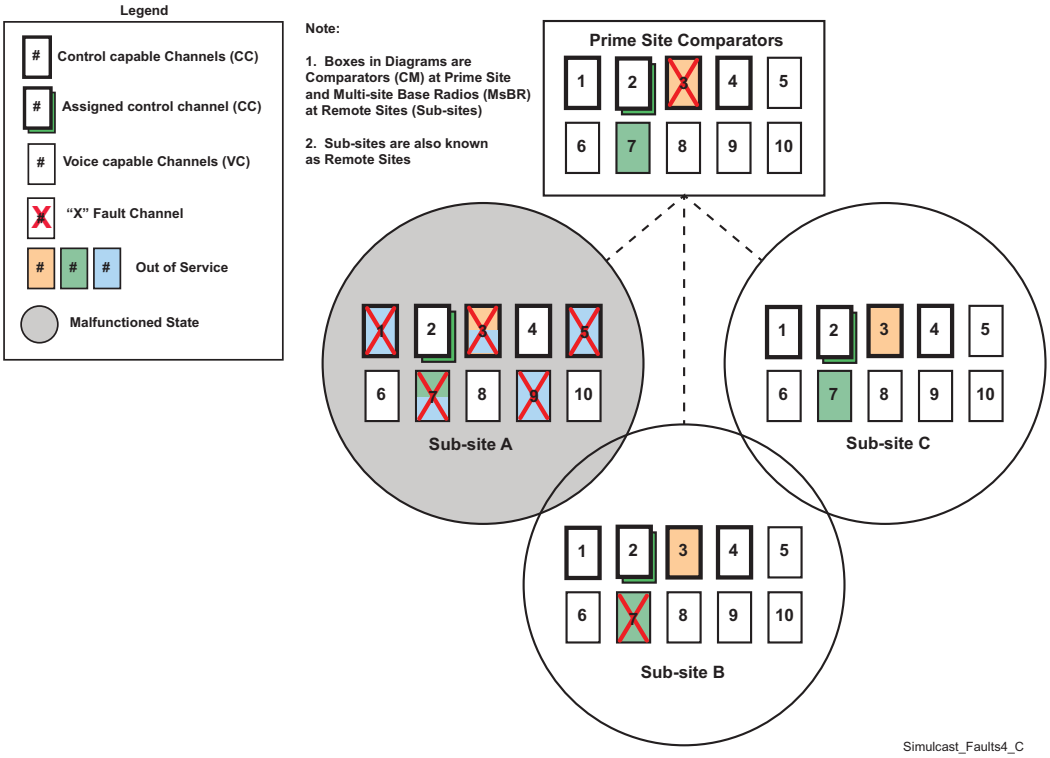
The computation of the percentage of subsite channels in the malfunctioned state is based on the number of channels that are programmed to be traffic capable, minus the number of channels that are user disabled. Channels that are unconfigured are ignored in this calculation: MSC = (CM/(CT-CD))x100.

- MSC is the percentage of Malfunctioned Subsite Channels (channels in the malfunctioned state)
- CM is the number of traffic channels at the Simulcast or STRV remote site which are in the malfunctioned state
- CT is the total number of traffic channels
- CD is the number of user disabled traffic channels

Aside from user-disabled channels, the determination of a state of a subsite is based solely on the state of the equipment at that subsite. Comparator capabilities do not affect the state of the subsites.

In the figure below, the transmitter combiner serving the odd channels of remote site A is in the malfunctioned state. Remote site A is in the malfunctioned state since five of its 10 channels are in the malfunctioned state and the remote site availability number is 50. Channel 3 is still out of service because of the comparator failure, and channel 7 is still out of service due to the channel failure at remote site B. Channels 1, 5, and 9 are in the impaired state. Since the transmitter combiner is causing the channel failures, the impaired channels at remote site A operate normally for the receive side of the channel, but no transmissions originate from remote site A for the impaired channels.

Figure 15: Remote Site-A Put in the Malfunctioned State Because of Availability Number Trigger



5.1.5
InterZone Communications Failure

The zone controller organizes InterZone communications with other zones, passing control messages, and routing audio system-wide. A failed InterZone Control Path causes InterZone communications failure. InterZone calls and sharing of mobility information with the failed zone also ceases.

5.2
Audio Plane Failures

Troubleshooting audio plane failures comprise the following:

- Subscriber radio
- Zone controller
- Embassy switch
- Zone Ambassador Interface Board (ZAMBI)
- Ambassador Board (AMB)
- Telephone Media Gateway (TMG)
- Other interconnect failure conditions

- ISSI.1 Network Gateway failure condition

5.2.1
Subscriber Radio Failure

If a subscriber radio fails, it is unable to communicate. The failure does not affect other subscriber radio users in the talkgroup, site, or zone.

5.2.2
Zone Controller Failure

Wide-area audio routing is stopped when a zone controller fails and telephone interconnect services are lost.

The following call processing subsystem capacity is lost upon failure of the zone controller server.

- ASTRO® 25 systems can be installed with redundant zone controllers. If the active zone controller fails, all sites in the zone go into site trunking mode until the switch to the redundant zone controller is completed.
- Fault management is unavailable for devices whose fault management information is proxied by the active zone controller.

5.2.3
Telephone Interconnect Control Paths Failures

IP Private Branch eXchange (PBX) and Telephone Media Gateways (TMG) interfaces an ASTRO® 25 system to the Public Switched Telephone Network (PSTN). This interface provides a means of making subscriber radio-to-landline telephone calls and landline-to-subscriber radio calls. The TMG and IP PBX must be colocated with the zone controller in each zone. Each zone can contain one IP PBX and up to 20 TMGs.

The following paths are required for telephone interconnect:

- Control Link Path – Each TMG and IP PBX is interfaced through the LAN switch to the zone controller.
- Audio Path – Audio connections between the IP PBX and the ASTRO® 25 system takes place through the TMG.
- Telephone Line Connectivity – An IP PBX can be configured to support analog ground start, loop start, Direct Inward Dial (DID), or DS1 trunks.

If the system has more than one telephone interconnect setup, failure of a telephone interconnect operation in a multiple zone system may be transparent to the user. If only one telephone interconnect setup exists in the system (single or multiple zone), only telephone call capability is affected. If the telephone interconnect operation fails, all other voice dispatch functions continue to operate.

For additional information, see the *Enhanced Telephone Interconnect* manual.

5.2.4
Other Interconnect Failure Considerations

If no interconnect-capable channels are available, interconnect calls cannot be placed. Channels may be unavailable because they are busy, interconnect incapable (interconnect capability turned off), or because they have failed. If all interconnect channels are busy, interconnect calls are busied. Following are some of the common reasons an interconnect call may be rejected:

- Only interconnect incapable channels are available
- All interconnect capable channels have failed

- No Telephone Media Gateway (TMG) resources are available
- No IP Private Branch eXchange (PBX) resources are available

Regardless of the infrastructure configuration, user limitations, or channel availability, Customer Programming Software (CPS) programming of the subscriber radio can prevent interconnect calls from being attempted. If shared service dictates that an interconnect call is busied, the call is busied regardless of whether an interconnect-capable channel is available at the site.

5.2.5
ISSI Troubleshooting for ISSI.1 Network Gateway and ISSI 8000/ CSSI 8000 Intersystem Gateway

For systems employing the ISSI 8000/CSSI 8000 Intersystem Gateway (ISGW), if calls to or from foreign systems are failing, check the Unified Event Manager (UEM) for any alarms or events associated with the ISGW. Also check the status of the ISGW by accessing the **admin** menu and selecting **Application Administration**, then select **Manage Application Status** to display the ISGW application status information. ISGW **admin** also includes setting the ISGW Heartbeat Key, setting the ZC-ISGW Key, and resetting the ISGW Application.

