4.2 SYSTEM DESCRIPTIONS

4.2.1 ASTRO® 25 System Description

4.2.1.1 Introduction

In response to the SFPUC Request for Proposal (RFP), Motorola Solutions, Inc. (Motorola) proposed and SFPUC accepted a P25 Phase 2 system ("SFPUC system") that will provide SFPUC with improved coverage, capacity, interoperability, and reliability, while also providing a radio system platform that will allow SFPUC to take advantage of the latest technologies to meet SFPUC's unique needs. The Motorola ASTRO 25 system is a proven platform to deliver on these capabilities.

The SFPUC system will be fully integrated with the ASTRO 25 system currently being deployed within the city of San Francisco. This will provide the SFPUC with an integrated system that will provide consistent communications throughout the coverage area from the City out through Hetch-Hetchy. As a single system, it will also provide ease of maintenance for the SFPUC.

Motorola's performance history in deploying new systems and migrating existing systems to the ASTRO 25 platform will provide the SFPUC with the comfort of knowing that the system will be deployed successfully and on schedule.

4.2.1.2 System Architecture and Site Configuration

ASTRO® 25 is the most widely used Project 25, Mission-Critical, Integrated Voice and Data (IV&D) communication network for public safety agencies. Installed worldwide, ASTRO 25 solutions meet and exceed IV&D requirements for day-to-day operations, as well as emergency response in the most demanding situations. ASTRO 25 is a wireless platform that combines uncompromising, real-world performance and the legendary reliability of Motorola.

ASTRO 25 is a flexible, modular network with advanced call processing capabilities designed to meet the needs of public safety. ASTRO 25 can adapt to accommodate additional users, increased geographic coverage, enhanced data applications, and connectivity to other networks—all to ensure an efficient and cost-effective solution for decades to come.

ASTRO 25 is optimized for the rigorous demands of public safety, providing reliable communications. When an emergency involves multiple agencies, first responders can share voice and data communication among their teams. In addition, centralized command and control can deploy resources efficiently, maintain communication security, and track personnel effectively.

The SFPUC system will be a sub-system add-on to the fully redundant San Francisco ASTRO 25 system with IV&D, the foundation of the Mission-Critical portfolio. By being fully integrated with the City system, the SFPUC sub-system will be capable of consistent system communications from the City, all along the SFPUC infrastructure, and out to the Hetch Hetchy watershed.

The SFPUC system will be comprised of the following:

- Capacity Licenses for the San Francisco ASTRO 25 Master site:
  - Nine (9) ASTRO 25 TDMA RF sites.
  - Presence and Location Services for up to 1000 devices.
  - (2,000) Subscriber Licenses.
  - A1 Text Messaging for up to 1000 devices.
  - Eleven (11) Dispatch Positions.
  - Network Management Capacity Licenses.
  - SVWTP and Intake will be conventional sites (1 channel).
- Three-Site Simulcast Cell in the Hetch-Hetchy Region comprised of:
  - Geo-Redundant GCP 8000 Simulcast Prime Site Controllers.
  - Geo-Redundant GCM 8000 Comparators.
  - Redundant Network and Backhaul Components.
  - Three (3) RF Channels, TDMA.
  - GPS Frequency Standard.
  - Three (3) RF sites with three GTR Expandable Site Subsystems (Duckwall, Burnout Ridge, Poopenaut,).
  - Remote Terminal Units for Environmental Alarms.
  - RF Distribution equipment at each site.
- Six (6) Standalone Trunked Repeater sites, each comprised of:
  - 3-RF channels, TDMA (Sawyer Ridge, Kings Mountain, Mount Allison, ACITD, Moccasin and CCWD).
  - Redundant Network Gateways.
  - High Availability Site Controllers.
  - Expandable Radio Frequency Distribution System.
  - Remote Terminal Units for Environmental Alarms.
- Network Management System with:
  - 3 Network Management Terminals (Moccasin, Sunol, Millbrae).
  - UEM with Advanced Navigation feature.
  - Microwave Map and Segment View.
  - UEM SNMP Element Management Tool Kit.
  - Email Alarm Notifications.
  - Flexible ATIA.
  - ZoneWatch.
  - Zone Historical Reports.
  - Radio Control Manager.
  - Affiliation User Reports.

- MCC 7100 IP Radio Dispatch Console at Moccasin Dispatch, comprised of:
  - Conventional Site Controller.
  - Redundant Network and Backhaul.
  - Conventional Channel Gateway, High Capacity.
  - Remote Terminal Units for Environmental Alarms.
  - Proxy Server.
  - Dispatch Firewall.
  - Five (5) Dispatch Positions, each with:
    - Dispatch PC with Elite Software.
    - Trunking and Advanced Conventional Licensing.
    - Instant Recall Recorder Soundcard and Software.
    - AES Encryption Software.
    - Ten (10) Channel Simultaneous Capacity License.
    - Audio Interface Module.
    - Two Headset Jacks.
    - Gooseneck Microphone.
    - Footswitch.
- MCC 7100 IP Radio Dispatch Console system for the Kirkwood Powerhouse, comprised of:
  - Network and Backhaul.
  - One (1) Dispatch Position with:
    - Dispatch PC with Elite Software.
    - Trunking and Advanced Conventional Licensing.
    - Instant Recall Recorder Soundcard and Software.
    - AES Encryption Software.
    - Ten (10) Channel Simultaneous Capacity License.
    - Audio Interface Module.
    - Two Headset Jacks.
    - Gooseneck Microphone.
    - Footswitch.
- MCC 7100 IP Radio Dispatch Console at El Camino Real Dispatch, comprised of:
  - Conventional Site Controller.
  - Redundant Network and Backhaul.
  - Conventional Channel Gateway, High Capacity.
  - Remote Terminal Units for Environmental Alarms.
  - Three (3) Dispatch Positions, each with:
    - Dispatch PC with Elite Software.
    - Trunking and Advanced Conventional Licensing.
    - Instant Recall Recorder Soundcard and Software.
    - AES Encryption Software.
    - Ten (10) Channel Simultaneous Capacity License.
    - Audio Interface Module.
    - Two Headset Jacks.
    - Gooseneck Microphone.
    - Footswitch.

- MCC 7100 IP Radio Dispatch Console at PUC Dispatch, comprised of:
  - Conventional Site Controller.
  - Redundant Network and Backhaul.
  - Conventional Channel Gateway, High Capacity.
  - Remote Terminal Units for Environmental Alarms.
  - *Two (2) Dispatch Positions, each with:
    - Dispatch PC with Elite Software.
    - Trunking and Advanced Conventional Licensing.
    - Instant Recall Recorder Soundcard and Software.
    - AES Encryption Software.
    - Ten (10) Channel Simultaneous Capacity License.
    - Audio Interface Module.
    - Two Headset Jacks.
    - Gooseneck Microphone.
    - Footswitch.
- Microwave System to connect the San Francisco system to the SFPUC microwave backhaul. The microwave system will be comprised of the following:
  - Nine (9) Redundant Microwave Hops:
    - Foresthill to Sawyer Ridge.
    - Sawyer Ridge to Kings Mountain.
    - Kings Mountain to Mt. Allison.
    - Mt. Allison to ACITD.
    - ACITD to CCWD.
    - CCWD to Pelican.
    - Moccasin Peak to Duckwall.
    - Duckwall to Intake Radio Site.
    - Hop to Poopenaut from one of these other sites.
  - Minimum 100 Mbps Capacity per Link.
  - Five 9's Reliability.
- Site Development and Improvements to Include:
  - Sawyer Ridge:
    - New 80' tower at Sawyer Ridge.
    - 35 KW Outdoor Generator.
  - Burnout Ridge:
    - Battery Bank for New RF Equipment.
  - Kings Mountain:
    - 195' Tower.
  - Duckwall:
    - 35 KW Generator.
    - Battery Bank for New RF Equipment.
- Spare Equipment for the System Based on a 10% Sparing Strategy.
- (540) APX 1000+ Project 25 Portable Radios:
  - High Capacity 2350 mAH LI-ION Battery.
  - Radio Management License.

System Block Diagram

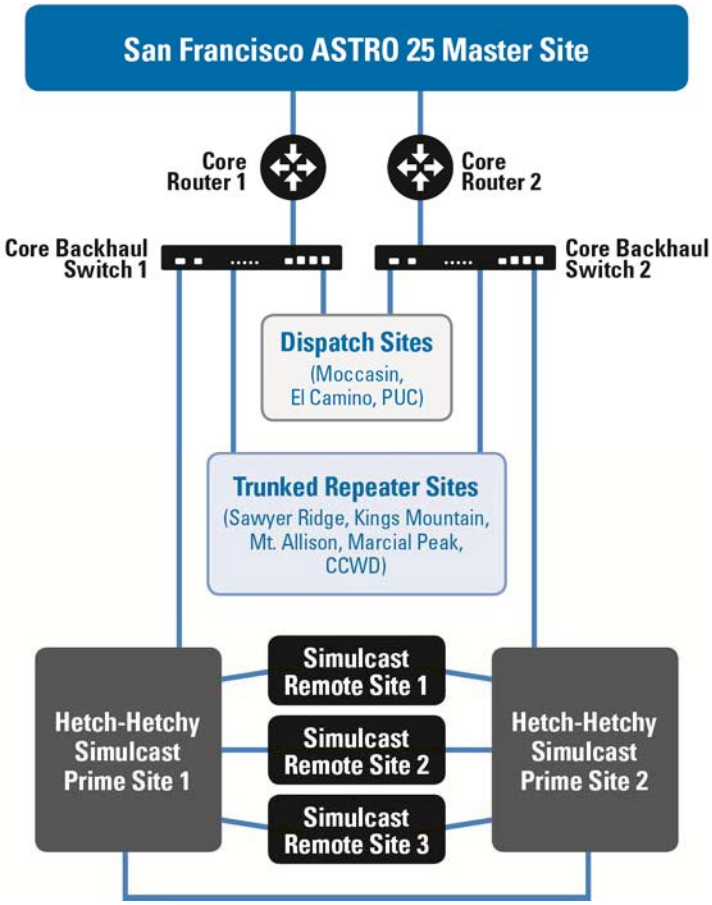

Figure 4-1: System Block Diagram

*SFPUC Dispatch has a single Motorola MCC console position already as part of the city of San Francisco system currently being deployed. Motorola will add two positions, redundant network and backhaul as well as other items listed in this section.

SFPUC has purchased the following items to enhance the coverage inside critical locations:

- Fifty-One APX 1500 Project 25 Mobile Radios.(*Final count to be determined during the project. If additional radios are needed, the SFPUC will pay the additional charges above the contract amount. If less radios are needed, a credit will be applied to other work required for the projec*t)
- One APX 4500 Project 25 Mobile Radio.
- One Vehicular Repeater System (DVRS).
- One Deskset.
- One Control Station—Local Controlled.
- One Control Station—Remote Controlled.
- One Control Station—Console Controlled
- Conventional Channel at the SVWTP Site.
- Conventional Channel at Intake Radio Site.
- Simulcast site at Poopenaut Pass including a microwave hop to Poopenaut from one of the other sites.

- Fixed DVRS Conventional Repeaters at:
  - San Antonio Watershed Cottage.
  - San Andreas Cottage.
  - Sawyer Camp Cottage.
  - Upper CS Cottage.
  - Pulgas Water Temple.
- Asset Management Licensing

Additional Information on each element of the systems is provided below.

4.2.1.2.1 Assumptions

Certain assumptions were made in the creation of the SFPUC system. Incorrect assumptions or modifications to these assumptions may result in a change order to the project. These assumptions include:

- Internal electrical work at the sites (e.g. running AC outlets above rack locations, adding breakers to electrical panels) will be the sole responsibility of SFPUC.
- Existing towers, upon which Motorola will be installing antennas, have as-builts and documentation regarding their existing loading in order for Motorola to perform loading analysis on these towers prior to installation of antennas.
- Solar sites in which Motorola will be modifying the site power system are in good working order and the power system modifications can be made. A detailed analysis of these will be performed post-sale.
- The SFPUC users operating on the current City of San Francisco system will be migrated to the new system on the schedule of the City and county of San Francisco system replacement project. System interoperability will be addressed during the SFPUC Design Review of the Migration Plan.
- The Microwave links have clear paths that can be built as proposed. Link viability surveys will be performed post-sale to ensure viability.
- The proper way to model in-building coverage is to apply a loss to the area to be covered that represents the loss for buildings. Motorola has chosen to model the in-building coverage with this method instead of the raising of reliability to 97% as requested in the RFP Section 4.5.2.b.i.
- For the Burnout Ridge and Duckwall sites, Motorola has included rack mounted batteries to supply up 8 hours of battery backup for the new P25 system equipment only.
- Motorola will assist SFPUC with negotiating agreements for the Kings Mountain, ACITD and CCWD sites , and will assist with re-negotiating the lease agreement for the Mount Allison site. Motorola cannot ensure that site owners will accept SFPUC terms. SFPUC is responsible for securing the site lease. The actual costs for the lease themselves are not included with the proposal and remain the responsibility of SFPUC.

4.2.1.3 The Benefits of ASTRO 25 IP Technology

Standards-based IP Modular Solution for First Responders

The SFPUC system is our ASTRO 25 platform with IV&D, the foundation of the Mission-Critical portfolio. ASTRO offers a Project 25, standards-based Internet Protocol (IP) modular solution, providing your first responders with:

- **Cost savings**—ASTRO 25 reduces costs by integrating your voice and data needs into a single solution.
- **Interoperability**—ASTRO 25 is compliant with APCO Project 25 standards, offering seamless interoperability with other compliant systems and radios, putting the highest level of interoperability in the end-users' hands, without the need of gateways or console patches.
- **Reliability**—Pre-release software and upgrade testing, third-party hardware and software certification process, fault-tolerant architecture with multiple fallback modes, multiple levels of redundancy, and real-time network and security monitoring provide Mission-Critical reliability.
- **Increased security**—Information Assurance (IA) enhances the confidentiality, integrity, and availability of the Radio Network Infrastructure (RNI). Multiple encryption algorithms keep end-to-end voice and data transmissions confidential.
- **Enhanced productivity**—Easy and intuitive interfaces to critical, real-time information is delivered to users when and where they need it.
- **Flexibility**—Scalable, flexible design allows ASTRO 25 to dynamically adapt to the operational demands of any size organization. The IP-based design supports a unique mix of voice, data, and geographical requirements, permitting easy system enhancements as the users' needs evolve.