You can also set the ISGW to collect troubleshooting data which creates a file you can retrieve for detailed information if necessary. If the ISGW is deployed redundantly, registration data is replicated and available on the newly active device. The ISGW and zone controller exchange registration data upon link establishment. In a non-redundant deployment, this exchange of data restores service for all units and groups foreign to the system (roaming in), and removes service from all units and groups which are home to the system but located elsewhere (roaming out). Other troubleshooting operations you can perform include resetting the ISGW application and running Packet Capture on the ISGW.

For more information, see the troubleshooting chapter in the *ISSI 8000/CSSI 8000 – Intersystem Gateway* manual.

5.3
Resolving Call Processing Problems

The zone controller is responsible for managing call processing in the zone. This management includes registration, individual calls, and group calls. If problems arise with call processing in the zone, the operator can troubleshoot the following components in the zone controller for problems:

- Verify that the most current Subscriber Access Control (SAC) and infrastructure database records are downloaded by viewing the Out-of-Sync flag in the UNC. To send the complete set of subscriber information, perform a forced initialization from the Unified Network Configurator (UNC) to the zone controller.
- If problems accessing a particular type of service or feature continue, check the Provisioning Manager (PM) records and profiles for subscriber radio settings, talkgroup settings, fleetmapping, system settings, encryption keys, and so on. Also verify that zone-level settings (such as timeouts) in the UNC are configured appropriately.
- Check the loading of call traffic and InterZone channel use through the Historical Reports application. Adjust loading as necessary by reconfiguring the PM and UNC settings.
- Verify that timeouts and other settings are configured appropriately in the subscriber radios.
- **Troubleshoot the Zone Controller Host Central Processing Unit (CPU) card**. This card processes all the activities in the zone and generates grant, busy, or reject messages to the subscriber radios. The Zone Controller Host CPU Card actively manages all the registration resources and call management activities in the zone and mobility management for talkgroups mapped to the zone. The physical CPU is controlled by a Virtual Machine (VM). Use the terminal server, the network fault management applicationor the VMS to evaluate the CPU card status. Refer to the *Virtual Management Server Software* manual for commands to view system faults.

- **Troubleshoot the Zone Controller Host Ethernet ports**. These ports send command messages and retrieve feedback from all sites in the zone. The ports also communicate and send call processing command messages to other zones over the InterZone link. The physical Zone Controller Host Ethernet ports are controlled by the VM . Use the terminal server, the network fault management applicationor the VMS to evaluate the Ethernet port status.

5.3.1
Effects of Loss of Service on Call Processing

For purposes of this discussion, **loss of service** indicates that part of the ASTRO® 25 infrastructure has failed, and the failure affects the ability of calls to be made through some part of the system.

NOTICE: Generally in an ASTRO® 25 system, a service state for a site other than wide-area trunking causes the subscriber radios at the affected site to attempt to register at a wide-area trunking site.

5.3.1.1
Zone Call Service States

Within a zone, three types of service states are available for sites that affect call processing: wide-area trunking, site trunking, and Site Failsoft.

Table 11: Zone Call Service States

State	Definition
Wide-Area Trunking	Wide-area trunking is the normal state for a site within a zone. In this state, the site receives call processing instructions from the zone controller. A subscriber radio registered at the site can communicate with any other subscriber radio in the system. The basic criteria for wide-area trunking include an active RF site control path between zone controller and site, an enabled audio Rendezvous Point (RP) in the zone, a control channel, and a voice channel at a site.
Site Trunking	Site trunking mode is entered when the remote site loses communication with the zone controller. In this mode, the remote site takes over call processing responsibility. In an ASTRO® 25 repeater site, one of the repeater sites functions as a controller for the site and performs all call processing functions for the call traffic at that site. A subscriber radio registered at the site can communicate only with other subscriber radios registered at the same site. In a simulcast subsystem, the simulcast prime site controller performs the same function as the site controller in a repeater site. Communication to the console and telephone interconnect are lost when the system is in site trunking.
Site Failsoft	Losing all site controllers or losing all the control channel capable base radios at a site forces the site into Site Failsoft mode. Basically, no trunking functionality exists. In this mode, and if programmed with Site Failsoft capability, the individual base radios become active (bring up their carrier) continuously. Individual subscriber radios can communicate in a conventional Frequency Division Multiple Access (FDMA) manner on fixed channels. The subscriber radios receive a data word from their base radio that instructs them to generate a tone at fixed intervals to indicate to the users that the system is in Site Failsoft. Communication to the console and telephone interconnect are lost when in Site Failsoft.

Table continued…

State	Definition
Site Off	The Site Off operational mode can be initiated from the diagnostic capability in the Unified Event Manager (UEM). In this state, the subsystem is not available to the subscriber radios.

5.3.1.2

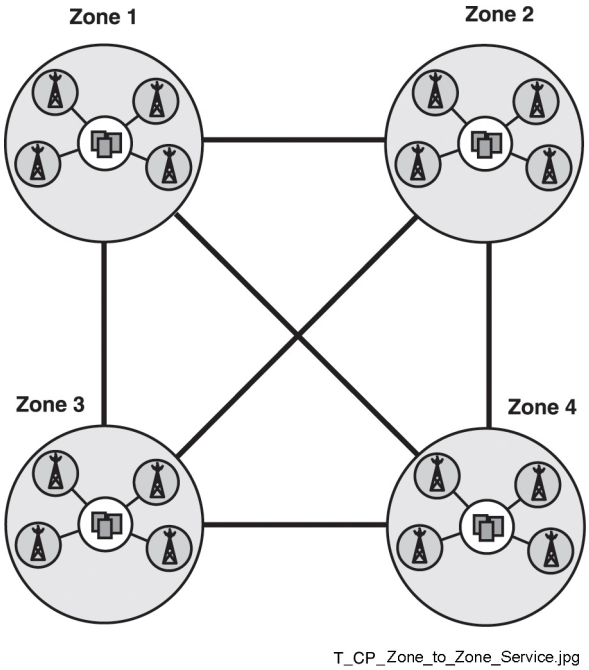
Loss of Service Between Zones

Loss of service between zones is a complex situation since a zone may be functional overall, but lose contact with one or more of the other zones.

InterZone trunking is a state between any pair of zones in a system. In a four-zone system, six pairs of relationships exist between the zones in the system:

- Zone 1 to Zone 2
- Zone 1 to Zone 3
- Zone 1 to Zone 4
- Zone 2 to Zone 3
- Zone 2 to Zone 4
- Zone 3 to Zone 4

Figure 16: Zone-to-Zone Service



T_CP_Zone_to_Zone_Service.jpg

5.3.1.3

Conditions Necessary for InterZone Trunking

For each zone pair, the following conditions must be in place for InterZone trunking to take place between the zones:

- A functioning InterZone control path between the zone controllers
- A functioning audio Rendezvous Point (RP) at each zone
- An identical talkgroup-to-home zone map in each zone

If any of these conditions are not met, the zone pair cannot enter InterZone trunking with each other. The trunking state between zones determines the manner in which InterZone calls are processed.

InterZone call processing is divided into two types of services:

- Group-based services
- Individual-based services

Group-based and individual-based services each have their own level of service availability based on their InterZone trunking state.