A description of some of the features and benefits of the ASTRO 25 platform are provided in this section below.

4.2.1.3.1 Interoperability

The ASTRO 25 system for SFPUC will provide seamless communications from San Francisco through to the Hetch-Hetchy region. The ASTRO 25 core will also provide interoperability with any other user connected to the ASTRO 25 core, including agencies in San Francisco.

The system also includes the capability of interfacing conventional channels into the overall system. This will provide SFPUC with the capability of communicating with other agencies throughout the region.

The ASTRO 25 core also has the capability of interfacing with other Motorola ASTRO 25 systems and other vendor P25 systems through the DEM Inter-Subsystem Interface.

4.2.1.3.2 TDMA Capability

The P25 system currently being deployed by the City and County of San Francisco is equipped for TDMA operation, which will integrate with the TDMA solution for the SFPUC system. The infrastructure and subscribers are capable of being operated in FDMA or TDMA mode. The RF subsystems for the SFPUC are TDMA only sites on the system for increased capacity.

The SFPUC system is built upon the proven ASTRO 25 platform. With the addition of P25 TDMA operation, the ASTRO 25 system leverages 2:1 TDMA channel efficiency to double voice path capacity (Figure 4-2), as compared to a P25 FDMA channel (Figure 4-3). This means that that Motorola will provide 4 talk paths. This enhanced capacity improves the Grade of Service (GoS), leading to fewer busied calls and faster callbacks during busy situations, relative to a standard P25 FDMA system.

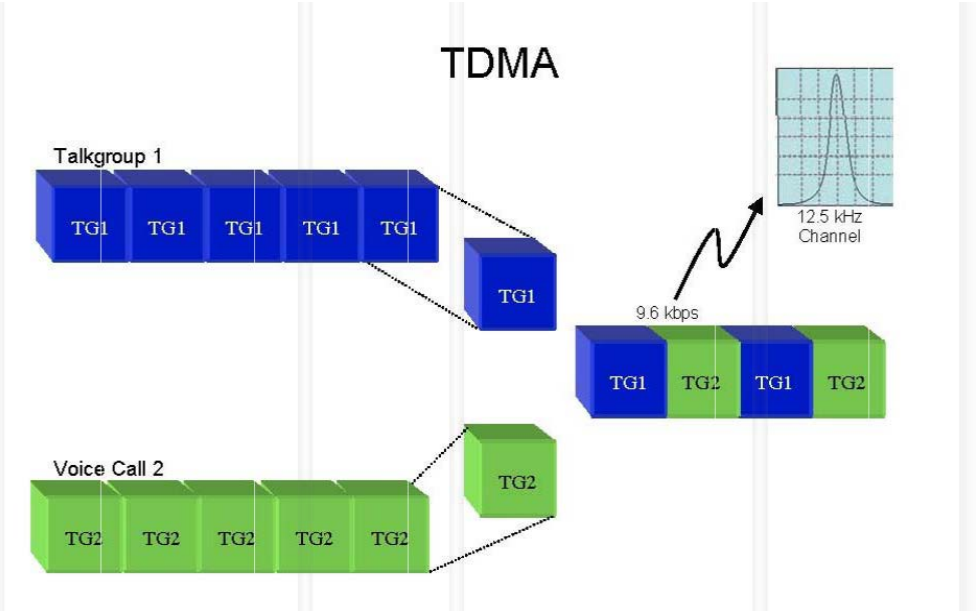

Figure 4-2: TDMA Operation divides a radio frequency into time slots and then allocates slots to calls

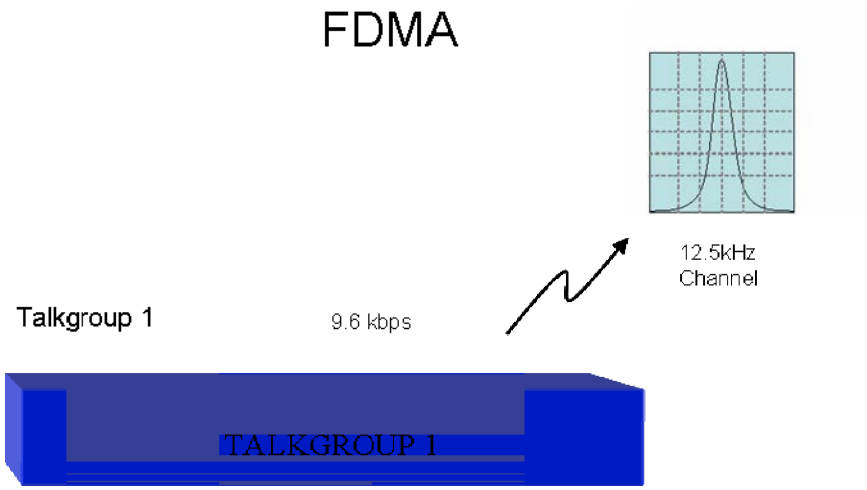

Figure 4-3: FDMA Operation divides spectrum into frequencies, which are then assigned to calls

This improvement is due to the fact that TDMA provides double the talk path capacity in the same RF bandwidth allocation. Having this additional capacity improves GoS by reducing channel busies. Furthermore, callbacks are faster due to the greater availability of talk paths in the TDMA solution. If more voice path capacity is not required, the RF spectrum can be redeployed for packet data services at the same site, or be redeployed at another site that needs more voice path capacity. P25 TDMA also provides 6.25e (6.25 “equivalent”) operation for satisfying certain future FCC spectral efficiency requirements.

4.2.1.3.3 Geographically Redundant ASTRO 25 Prime Sites

Maintain Wide-Area Communications During the Worst Disasters

Motorola has included geographically redundant Prime sites for the Hetch-Hetchy simulcast cell. Each Prime site is equipped with active components that back each other up. For example, if the channel 1 comparator at Prime site 1 becomes unavailable, the system automatically re-routes the audio packets to the active backup channel 1 comparator at Prime site 2. Likewise for the other components at the Prime sites, such as the Prime site controllers and networking equipment.

SWITCHOVER IS FAST, AUTOMATIC

An ASTRO 25 IP system provides a wide variety of design options to achieve 99.999% availability. Motorola recognizes that one solution does not fit all customers. That is why ASTRO 25 systems have an extensive range of designs that allow customers to tailor their system to meet their resiliency needs. These options allow customers to customize the solutions which optimize resiliency, functionality, and budget for their specific environment. For certain parts of the system redundant components at the same location may be sufficient. Other parts of the system that are more critical or more vulnerable may require distributed redundancy

A simulcast cell in Hetch-Hetchy means that should the simulcast cell become isolated from the rest of the system, the users in that region will still be connected together and able to communicate as the simulcast cell will enter into site trunking mode, as described in the next section.