5.3.1.3.1
Levels of Group Service Availability

The three levels of group service availability are based on a group member's perspective from the current zone to every other zone in the system, and whether the current zone is the group's assigned home zone.

Table 12: Levels of Group Service Availability

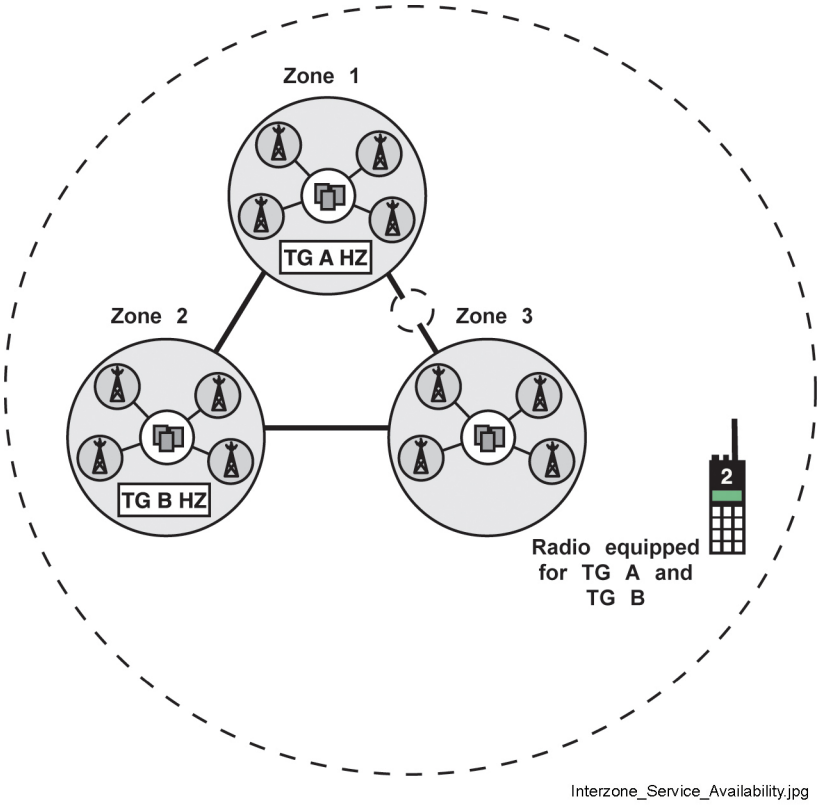
Service Level	Description
Full InterZone	All zones are in a state of InterZone trunking with respect to the group's home zone.
Reduced InterZone	At least one participating zone is in InterZone trunking with the group's home zone, and at least one zone is not.
Zone Isolated	The current zone may only process the group's calls locally within the zone. This occurs when either the participating zones have no InterZone trunking with the group's home zone, or when the home zone loses InterZone trunking with all the other zones in the system.

5.3.1.3.2
Interzone Group Service Availability Example

It is possible for some members of a talkgroup to have zone isolated service for a short interval during loss of the links between the zones (generally microwave).

- In the diagram below, the microwave link between Zone 1 and Zone 3 is down (interruption of InterZone trunking), while the links between Zones 1 and 2, and between Zones 2 and 3, are intact.
- Talkgroup A's home zone is Zone 1.
- Talkgroup A user is placing a call in Zone 1 or Zone 2 has full InterZone service availability.
- Talkgroup A members in Zone 3 have zone isolated group service availability for a short period of time while the exit routers reestablish the call through an alternate IP path, in this case, through Zone 2.

Figure 17: Reduced InterZone Service Availability



5.3.1.3.3

InterZone Individual Service Availability

InterZone individual services do not have the same service availability concepts as group calls. InterZone individual calls are always two-zone calls, with the controlling zone dynamically assigned as the zone responsible for initiating the audio.

5.3.1.3.4

Conditions for InterZone Unit-to-Unit Calls

The following conditions must be in place for unit-to-unit calls to take place between the zones:

- The two zones involved in the call must be in InterZone trunking.
- The call requestor's zone must have, at minimum, an active zone controller-to-zone controller InterZone control path between itself and the target subscriber radio's home zone so it can access the target subscriber radio's individual Home Location Register (HLR).
- The target subscriber radio's zone must have, at minimum, an active zone controller-to-zone controller InterZone Control Path between itself and the requestor's home zone so it can access the requestor's individual HLR.

5.3.1.3.5

Interzone Unit-to-Unit Calls Example 1

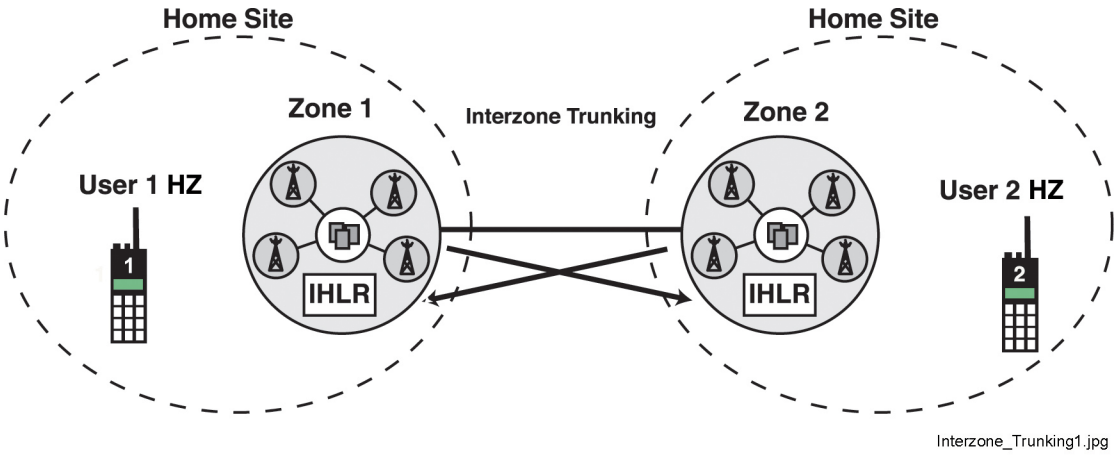
In this example:

- User 1 is in Zone 1, its individual home zone.
- User 2 is in Zone 2, its individual home zone.

- Zone 1 and Zone 2 are in InterZone trunking.

In the case shown, all criteria are met.

Figure 18: InterZone Individual Call with Subscriber Radios in Their Home Zones



5.3.1.3.6

Interzone Unit-to-Unit Calls Example 2

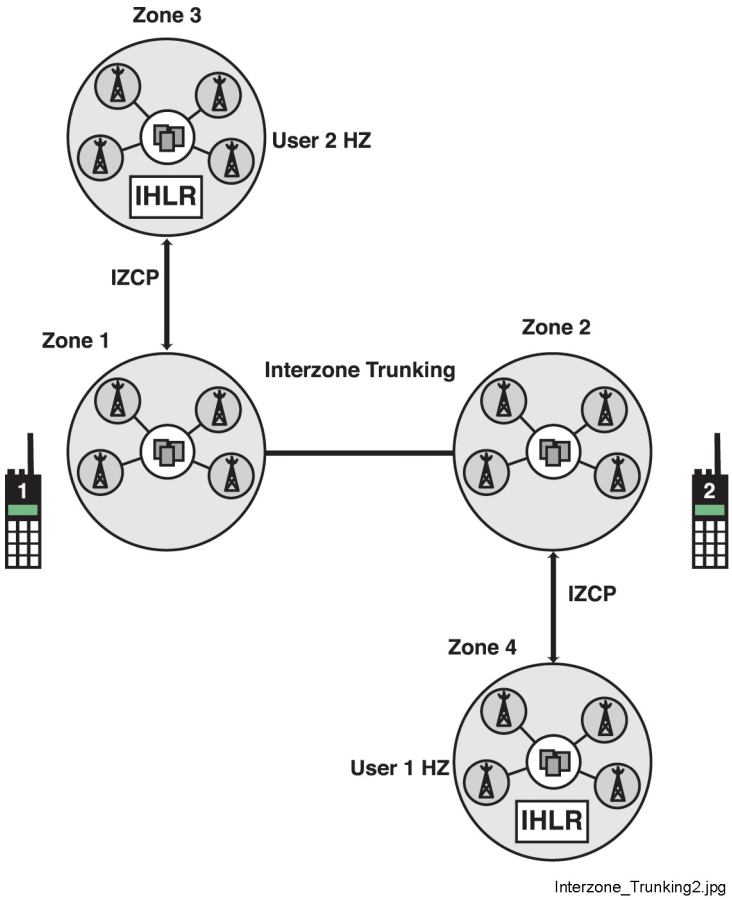
In a less commonly occurring example:

- User 1 is in Zone 1 but its individual home zone is Zone 4.
- User 2 is in Zone 2 but its individual home zone is in Zone 3.

To make an InterZone individual call between User 1 and User 2, the following conditions must exist:

- Zone 1 and Zone 2 must be in InterZone trunking.
- Zone 1 must have at least an InterZone Control Path to Zone 3.
- Zone 2 must have at least an InterZone Control Path to Zone 4.

Figure 19: InterZone Individual Call with Subscriber Radios Not in Their Home Zones



5.3.1.3.7

States of System Operation

States of system operation can be broken down into two main categories: intrazone and InterZone. Intrazone denotes communications within a zone, and InterZone denotes communications between zones.

Intrazone communication is completely dependent on the state of every site within its boundaries. InterZone communication, on the other hand, is completely dependent on the operational state of each of the three links between the zones: InterZone audio, zone controller-to-zone controller control data, and network WAN connections. This dependency means that total failure of a site in any given zone may mean this particular site is not in wide-area trunking, but the system is still in InterZone trunking. In such a failure situation, certain users may experience total system failure while others experience a fully functional system.

5.3.1.3.8

Intrazone Operation

A site can exist in one of four states:

- Wide-area trunking
- Site trunking
- Site Failsoft
- Local Failsoft at a remote site

5.3.1.3.9
Wide-Area Trunking

Wide-area trunking is the normal operating state for a site. Subscriber radios affiliated at a site in this state can communicate with subscriber radios at other sites in the same zone in the wide-area trunking state, and with subscriber radios at sites in the InterZone trunking state in other zones.

At a multi-channel site, some channel resources can be lost yet operation stays in wide-area trunking. Users at that site can experience increased busies due to the loss of resources. The quantity and type of channels determine when channel loss can cause a site to transition out of wide-area trunking.

An ASTRO® 25 site can remain in wide-area trunking as long as the following resources are available:

- One voice channel
- One control channel
- A site controller
- Connectivity through the Ethernet switch or switches
- A site router/gateway
- A physical link between the subsystem and the Master Site/Zone Core
- A logical path between the site router/gateway and the Master Site/Zone Core IP equipment

5.3.1.3.10
Site Trunking

A site enters the site trunking state when it loses its ability to communicate with the zone controller or Embassy switch, at the zone Master Site/Zone Core. For example, a site transitions to site trunking if the site data link to the zone controller is lost, or if transport fails and drops all audio links to the voice channels.

When a site transitions to site trunking, the zone controller removes the site from its list of available wide-area resources, so wide-area communications at other sites can continue without waiting for talkgroup members at the failed site to join the call, even if the failed site is a critical site. At the site, the site controller takes over responsibility for handling call requests. Subscriber radios affiliated at the site can communicate only with other subscriber radios affiliated at that site.

Depending on the preferred site selection, subscriber radios at the failed site may try to affiliate with the closest working site. Subscriber radios with always preferred setting stay at a site that transitions to site trunking without trying to find a new site. If a subscriber radio is out of range of other working sites, the subscriber radio stays at the current site.

When the conditions needed for wide area are restored, the site automatically returns to the wide-area state.

5.3.1.3.11
Site Failsoft

Site Failsoft serves as a final recourse when a site loses wide-area communications and cannot perform site trunking. In the Site Failsoft mode, a site's base radios independently enter a conventional (non-trunked) mode of operation. Each base radio transmits a Site Failsoft word to indicate to subscriber radios that a failure has occurred and the site has entered the Site Failsoft mode. Users hear a tone generated by the base radios every 10 seconds indicating that the site is in the Site Failsoft mode.

To operate in Site Failsoft mode, a call is always established as a Frequency Division Multiple Access (FDMA)-only call using either a Time Division Multiple Access (TDMA)-capable or non-TDMA-capable channel.

Audio in the Site Failsoft mode is local to the site. A subscriber radio can communicate only with other subscriber radios in FDMA mode programmed for and operating on the same Site Failsoft channel. Normal console operation with a site in Site Failsoft mode is not supported.

Site Failsoft mode of operation at an ASTRO® 25 site takes place only when one of the following conditions occurs:

- Both site controllers fail
- The Ethernet switch fails, or both fail in a dual-switch configuration.
- All control channels are lost.
- All voice channels are inoperative.
- All ASTRO® 25 sites capable of site controller operation fail.
- Someone forces a Site Failsoft using the diagnostic capability in the Unified Event Manager (UEM).

In Site Failsoft mode, the subscriber radio checks the last active control channel in its list for the site. If it does not find that channel, it attempts to find the second control channel. If that channel is unavailable, the subscriber radio displays **Out of Range** until a control channel is available.

When a site enters Site Failsoft mode, affiliated subscriber radios attempt to affiliate to another trunking site, regardless of their preferred site setting. Normally, a subscriber radio only stays at a site in Site Failsoft mode when it is out of range with all other acceptable sites.

When the conditions needed for either site trunking or wide area is restored, the site automatically returns to the available state.

5.3.1.3.12

Local Failsoft at Remote Site

Local Failsoft provides a fall-back mode of operation at simulcast trunking remote sites. Local Failsoft occurs when the simulcast prime site is completely inoperable and no wide-area communication is possible, or if a simulcast remote site has lost the link to the prime site.

Upon detecting that the link to the comparator at the simulcast prime site has failed, the base radios enabled for Local Failsoft enter Failsoft mode of operation after a configurable wait time. In Local Failsoft mode, a base radio provides a conventional mode of operation in a similar way as the Site Failsoft Mode, except Local Failsoft is executed at a remote site by configuring the base radio for Local Failsoft. In Local Failsoft mode, communication occurs only within the coverage area of a single remote site. Subscribers cannot communicate from one remote site to another. The base radio generates a Failsoft beep tone every 15 seconds.

Local Failsoft is supported by channels configured for Frequency Division Multiple Access (FDMA) or Time Division Multiple Access (TDMA) mode are supported, but channels in Local Failsoft only operate in FDMA mode.

IMPORTANT: Local Failsoft channels must be configured and managed correctly to ensure the simulcast remote sites operating in Local Failsoft do not interfere with the operation of the rest of the system. Only one or two critical simulcast remote sites are recommended to be chosen for Local Failsoft coverage. For each channel operating in Local Failsoft mode at the remote site due to link malfunction between the prime site and the critical remote sites, the channel may need to be manually disabled for the rest of the system to prevent RF interference because the rest of the subsystem may remain trunking in site-wide Failsoft.