The SFPUC configuration is shown in Figure 4-4.

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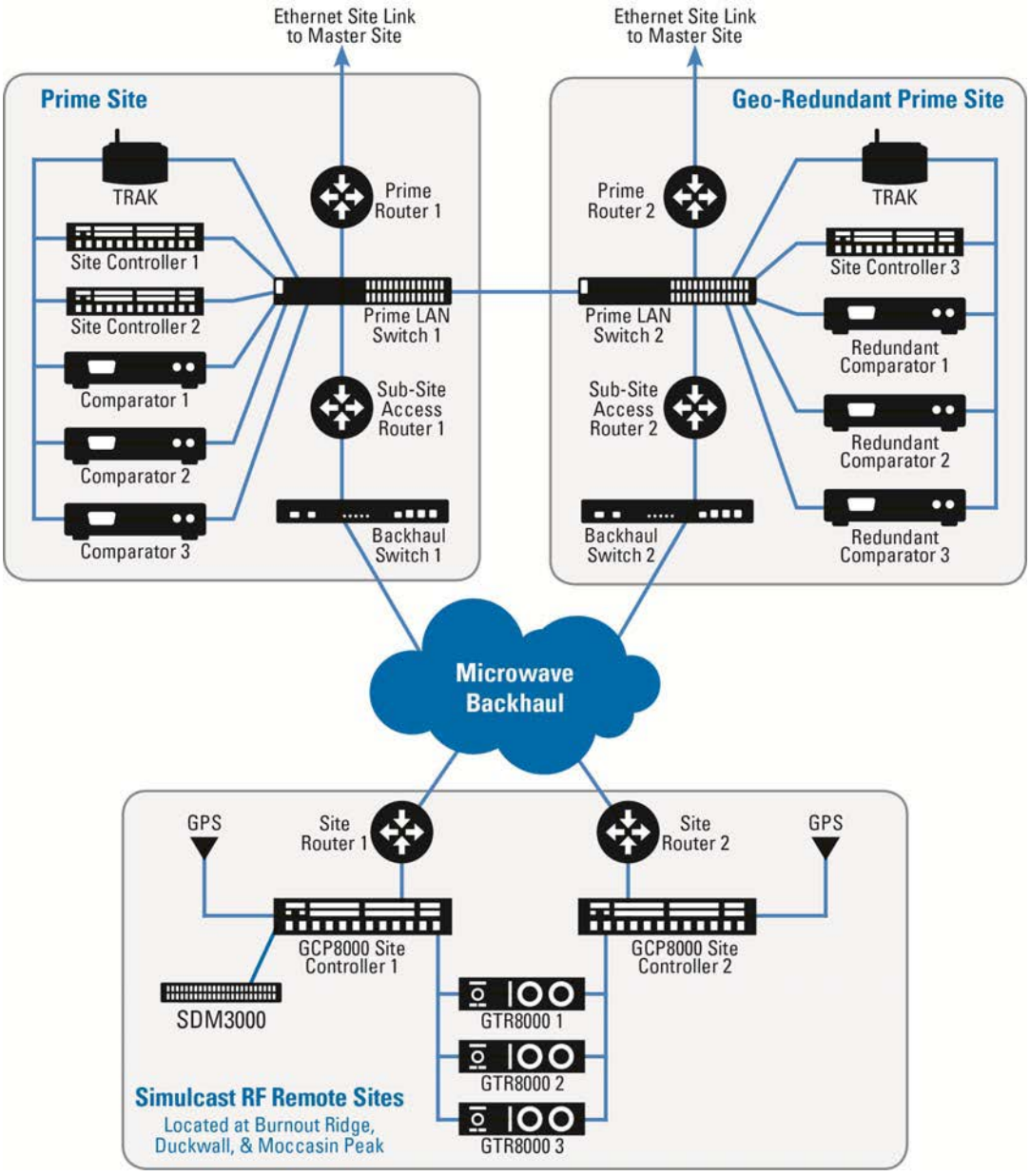


Figure 4-4: Sample Redundant Prime Site Configuration

4.2.1.3.4 Fallback Operations

Motorola's ASTRO 25 trunking networks have three modes of operation for increased reliability. The normal mode of operation is wide-area trunking. In the event of multiple component failures that lead to system disruption, the system is equipped to continue operation in two reduced feature operational modes: site trunking and failsoft.

Wide-Area Trunking

Wide-area trunking is the ASTRO 25 system's normal mode of operation. Wide-area trunking implies that the Fixed Network Equipment is operating properly. All simulcast cells and ASTRO 25 repeater sites are communicating with the Master Site. Subscriber units automatically roam between the various network RF cells. Talkgroup calls occur in the appropriate RF cells if users are distributed throughout multiple cells. Data applications are properly assigned channels for communication between the subscriber units and the host application.

Site Trunking

Site trunking is the first failover mode of operation. Site trunking impacts individual RF cells within a network. In multiple RF cell systems, like the SFPUC system, one RF cell can be in site trunking, while the rest of the system remains in wide-area trunking. Site trunking implies that the simulcast prime site controller or the ASTRO 25 repeater site has lost connectivity with the Master Site. Talkgroup calls initiated in the RF cell that is in site trunking will only be broadcast in that RF Cell. Dispatch consoles use control stations, or the operators use portable radios to communicate on a site trunking RF cell. Console priority is not available in site trunking. Data applications are not available on a site in site trunking and will have to be reinitiated once the system reverts to wide-area trunking.

MAINTAIN SYSTEM COMMUNICATIONS IN CRITICAL EVENTS

Radios detect if a site is in wide-area trunking or site trunking. Radio models with a display will indicate to the user when the site is operating in site trunking. The radio alternately displays the selected talkgroup and "Site Trunking." Depending on how the system and user equipment are programmed, subscriber units will try to roam to an RF cell that is in wide-area trunking.

Failsoft by Talkgroup

Subsystem/site failsoft is the final fallback means of communication if a site no longer maintains wide-area or site trunking operation. Multiple failures have to occur for the system to enter failsoft. Failsoft impacts individual RF cells within a network. In multiple RF cell systems, one RF cell can be in failsoft, while the rest of the system remains in wide-area trunking. The subsystem goes into failsoft mode in any of these scenarios:

- The site controllers are not functioning properly.
- When all control channels are disabled or malfunctioned.
- When only one channel is enabled.

Failsoft operation provides communications in conventional mode via repeaters/base radios in order to maintain vital communications. In an IP multi-site simulcast subsystem, in subsystem-wide failsoft, received audio is routed to the comparator for voting and redistributed to all of the sites for simulcast transmission.

The subscriber's operation in failsoft mode is determined by the subscriber's programming. A subscriber can be programmed to behave in the following manner:

- **Failsoft by control channel operation**—The subscriber first scans for alternate control channels outside the multi-site subsystem, then scans the control channel frequencies for failsoft data.