A base radio automatically exits out of Local Failsoft operation to the available states after detecting that the link to the comparator has been reestablished or that the Local Failsoft has been disabled on the base radio.

Local Failsoft is configured on each base radio in the Configuration/Service Software (CSS). See the *CSS Online Help*.

5.3.1.3.13

InterZone Operation

Between any two zones, the following two InterZone operating states can exist:

- InterZone trunking
- No InterZone trunking

For each zone relationship pair, the following conditions must be in place for InterZone trunking to take place between the zones:

- A functioning zone controller-to-zone controller data link
- At least one pair of InterZone audio channels, with each zone controlling one channel
- A valid talkgroup to home zone map table in each zone's zone controller

If any of these conditions are not met, the two zones cannot enter InterZone trunking. The trunking state between zones affects how InterZone calls are processed.

InterZone call processing differs between group-based services and individual-based services. Each service has its own set of services available based on the InterZone trunking state.

5.3.1.3.14

InterZone Failure Recovery

During an InterZone failure, users can experience either reduced InterZone group service (for systems with three or more zones) or zone isolation. The manner in which calls are handled during system recovery depends on the type of call and on the relationship of the controlling zone (for group services) to the zone in recovery.

A subscriber radio user receives no message indicating that the system is in a reduced InterZone trunking service availability. Therefore, a user placing a call does not know that some talkgroup members are not included in the call. If a failure occurs during an active call, the user may experience, for example, the loss of audio or an inability to reach an individual to whom the user was just talking if a zone transitions into zone isolation. The system manager must be able to explain the situation to the user community if such a condition arises.

The system recovers automatically when the condition causing the InterZone failure is resolved. The system gives no indication to the user that it has recovered during an in-process call. The next Push-To-Talk (PTT) on any active group call reconnects all currently affiliated group members into the InterZone call. If a zone-isolated group call was active, that call is ended immediately, and all group members in the formerly isolated zone join the InterZone group call in progress.

5.4

Typical Reasons for Rejects

When a subscriber radio requests a particular service, the Zone Controller (ZC) can choose to grant the request, reject the request, or respond with a busy signal. When a service is granted, the ZC assigns the appropriate resources and sends a message to the requestor granting the service. When the ZC rejects a request, the ZC sends a reject message to the requestor. When the ZC is experiencing a busy situation, the ZC sends a busy signal to the requestor.

When a subscriber radio is rejected from using a particular service, the ZC sends an abort message to any resources that need to be released from the service, then sends a reject message to the subscriber radio. The following items are typical reasons why a subscriber radio may be rejected during registration or during a call request:

- The subscriber radio may be sending an individual ID or talkgroup ID not loaded in the ZC's memory.

- The subscriber radio may be requesting a service restricted or not available to the particular subscriber radio.
- The system or the receiving subscriber radios may not support the call type requested by the initiating subscriber radio.
- The system may be in a failure situation. Depending on the settings and the situation, the sites may be in site trunking and only allow certain types of calls, or the ZC may be using default access permissions.
- The subscriber radio may be calling an individual subscriber radio or talkgroup that does not exist or is not registered with the system.
- The subscriber radio may not be configured to make the requested type of call.
- The subscriber radio is not operating at one of its valid sites.
- The zone is not able to communicate with the home zone of the initiating subscriber radio.
- The zone is not in InterZone trunking with the other zones that need to participate in the call. The particular resources may not be available for the call.

5.5 Resolving Resource Management Problems

The Zone Controller (ZC) is responsible for managing all the resources for subscriber services, including dynamic site allocation and other infrastructure arrangements. A service can be granted, busy, aborted, or rejected. If a service request is busy, aborted, or rejected, the ZC sends the message to the subscriber radio and releases all associated resources from the service. Check the following items if a resource management problem exists:

- Verify that the most current infrastructure database records are downloaded using the Unified Network Configurator (UNC).
- Check if the ZC Host (hard drive, fans, or power supply) has a problem. See the *Virtual Management Server Hardware* and *Generic Application Server* manuals for details.
- Check the physical condition of the Virtual Machine (VM) or Generic Application Server (GAS) chassis. Check the LEDS and verify that power is being supplied to the components. See the *Generic Application Server* and *Virtual Management Server Hardware* manuals.
- Check the site access profiles in the Provisioning Manager (PM), and adjacent control channel settings from the UNC. Verify that the settings are correct.
- Check the ZC compliance at the UNC.
- The ZC Host CPU card within the VM or GAS processes all resource management commands for equipment within the zone.
- The ZC sends site management messages over the network management plane. Troubleshoot the ZC Host CPU Card and Ethernet connections on the VM or GAS, to determine if any problems exist. See the *Generic Application Server* and *Virtual Management Server Software* manuals for details.

5.6 Resolving Mobility Management Problems

The Zone Controller (ZC) tracks all subscriber radios located in its zone in its Visitor Location Register (VLR) and mapped to its zone in its Home Location Register (HLR). The ZC uses the site location of subscriber radios to identify where they are located and to arrange point-to-point individual calls and one-to-many (multicast) group calls. Check the following items if there is a mobility management problem:

- Mobility information is passed up from the sites. Verify that the site links are operational and troubleshoot the ZC Host CPU card and Ethernet ports on the Virtual Machine (VM) or Generic Application Server (GAS) as necessary. See the *Generic Application Server* and *Virtual Management Server Software* manuals.
- Verify that the subscriber radio/talkgroup records and profiles are programmed correctly into the Provisioning Manager (PM). HLR records are not kept for subscriber radios or talkgroups not entered in the PM. Also verify that home zone mappings are programmed appropriately.
- If problems exist in a multizone system, verify that each zone is operational and that each zone is in InterZone trunking mode.
- If the ZC has recently been reset or has recently experienced a failure, the mobility management databases take some time to rebuild. During the recovery process, mobility information is gathered from the sites and other zones.
- Mobility information is stored in RAM on the ZC Host CPU card in the VM or GAS. A fault in the ZC Host CPU card can cause all the mobility information to be lost or corrupted. See the *Generic Application Server* and *Virtual Management Server Software* manuals.

5.7 Resolving InterZone Communications Problems

The Zone Controller (ZC) coordinates services with ZC units in other zones. The ZC shares command messages and mobility information, and coordinates audio calls with the other zones through the InterZone control path. Check the following items if an InterZone communications problem exists:

- Check the zone call processing status for each affected zone controller. Verify that all the zones are InterZone trunking capable.
- Check the network configuration for each affected ZC. Verify that the ZC is given the appropriate zone number. If the ZC is configured with the wrong zone number, all the IP addresses for the ZC are incorrect.
- Check the InterZone channel loading through the Historical Reports application. Adjust InterZone traffic by adjusting home zone mapping for talkgroups or subscriber radios as necessary.
- The ZC sends and receives InterZone control information through the LAN switch, exit router, and gateway router. Verify proper operation of the devices along these traffic paths.

5.8 Resolving Network Management Problems

The Zone Controller (ZC) receives its operating information from the network management subsystem, particularly the Unified Network Configurator (UNC). The UNC downloads all the infrastructure and Subscriber Access Control (SAC) records from the bulk download of files to the ZC, and the Radio Control Manager (RCM) sends all its pending commands to the ZC. The ZC arranges the SAC information accordingly in its location registers and stores the infrastructure information within the ZC application.

Problems with the network management links can affect the fault management capabilities and remote command capabilities from the network management subsystem. Network management problems can isolate the ZC from any new information programmed in the Provisioning Manager (PM) or UNC, and information flow to the remote sites can be restricted.

Check the following items if a network management problem exists:

- Check the display status in the Zone Controller Administration menus.
- Check the condition of the Ethernet link system status in the Zone Controller Administration menu.

- Verify that the network configuration for the ZC is set up for the appropriate zone in the administration menus. Also, check the IP configurations of the network fault management application, and any other network management servers affected.
- The ZC Host CPU Card in the Virtual Machine (VM) supports the network management link between the ZC and the network management servers. Verify operation of the CPU, if necessary. See the *Virtual Management Server Software* manual.

5.9 Historical Reports

The Historical Reports application creates standard or customized reports for different types of activities within the zone or system. Standard reports can be generated to show statistics for subscribers, talkgroups, sites, or channels within the system or zone. These reports typically provide information about the call types, busies, and call durations experienced in the system.

In addition to the call reports, several Air Traffic Information Access (ATIA) reports can be generated to show statistics for different types of ATIA packets logged within a zone. Reports can also be generated to show shared service statistics, or custom reports can be generated showing user-specified information.

The Zone Historical Reports function allows creation of different types of zone-level reports by resources, such as channel, user, site, talkgroup, zone, ATIA packets, and shared service. Standard Zone Historical Reports provide Site Busy Frequency Division Multiple Access (FDMA) and Site Busy Time Division Multiple Access (TDMA) report templates for zone level analysis of average and maximum call busy durations for different call types by site within a zone. A number of other FDMA and TDMA reporting is also available.

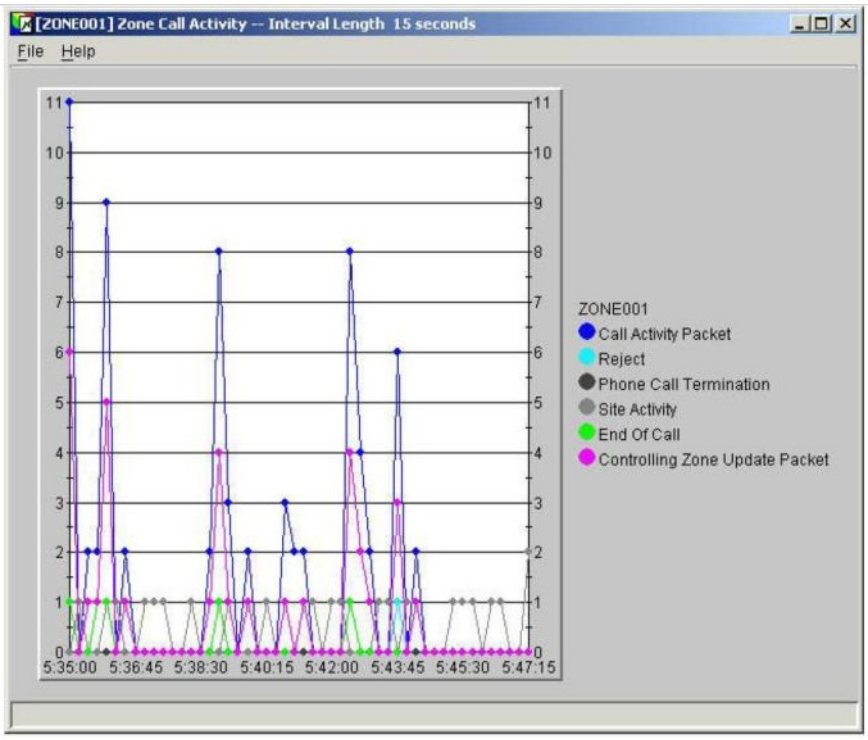
Historical Reports is an application in the Private Radio Network Management (PRNM) application suite. Detailed information for Historical Reports can be found in the *Historical Reports online help* and in the *Performance Management* manual.

5.10 Dynamic Reports

The Dynamic Reports application shows real-time graphical reports of system activities. Reports can be created to view a variety of information including channel use, call activities, busy information, and many other call statistics for the zone or a particular site.

Dynamic Reports is an application in the Private Radio Network Management (PRNM) application suite. Detailed information for Dynamic Reports can be found in the *Dynamic Reports online help* and in the *Performance Management* manual.

Figure 20: Dynamic Reports



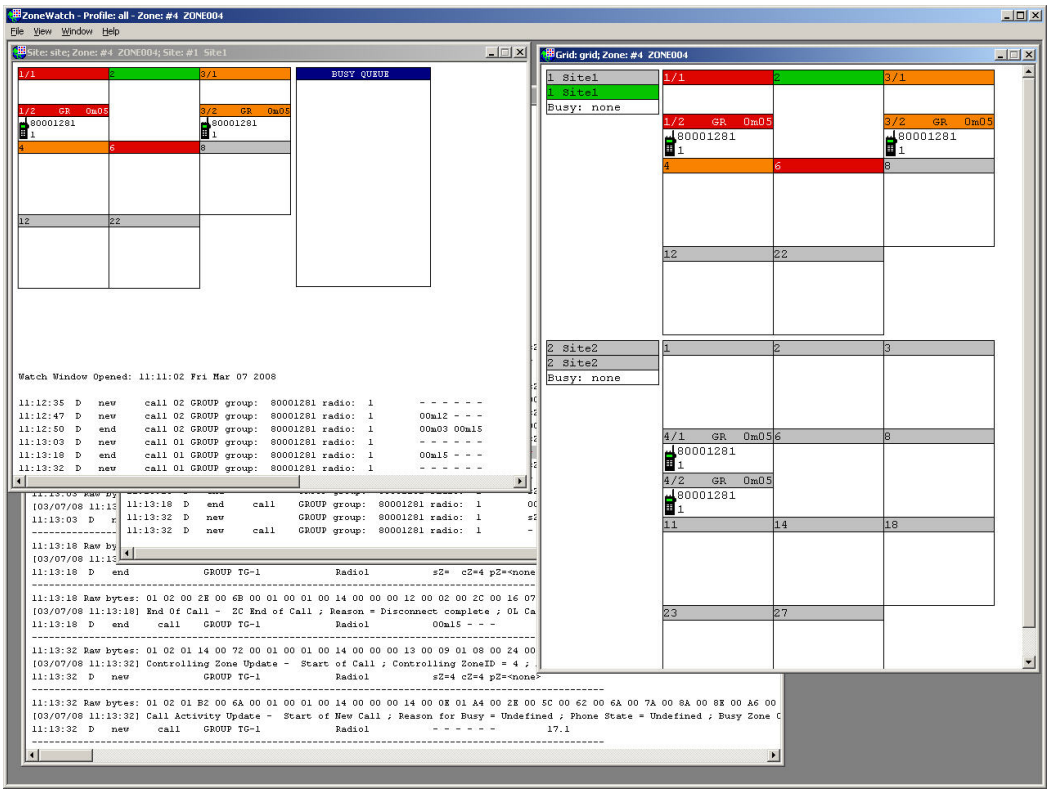
5.11 ZoneWatch

The ZoneWatch application permits monitoring of site and channel activity within the zone. Grid windows display the condition of the sites and channels, and show any activities as they take place. Raw Air Traffic Information Access (ATIA) traffic can also be displayed to view different call processing messages and status updates taking place in the zone.

ZoneWatch can be configured with a variety of different profiles to define the watch windows by setting custom profiles. A variety of different data filters can also be set through the Provisioning Manager (PM) application to filter the types of information monitored by ZoneWatch.