- **Failsoft by working group**—The subscriber looks for Failsoft data on a pre-programmed frequency after a scan for alternate control channels outside the multi-site subsystem is unsuccessful. If the subscriber cannot decode failsoft data on the pre-programmed frequency, the subscriber then scans the control channels in the simulcast subsystem for failsoft data.

Subscriber units in an RF cell that is in failsoft will try to roam to an RF cell that is in either wide-area trunking or site trunking. Dispatch consoles use control stations or the operators use portable radios to communicate on a site trunking RF cell. Console priority is not available in site trunking. Data applications are not available on a site in failsoft and will have to be reinitiated once the system reverts back to wide-area trunking.

4.2.1.3.5 Encryption

Protect Your Network and Users

All of the equipment and subscribers in the SFPUC system can support encryption. Motorola has included AES encryption on the dispatch consoles. Encryption ensures only authorized units in the system can listen to transmissions being made. Encrypted calls are protected end-to-end throughout the network.

Project 25 Encryption Algorithms

ASTRO systems can be equipped with current Project 25 algorithms and are fully compliant with all Federal Information Processing Standards (FIPS). The following encryption is available: DES-OFB, DVI-XL, DVP-XL, DES-XL, AES, and ADP.

Software-Based Encryption Algorithms

Advanced Digital Privacy (ADP) is an entry-level encryption algorithm, offered exclusively by Motorola. ADP allows users to protect any and all communications from eavesdroppers and scanners for less cost than the hardware-based encryption algorithms. With Health Insurance Portability and Accountability Act (HIPAA) compliance being more closely scrutinized, many users are implementing this cost-effective security feature for all users.

4.2.1.3.6 System Access Features

Efficient and Intuitive Access

To ensure system access, simplify radio operation, and limit operator involvement, the ASTRO 25 platform has many access features, as described below.

Busy Queuing/Call Back

This system has been designed to maximize availability to the end-user. In the unlikely event that all the channels are busy, a user depressing the Push-To-Talk (PTT) will be given a busy signal, and placed into a busy queue. When a channel becomes available, the system assigns the users to a channel via pre-assigned priority levels. Once a channel is assigned, the system notifies the user with a call back tone. This feature makes it unnecessary for the radio operator to waste valuable time rekeying the radio in order to gain channel access.

Automatic Retry

If a channel request is not received at the Zone Controller, the individual radio unit continues sending channel requests until the Controller acknowledges the request, or until a total of 16

automatic retries occur. This feature eliminates the need for the operator to continually key and de-key the radio, or to keep the radio keyed in order to gain system access.

Recent User Priority

To ensure uninterrupted communications, a recent radio user priority provides those users who have been recently assigned a voice channel priority over the other system users. Recent user priority ensures that a talkgroup engaged in a conversation receives priority system access for up to 10 seconds between transmissions.

Misdirected Radio Protection

To ensure a radio from one talkgroup cannot accidentally be assigned to a voice channel being used by a different talkgroup, the system utilizes embedded signaling. If a unit from a different talkgroup is accidentally assigned the same channel, the radio will recognize that it has been assigned incorrectly, and will automatically revert to the control channel.

Continuous Assignment Updating

Once a talkgroup is assigned a voice channel, the control channel continues to transmit the channel assignment for as long as that talkgroup is using the channel. This ensures a radio just coming into service will be sent to the appropriate voice channel to join the rest of its talkgroup.

Talk Prohibit Tones

In the event a user attempts to perform an unauthorized function as defined by system permissions, a talk prohibit tone is given.

User Talkgroup Features

To enhance user functionality, the ASTRO 25 platform has many talkgroup features, also known as group call, as described below. These features are configurable by the System Administrator.

Emergency Alarm/Call

Emergency alarm/call provides users the capability to inform dispatch personnel of a life-threatening situation. By pressing the radio's emergency alarm button, an audible and visible alarm and the user's ID is sent to the dispatcher and, potentially, other talkgroup members.

In emergencies, the dispatch center is notified immediately, regardless of whether the system is busy. If one or more voice channels are available, one of those channels will be assigned immediately to the emergency call when the user presses the PTT switch. The duration of the emergency call can be defined by the system administrator.

In the event that the system is busy, two alternatives are provided for handling emergency traffic:

- ***Top of the Queue***—When an emergency is initiated and no channel is available, the emergency user is put at the top of the busy queue. As soon as the first user on any channel de-keys, the emergency caller is assigned that channel. The major advantage to this approach is that there is no contention for the channel.
- ***Ruthless Preemption***—When an emergency is initiated and no channel is available, the Zone Controller selects the channel assigned to the lowest priority user and assigns it to the emergency caller—a feature unique to Motorola trunking systems.

Multiple Priority Levels

The system provides 10 priority levels, allowing administrators to segment their users according to their communications needs. Priority 1 is always reserved for emergencies. Priorities 2 through 10 can be assigned by the System Manager on a per radio or talkgroup basis. These priorities are only applicable when the system is busy.

Multi-Group Call

Multi-group call is used to make a simultaneous call to multiple talkgroups, and allows all units to be configured for talk back capability. The System Manager can program this call to operate in one of two-ways:

- The requesting user waits for all requested talkgroups to finish all calls in progress.
- The requested call immediately interrupts other conversations in progress without waiting for active users to de-key. Radio users who are transmitting on a voice channel will not hear the call until they de-key.

Priority Monitor

Priority monitor allows the radio user to scan talkgroups in their system, and mark up to two talkgroups in their scan list as Priority. A non-priority conversation will be interrupted by Priority 1 or Priority 2 talkgroup activity.

Dispatch Console/Talkgroup Merge

Talkgroup merge is a dispatch function that allows multiple talkgroups to operate together on one voice channel, improving channel efficiency. This is a standard feature of Motorola wireline consoles.

4.2.1.3.7 Individual Call Features

ASTRO 25 Offers Popular and Valuable Features

In addition to user talkgroup features, the ASTRO 25 platform has individual call features, as described below. These features are configurable by the system administrator and are available on the SFPUC system.

Call Alert

A dispatcher or radio user can page another dispatch position or individual's radio. When the Call Alert is delivered, the initiating radio receives an acknowledgement.

If the receiving radio is not in a voice call, a tone sounds on the receiving radio. If the receiving unit has a display, it will show and store the sending unit's ID.

Call Alert signaling uses the control channel and does not affect voice channel capacity.

In-Call User Alert

In-Call User Alert builds on Call Alert. When In-Call User Alert is enabled on the system, radios are able to receive Call Alerts even when involved in voice and data services. The alert tone sounds in the background, so the voice message comes through clearly.

Radio Talkgroup Muting

Radio Talkgroup Muting allows the radio user to mute all voice traffic for the currently selected talkgroup, including emergency voice received.

The radio can be automatically un-muted by the console dispatcher or another radio user by

sending the muted radio a Call Alert.

Private Call

Private Call allows a radio user or console dispatcher to selectively call and carry on a private conversation with another individual radio, as long as that unit is not already engaged in another Private Call. The calling unit will receive an acknowledgment of a successful Private Call. If the receiving radio has a display, it will show the calling party's unit ID.

To protect channel availability for mainstream operations, Private Call management can control how many resources are dedicated for private calls at a trunking RF site. The system manager can pre-configure and limit the number of simultaneous private calls that are active at a particular site, or even disallow private calls entirely.

4.2.1.3.8 Site Selectable Alerts

Only P25 Vendor to Superimpose Tones Over Voice Transmissions

ASTRO 25 trunking systems can provide alert tones or voice messages to all APX subscriber radios at selected RF sites or zones. The alert sounds in the background of an active call and on idle radios. Subscribers display a short message.

Up to 15 alerts can be configured in advance then selected by the subscriber to be broadcast once or repeated at a specified cadence.

Preconfigured notifications are ideal for alerting team members to:

- Vacate the Area.
- Move to Stage 3.
- Return to the Command Post.

Figure 4-6: APX Radio Screen

4.2.1.3.9 Data Applications

The Project 25–compliant Integrated Voice and Data (IV&D) operation allows data traffic to seamlessly utilize your existing ASTRO 25 stations, improving in-field efficiency. Voice is prioritized, allowing Mission-Critical traffic to always take precedence over data transmissions. The IV&D service creates a data transport layer capable of supporting both industry-standard IP and customer-developed applications, including:

MAXIMIZING USER BENEFIT AND EASE OF USE

- Advanced Messaging (Included).
- Outdoor Location (Included).

Users can achieve a number of important benefits, including:

- Conservation of valuable airtime.
- Increased communications accuracy.
- Allows users in the field to perform queries without dispatch.
- Better return on investment—same assets for multiple functions.
- Utilizes common radio units for both voice and data applications.

Outdoor Location Solution

A Map-Based Location Application

Motorola's ASTRO 25 Outdoor Location Solution is offered to SFPUC on the ASTRO 25 IV&D system being deployed by San Francisco. Motorola has added licensing for up to 1,000 subscriber radios to utilize the Outdoor Location Solution. It uses Global Positioning System (GPS) satellites to provide the location of personnel and Vehicles. These locations can be fed to a map-based location application, providing dispatch operators with an invaluable tool for managing and tracking personnel and resources. The ability to locate users in a critical situation dramatically increases user safety, while improving resource allocation and responsiveness.

KNOW THE LOCATION OF YOUR FLEET IN A CRITICAL SITUATION

Figure 4-7 shows an example of the main components for the Outdoor Location Solution.

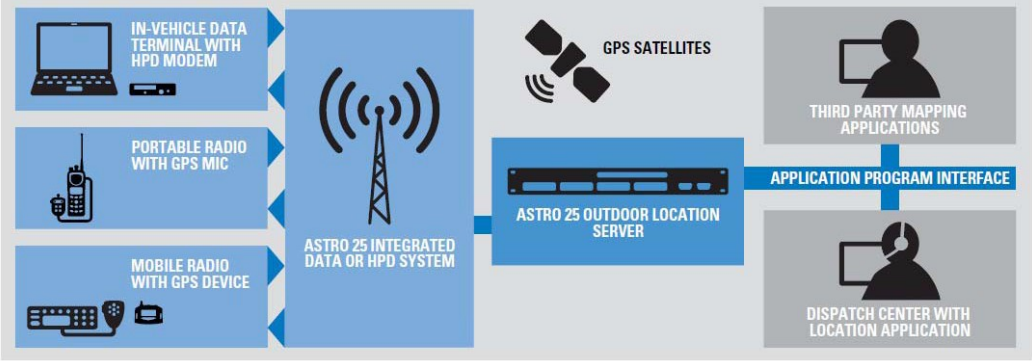


Figure 4-7: ASTRO 25 Outdoor Location Solution

4.2.1.4 Network Management System

Management of Your Network of Servers

The Network Management System (NMS) that is part of the ASTRO 25 platform can be viewed as a set of software applications or tools used to manage the ASTRO 25 wide-area trunked radio system and its constituent components. SFPUC will have access to the capabilities inherent on the City ASTRO 25 system to through the three Network Management Terminals running the appropriate applications. The NMS supports the following services:

MANAGE YOUR SERVERS AT THE ZONE AND SYSTEM LEVEL

- **Fault Management—**The capability is provided to manage the health of all devices that are part of the communication network and the system environment.
- **Configuration Management**—The necessary tools are provided for entering and maintaining the operational parameters of the infrastructure components and user devices (i.e., the mobile and portable radios).
- **Accounting Management**—NMS supports the tracking of radio usage of the system by providing an optional (not included) interface to third-party accounting and/or billing applications.

- **Performance Management**—Standard applications are available for monitoring, reporting, controlling, and optimizing the use of system resources.
- **Security Management**—NMS includes features for setting user privileges and controlling their access to view and/or modify information contained in the configuration databases.

The Network Management subsystem will include the following servers at the zone and system levels of the ASTRO 25 system:

- **NMS Zone-level Servers (one each per zone)**—Air Traffic Router (ATR), Zone Database Server (ZDS), Unified Event Manager (UEM), and Zone Statistics Server (ZSS).

4.2.1.4.1 Fault Management

This section provides information about the applications that provide fault management capabilities within the ASTRO 25 network. These devices are the Unified Event Manager (UEM) and the NFM System.

Unified Event Manager

Manage LMR System Devices From a Single Screen

The Unified Event Manager (UEM) application allows system management personnel to manage LMR system devices from a single screen. Historical and real-time traffic screens give users access to radio events, radio status, and any device alarms. Other features include:

HISTORICAL AND REAL-TIME TRAFFIC SCREENS TO GIVE ACCESS TO ALL RADIO EVENTS AND ALARMS

- Graphical views/maps.
- Active alarms and summary views.
- External notification flexibility.
- Remote site control.
- Fault reporting capabilities.
- Device inventory.
- External notification.
- Customized views.
- Role-based access.

The UEM provides a customized discovery process for optimization and deep discovery of subcomponents reported on by a device. The application also allows for automatic registration of the devices without pre-configuration. Interpreting and displaying events in an easy-to-understand and meaningful format—along with a topology of the network and devices tailored for the ASTRO 25 network—will ease navigation and present the network in a manner that is intuitive to a system operator.

Health of services is provided in addition to device-based alarms, including rules for determining the overall status of services in a separate view (e.g., redundant controller is down—service is still up; both views are represented). Rules have been developed for calculating alarms based on interpreting incoming events. Security procedures are in place to roll SNMPv3 keys and maintain the ability to receive SNMP inform requests through the key role of an entire network. Device commands are presented in a manner specific to each device type. During discovery, a complete device inventory with specific rules to identify service and proxied components is accomplished for all individual devices. Table 4-2 outlines features and benefits of the UEM.