ZoneWatch is an application in the Private Radio Network Management (PRNM) application suite. Detailed information for ZoneWatch can be found in the *ZoneWatch online help* and in the *Performance Management* manual.

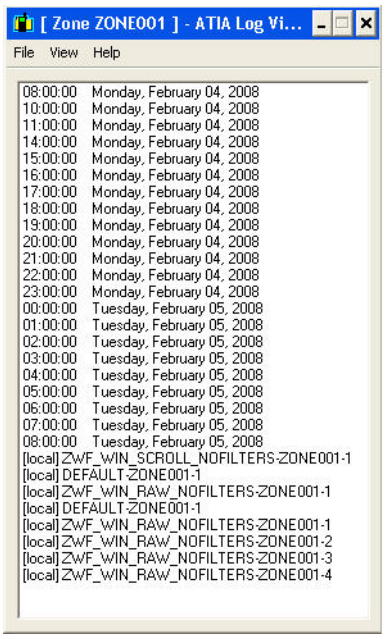
Figure 21: ZoneWatch



5.12 Air Traffic Information Access Log Viewer

The Air Traffic Information Access (ATIA) Log Viewer application displays ATIA log files archived in the zone. ATIA messages are recorded and archived daily for all the call processing activities and other site events in the zone. The ATIA Log Viewer allows selection of a daily log file and viewing of activities that took place in the system.

Figure 22: ATIA Report



ATIA messages include the date, time, and description of the event that occurred, such as a subscriber registration, call request, or site handover.

Chapter 6

System Service Mode

This chapter provides a functional description of the System Service Mode in an ASTRO® 25 7.13 system release, and to differentiate it from Base Radio Service Mode as both should be understood to avoid undesirable results when implementing the System Service Mode. To differentiate the System Service Mode from the Base Radio Service Mode, this appendix provides a brief description of Base Radio Service Mode.

6.1 System Service Mode Description

The System Service Mode is a system-level feature that alters system call processing behavior to facilitate troubleshooting by system service personnel. This feature is set for the system in the Provisioning Manager (PM) and Unified Network Configurator (UNC). For detail of operation of System Service Mode, see System Service Mode Function on page 141.

6.1.1 Base Radio Service Mode Description

The Base Radio Service Mode, a configurable mode of the base radio, causes the base radios to suspend normal transmit/receive operation to allow maintenance and tuning of the base radio. For details on base station local service mode operation, see the *GTR 8000 Base Radio* manual, or the *GTR 8000 Expandable Site Subsystem* manual, and QUANTAR® station or STR 3000 manual as necessary.

6.2 System Service Mode Function

The System Service Mode is used to steer traffic from one or more System Service Mode-designated talkgroups to one or more channels configured for System Service Mode call processing operation.

When at least one talkgroup and at least one voice channel at a site are configured for System Service Mode operation, any user voice request on a System Service Mode talkgroup is steered only to channels designated as System Service Mode channels. Call requests for normal talkgroups not configured for System Service Mode operation are assigned only to channels not designated as System Service Mode channels.

IMPORTANT: The System Service Mode function applies to talkgroups that are temporarily designated by the system as a “supergroup” as part of a patch or MultiSELect (MSEL) call. Take care to configure all members of a patch or MSEL with the same enable/disable setting for system service mode so you do not experience unexpected results.

6.3 System Service Mode Characteristics

The System Service Mode function has the following characteristics:

- Applies only for voice call talkgroup operation.
- Operation with multigroups is not supported.
- Applies only when a site is in wide-trunking and cannot be used in site-trunking.
- A System Service Mode channel can also be Base Station Identifier (BSI) or control capable.

- Is available in all trunking system configurations, including M and L core and Express Trunking. Is available on SmartX, ISR, and Multisite site types.
- Can be used with MCC 7500 console operator positions.
- Has no capability to steer a private call (unit-to-unit) to a service mode channel at a site.
- A System Service Mode channel can also be Base Station Identifier (BSI) or control capable.
- The system uses another non-System Service Mode control-capable channel as the current control channel if one is in-service.
- Integrated Voice and Data (IV&D) data calls are never assigned to System Service Mode channels.
- When used in a Time Division Multiple Access (TDMA) system, a System Service Mode designation on a TDMA-capable channel results in making both TDMA time slots service-mode capable.
- Has no capability to designate a particular TDMA slot on a channel for System Service Mode calls.
- When System Service Mode is in use, normal TDMA call processing rules still apply. If a TDMA-only talkgroup is designated as a service mode talkgroup, a TDMA-only or Dynamic Dual Mode (DDM) channel must be available for the call. Service mode channels observe normal rules for inclusion of sites and consoles in the call.
- Each channel at each site expected to be included in the call needs to be configured as System Service Mode-capable and a radio must be affiliated at the site (or the site must be a “requested” or “critical” site). Configuration of a service mode for a channel must be made through the Unified Network Configurator (UNC) and not via Configuration/Service Software (CSS).

6.4 System Service Mode Configuration

When and where to use: Use this process to enable the System Service Mode for a talkgroup and a channel to steer traffic from one or more System Service Mode-designated talkgroups to one or more channels that have been configured for the System Service Mode call processing operation.

CAUTION: Improper use of the system-level System Service Mode function can result in voice call processing outages. The System Service Mode function is intended for short-term use to steer talkgroups to particular channels for troubleshooting purposes. It is typically turned on only for one or two channels at sites where it is needed. If all channels at a site are designated as service mode channels, users on non- System Service Mode talkgroups are unable to make or receive calls. Administrators interested in a general-purpose channel-call steering function should instead use the Channel Partitioning function.

Process:

1. The base radio must not be set to service mode (Base Radio Service Mode) when enabling the System Service Mode for a talkgroup and a channel to steer traffic from one or more System Service Mode-designated talkgroups to one or more channels configured for System Service Mode call processing operation.
2. See procedure Setting the Service Mode of a Talkgroup Using Provisioning Manager on page 143 to set the System Service Mode to yes. For a single site trunking system, see procedure Setting the Service Mode of a Talkgroup Using Configuration Manager on page 145.
3. Set the service mode of a channel as directed in procedure Updating the Service Mode of a Channel Process Using Unified Network Configurator on page 145.

For details regarding the Provisioning Manager, CM and UNC, see *Provisioning Manager*, *Configuration Manager - Conventional*, and *Unified Network Configurator* manuals.

6.5

Setting the Service Mode of a Talkgroup Using Provisioning Manager

When and where to use: Use the Provisioning Manager to set the System Service Mode of a talkgroup. This procedure involves making the change to enable service mode, then downloading the configuration record to the system.

NOTICE: The ASTRO® system uses the Provisioning Manager to set the System Service Mode to **yes**.

Procedure:

1. To enable Service Mode for a talkgroup, open the Provisioning Manager. Select the **Subscriber Object**.

   NOTICE: The System Service Mode function applies to talkgroups which are temporarily designated by the system as a “supergroup” as part of a patch or MultiSELect (MSEL) call. Take care to configure all members of a patch or MSEL with the same enable/disable setting for system service mode so you do not experience unexpected results.

2. Under **Groups**, select **Talkgroup**.
3. Under **Configuration**, set the **Service Mode** parameter to **Yes**. For details about Provisioning Manager, see the *Provisioning Manager* manual.
4. After setting the System Service Mode of a talkgroup using the Provisioning Manager, use the Unified Network Configurator (UNC) to publish/distribute the change to the system. See Distributing Full Configurations Using Provisioning Manager on page 143 and Distributing Partial (Delta) Data Configurations Using Provisioning Manager on page 144.