Table 4-2: Unified Event Manager (UEM) Features and Benefits

Feature	Benefit
Optimized Discovery Based on System Design	UEM supports subnet discovery of the IP addresses which are designated for radio system devices. This translates to an efficient device discovery process.
Discovery of Fault Managed Devices	Based on the device type the UEM has pre-determined rules for discovery of the custom entities supported on the device. Additional rules are used for event translation and alarm generation.
Fault Manager Registration	Procedures are in place to register the manager's IP address as a trap/inform destination.
Centralized View of the Communications Network	System Managers can view the ASTRO 25 system status and quickly isolate problems to the board level.
Intuitive Graphical User Interface (GUI)	System Managers are quickly notified of failures on the system and can diagnose device problems. Summary and Detail maps provide a graphical display of site status in their geographical location within the system.
Active Alarms View and Alarm Summary	Persistent single view of all failure conditions ("What's Inoperable") in the network and a quick reference summary of alarms by severity, allowing users to quickly pinpoint the highest priority failures.
Secure Device Access	SNMPv3 protocol with SHA and AES 128-bit encryption to prevent security breach attempts.
Role-Based Access Control	Assignment of user privileges for access to views and operational capabilities.
Email Notifications	User-specified event notifications are sent via secure email or forwarded to a portable mobile device, which allows System Managers to work away from the System Management Terminal but remain aware of system events.
Fault Reporting Capabilities	Event history data is auto-archived and exported for further analysis and reporting.
Remote Command Operation	Remote state change capability helps to service remote devices and avoid unnecessary trips to the sites for troubleshooting.
Network Inventory	Tabular view of the devices and their associated status.
Audit Trail and Job Status	Traceability and status for commands and actions executed.

The UEM is optimized to quickly discover the devices in our network—making installation and setup quick and error-free. The UEM has a built-in capability to identify the type of device it is discovering; it will activate the pre-determined rules for discovery of the devices, which results in faster event translation and alarm generation in the manager. Each device, via its various entities (i.e., fan, power supply, etc.), will quickly inform the manager what it needs to monitor. Procedures built into the UEM will configure the IP address in the device to give the correct path for sending its information during operation.

Quick and accurate interpretation of the system activity is crucial in effective management of the devices. The UEM translates the events into intuitive information, which will inform the user of either the severity of the failure or implication of the event.

UEM translates the events into active alarms, which make the user aware which events require immediate attention versus more minor events/alarms. The alarm view dynamically updates based on the condition of the reported device (i.e., the alarm will be cleared from the alarm view when a device sends a clear event to the UEM).

The Reliable Communication design in the UEM provides Supervision and Synchronization services:

- **Supervision**—Provides periodic SNMP Polling to ensure communication is established with each device on the network. The UEM generates communication failure alarms/events when communication between the agent and the manager fails.
- **Synchronization**—Used to ensure the accuracy of the state that the device is reporting. If the connection between the UEM and the device is lost, the device will queue up the missed fault events and re-send when the connection is re-established. These Motorola-defined procedures were put in place to enhance the reliability of basic SNMPv3 trap messaging. These procedures manage the re-synchronization of missed failures. The UEM utilizes SNMPv3 informs to enable the device to detect whether the connection has been interrupted.

NFM System––Local Site Alarms (RTU)

Comprehensive Monitoring for Alarms

The Network Fault Management (NFM) system included with the SFPUC system is an end to end solution which collects alarms from devices and equipment at communication sites. The information is then sent to the UEM, where the information is stored so that it can be displayed and analyzed by system technologists and managers. Motorola has included SDM3000 Remote Terminal Units (RTU) at each of the RF sites and also at the dispatch sites and Microwave Only sites included as part of the SFPUC system. Features and benefits of the NFM system are outlined in Table 4-3.

Table 4-3: MOSCAD NFM System Features and Benefits

Feature	Benefit
Collection of Environmental Alarms	A single SDM3000 supports data interfaces and digital alarm inputs to site equipment such as doors, tower lights, UPS, security, and third-party devices.
Data Interfaces to Site Equipment	The SDM3000 collects alarms and values from a wide range of Motorola stations, Microwave Radios, Channel Banks, Frequency Standards, and more via RS232, SNMP V1 & V3, and IP.
Collection of Analog Information	The SDM3000 interfaces to site equipment with analog outputs such as temperature sensors, fuel sensors, RF Power sensors, etc.
Initiation of Site Controls	The SDM3000 interfaces to site equipment which can be controlled, such as doors, generators, security, equipment switching, etc.
Local Web Server	The SDM3000 incorporates a built-in Web Server so that Service Technologists can view alarms of equipment and devices while on site or over the ASTRO network infrastructure.
Reliable Communications	The SDM3000 provides reliable communications to the UEM via encrypted SNMP V3.

Feature	Benefit
Intuitive Drill Down Display of Alarms	The UEM incorporates an intuitive “Drill Down” display of alarms: Multi-Zone level, Zone level Map Screen, Site level, Device level, and Alarm level.
Intuitive Representation of Equipment	Chassis view graphics of the equipment are displayed on the UEM and GUI, giving System Technologists and SFPUC Technicians an immediate understanding of the equipment and subcomponent which is in alarm.
Analog Display Screen	Graphical meters display the analog information of the site (i.e., Generator Fuel Level).
Equipment Control Screen	Equipment and devices and be controlled (turned On/Off, Open/Closed) from the control screen.
Immediate Update of Alarm Status	A combination of polling from the UEM and event reporting from the SDM3000 ensure alarm information is displayed on the UEM as quickly as possible.
Auto Archive of Alarms	Alarm information is automatically archived on the UEM server for future access by the Historical Alarm Report tool.
User-Defined Historical Alarm Reports	Historical Alarm data in the SQL database on the UEM can be easily accessed to produce reports with the Report Generator function.
Multiple User Levels	Up to 8 user levels, ranging from Administrator to Guest, allow definition of operational capabilities from system configuration through system control to viewing and acknowledgment of alarms.
Alarm Summary Window	The Alarm Summary Window lists all time stamped alarms and can be sorted by Zone, Site, and Equipment, and by acknowledged/un-acknowledged alarms. This allows users to quickly identify any issues with their system.
Station Values Displayed	Station and Microwave values such as RSSI, BER, RF Power, and VSWR are displayed on the UEM, providing System Technologists with analytical information on the site they are troubleshooting.
Alphanumeric Paging of Alarms	The UEM can send specified descriptive alarm messages to alphanumeric-capable pagers over paging networks such as SkyPager or Skytel.
Client View of Multi-Zone System	Each UEM client can view alarms from the UEM Server, which minimizes the total number of clients needed in the system.

4.2.1.4.2 Configuration Management Applications

Manage Your Networks and Devices in the ASTRO 25 System

This section provides information about the applications that provide configuration management capabilities within the ASTRO 25 network. These devices are the Unified Network Configurator (UNC) and the Provisioning Manager (PM).

Unified Network Configurator

The Unified Network Configurator (UNC) is a network change and configuration management tool that enables users to efficiently manage the configurations of networks and devices in an ASTRO 25 system. The UNC is built on VoyenceControl, which is an automated compliance, change, and configuration management system. The UNC provides a single application for the configuration of all radio system and transport devices. Some of the key features that the UNC provides include:

- Efficient, role-based user setup.
- Auto discovery of devices/configurations, reducing configuration errors and initial configuration time by providing minimal data entry.