6.5.1

Distributing Full Configurations Using Provisioning Manager

When and where to use: After using the Provisioning Manager to set the Service Mode parameter to **Yes**, use the Provisioning Manager’s Update Manager to distribute or publish the configuration change to the system.

Procedure:

1. Log on to the Provisioning Manager.
2. In the main menu, select the **Update Manager** tab.

   The **Update Manager** menu opens.

3. Select the **Force Initialize Configuration** tab.

   The **Force Initialize Configuration** window opens.

4. In the list of agents on the left side of the window, click the + button on the left of a device type, and double-click the agents to which the full configuration download is to be distributed.

   NOTICE:

   - To add all devices of a given type to the distribution list, double-click the device type.
   - As an alternative method to add to or remove devices from the list, select a given device and click the respective arrow button.

   The selected agents are added to the distribution list on the right side of the window.

5. Select **Force Initialize Configuration**.

NOTICE: If the Unified Network Configurator (UNC) **User Configuration** login window appears, enter the UNC login and password, select the box **Remember for this session**, and click **Apply**. This operation enables the operator to **Force Initialize Configuration** without entering the UNC user credentials many times while the session is active. To prevent this window from appearing in future sessions, enter the UNC user credentials in the **UNC User Configuration** section of the **Provisioning Manager User** record.

One of more jobs are scheduled and a message with the ID of the job(s) scheduled is displayed.

NOTICE: See the *Provisioning Manager* manual for details.

6.5.2

Distributing Partial (Delta) Data Configurations Using Provisioning Manager

When and where to use:
After using the Provisioning Manager to set the Service Mode parameter to **Yes**, use the Provisioning Manager's Update Manager to distribute or publish the configuration change to the system.n the delta configuration download, only configuration changes performed since the last successful download are distributed. Therefore, the delta download is much faster than the full configuration download.

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Procedure:

1. Log on to the Provisioning Manager.
2. In the main menu, select the **Update Manager** tab.

   The **Update Manager** menu opens.
3. From the object menu on the left, click **Manage**.

   The list of distribution types appears.
4. Select the **Distribute Configuration Changes** tab.

   The distribution menu appears.
5. In the distribution menu, click the **Distribute Changes** button.

   One of more jobs are scheduled for distribution, and a message with the ID of the job(s) scheduled is displayed.

   NOTICE: See the *Provisioning Manager* manual for details.

6.6 Setting the Service Mode of a Talkgroup Using Configuration Manager

When and where to use: Use the Configuration Manager (CM) to set the System Service Mode of a talkgroup by making the change to enable service mode, then downloading the configuration record to the system.

Procedure:

1. Open the CM. Select the **Talkgroup** Object.

   NOTICE: The System Service Mode function applies to talkgroups which are temporarily designated by the system as a “supergroup” as part of a patch or MultiSELect (MSEL) call. Take care to configure all members of a patch or MSEL with the same enable/disable setting for system service mode so you do not experience unexpected results.

2. Select the **Configuration Menu**, then set the **Service Mode** parameter to **Yes**. See the *Configuration Manager – Trunking* manual for details.
3. After setting the System Service Mode of a talkgroup using the CM, download the change to the system. See Distributing Configuration Changes Using Configuration Manager on page 145.

6.6.1 Distributing Configuration Changes Using Configuration Manager

When and where to use: After using the Configuration Manager (CM) to set the Service Mode parameter to **Yes**, use the CM’s Update Manager to distribute or publish the configuration change to the system.

Procedure:

1. Log on to the CM. Select the **Update Manager** tab.
2. In the **Update Manager** window, select the **Distribution Management** menu and choose the appropriate device from the drop-down list.
3. To implement a delta configuration download or full configuration download, select either **Delta Configuration Download** or **Full Configuration Download**. See the *Configuration Manager – Trunking* manual for details.

   The configuration change is distributed to the system.

6.7 Updating the Service Mode of a Channel Process Using Unified Network Configurator

When and where to use: Use one of the following procedures to update the System Service Mode capability of a channel.

NOTICE: The names EMC Smarts™ and VoyenceControl are used interchangeably for the product used in this process.

Procedure:

1. Update the System Service Mode for a channel using Unified Network Configurator (UNC) Wizard.
2. Update the System Service Mode for a channel using UNC/VoyenceControl to execute a Zone Controller Quick Command.

NOTICE: Use only one, not both, of the above procedures to update the service mode capability of a channel.

6.7.1
Updating the System Service Mode Channel Setting Using UNC Wizard

When and where to use: The following procedure describes updating the service mode channel setting using the Unified Network Configurator (UNC) Wizard. The parameters may differ depending on the site type in which the channel is created.

Procedure:

1. Log on to the UNC Wizard.

   The UNC Wizard home page appears.

2. From the list of available wizards on the left side of the UNC Wizard, under **RF Site Level Configuration, select Channel**.

   The **Channel Configuration** side of the window is updated with a list of zones.

   NOTICE: In a single-zone system, instead of listing zones, the wizard goes directly to the list of sites.

3. Select the Zone ID of the zone containing the channel requiring modification.

   The **Channel Configuration** side of the window is updated with a list of sites in the selected zone.

   NOTICE: In a single-site system, instead of listing sites, the wizard goes directly to the list of channels.

4. Select the **Site ID** of the site containing the channel requiring modification.

   The **Channel Configuration** side of the window is updated with a list of channels in the selected site.

5. Select the **Channel ID** of the channel requiring modification.

   The **Channel Configuration** side of the widow is updated with the **Channel Configuration** form for the selected channel.

   NOTICE: For more details, refer to the *Channel Parameters Depending on the Site Type* table in the *Unified Network Configurator* manual.

Figure 23: Typical UNC Wizard Screen Showing Channel Configuration

6 Update the **Service Mode** field and select **Submit**.

VoyenceControl processes the update request and then audits all devices to assess whether their current configuration complies with the updates. For any device that does not comply, the system creates an individual remedy job to bring the device back into compliance. When this process is complete, the `Configuration updates successful` message appears at the top of the form.

6.7.2
Updating the System Service Mode Channel Setting Using UNC/ VoyenceControl

Prerequisites: Before using this quick command, ensure that the UNC has a current ZC configuration by executing the `Pull Config` command. See *How to Pull the Configuration for a Single Device* procedure in the *Unified Network Configurator* manual.

CAUTION: The Quick Command must be executed on an active ZC. The Quick Command fails if executed on a non-active ZC. This Quick Command keeps track of channels set into service mode on a per-site basis.

CAUTION: The Quick Command fails if the parameters are out of range: command 1 or 2, site ID 1 – 100, channel ID 1 – 30. It fails if the entered channel is not configured in the current ZC configuration.

When and where to use: To use the Unified Network Configurator (UNC)/VoyenceControl to execute a Zone Controller (ZC) quick command to set a channel to service mode, see the *UNC manual - Executing Quick Commands*, procedure *How to Run Quick Commands*. Perform the following Zone Controller Quick Commands, Manage Channel Service Mode procedure for the quick command to set a channel to or clear channels from service mode.

Procedure:

1 Complete the fields on the **Device Command Parameters** window to execute the command.

a Enter 1 to set a channel into service mode. Only one channel can be in service mode at a time. If a channel was previously set into service mode, that channel is cleared from service mode and the entered channel is set into service mode. However, the command fails if you try to execute it on a channel already in service mode.

b Enter 2 to clear all channels at a site from service mode, even if you enter an ID of a channel that was not in service mode.

2 Enter the desired site and channel IDs.