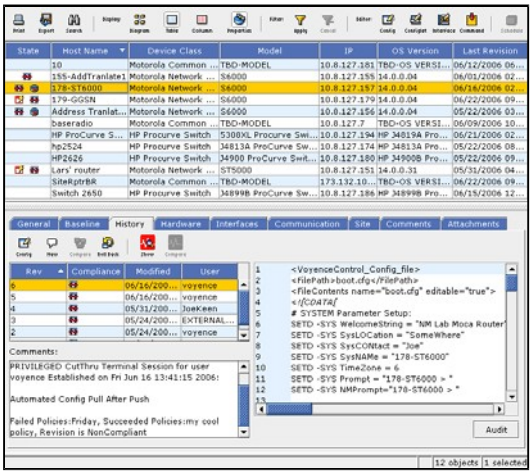


Figure 4-8: Sample UNC Screen

Historical configuration information is easily accessible, along with forensic information and the ability to roll back to previous versions. A valuable tool that the application provides is the ability to create a configuration and not implement it immediately. The UNC allows another user to approve and implement changes, which can help distribute those changes during off hours when system loading is minimal.

The UNC application allows system management personnel to see planned and current configurations simultaneously for quick comparison. This application offers easy editing screens and configuration “wizards” to reduce data entry.

Benefits of the UNC are outlined in Table 4-4.

Table 4-4: UNC Benefits

Feature	Benefit
Built-in Network Tool kit to enable features	Tools provide a methodical process to enable features in the system with minimal labor and chance of error. Examples of these are: turning on authentication on a set of protocols within the Gateways; locking Ethernet switch ports; setting delay; and jitter alarm thresholds.
Auto Discovery of Devices	Components are automatically discovered, and their configurations are added to the database without the need for any manual entry of data.
Scheduled Distribution	Users can determine the time of day when they would like configurations to be sent to the devices, or delay the distribution of a configuration change until approved.
Distribution Monitoring	Allows users to view the status of configuration changes, such as whether the change is in progress, has successfully completed, or has failed.
Change Logging/Audit Trail	Maintains a log of various user interactions with the configuration system that can be used to help diagnose issues.
Configuration Versioning	Constantly tracks and logs versions that have changed and provides the ability to view or compare versions.

Feature	Benefit
Management of Credentials	SSH and SNMP passwords can be managed. Automated mechanism allows seamless password and passphrase rolling, which can be performed automatically if desired.
Wizards for Common Operations	Radio system administrators can perform common operations using a simple web-based interface specifically developed for ASTRO 25 users. Provides an intuitive guide to assist in easy-to-follow setup procedures.
Rollback to Previous Version	Immediately reverts the device configuration to a previously created version.

4.2.1.4.3 Provisioning Manager

Centralized Interface for User and System Configuration

The Provisioning Manager provides a friendly and intuitive graphical user interface which allows an easy method to provision the infrastructure and devices utilized on the ASTRO 25 network.

These applications allow for configuration by authorized users, which adds a level of security. An integrated database enables you to enter data only once, helping to save time and keeping data integrity sound by reducing errors.

- **Streamlined and intuitive web-based graphic user interface**—Utilizes less key strokes to manage critical information. Provides a central point for the configuration of operational parameters: Radio System Subscribers, Console Operator positions, and Management Users.
- **Batch creation of radios and talkgroups**—Allows for previous capability referred to as "Multi-Instance Creation"; which offers convenient mechanisms to minimize data entry and reuse configuration information.
- **Enhanced Agency Partitioning**—System managers are able to define data partitions to partition system management resources among various agencies and users.
- **Advanced Security Features**—Centralized user authentication, single sign on, and role based access controls are supported to provide enhanced Network Security to the system by enabling confidentiality, availability, and integrity of critical data.
- **Provisioning Manager Audit**—Enables stricter enforcement of system policies and provides an efficient way of troubleshooting when identifying misconfiguration issues. The administrator can navigate from an audit record to the corresponding configuration record and vice versa.
- **External Provisioning Manager Interface**—Provides a solution interface that partners with an identified 3rd party vendor (Genesis, MCM, Premier One, NGI) which can provide an integrated solution. Offers convenient mechanism to utilize critical customer applications on the system. Provides capability of integrated solution with Asset Management, Billing, and Fleet Mapping applications.
- **Radio and Radio User fields have been combined into one window**—Efficient management of subscriber provisioning by reducing the need to enter device information multiple times. Estimated time spent in maintaining subscriber configurations would be significantly reduced.

- **Import/Export Capabilities**—Offers a convenient mechanism to export and import data from external applications via .csv protocol.

4.2.1.4.4 Performance Management Applications

Monitor, Manage and Report on System Performance

The Motorola performance suite enables a customer to monitor, manage, and report on system performance in near real-time. The applications empower system managers to proactively plan for expansion. The performance suite is composed of both Motorola and third-party solutions that are all certified, sold, and supported by Motorola. Each application has a unique set of features and benefits to facilitate efficient and effective system management. Together, these applications complete the big picture: how the system is performing, operating, and being used, by providing insight into the activity of each zone, site, subscriber, or talkgroup.

Motorola offers Performance Management as a standard feature of ASTRO 25 systems. Standard features include ZoneWatch, Historical Reports, and Dynamic Reports and enable customers to manage their communications system business more efficiently. ZoneWatch displays real-time communications activity, while Dynamic and Historical reports collect traffic statistics over predetermined intervals for report generation. These applications are used to monitor, collect, log, and evaluate network performance and resource utilization; they collect statistics about radio resource usage for radio units, talkgroups, channels, sites, zones, and system-wide activity report generation. Dynamic and Historical Reports have archival and export features for saving reports for offline data analysis. Statistics are aggregated into detailed and summarized reports on both an individual zone and system-wide basis.

Additionally, Motorola offers enhanced Performance Management features for ASTRO 25 systems, which are described below. Enhanced Performance Management features are available to provide further insight into system performance. Applications perform a variety of tasks, such as polling system resources, detailed reporting, long-term archiving and logging, and data stream collection.

Dynamic Reports

Dynamic Reports monitor and report usage trends in order to improve radio and talkgroup system management. System managers can closely examine what happens during a shift or set period of time: for example, checking the busy count to see if calls are being missed. Dynamic Report recommendations can be made on system expansion and design to improve communication.

Historical Reports

Historical Reports generate reports on system-wide activity as well as individual zone activity. The reports contain statistical data gathered at specific, predefined time intervals. They monitor and analyze information about zones, sites, channels, talkgroups, and users to assist a system manager in understanding how the system is performing; they are utilized to more efficiently manage resources. Individual reports cannot exceed 16,000 objects (radio users, talkgroups, etc.). Reports can be exported to CSV, HTML, PDF, and XML formats. Table 4-5 outlines the features and benefits of Historical Reports.

Table 4-5: Historical Reports Features and Benefits

Feature	Benefit
Real-Time Display	Monitor and analyze information about zones, sites, channels, talkgroups, and users to understand how the system is performing and utilized to more efficiently manage resources.
Reports	Create various types of reports at the zone or system level, organized by system resources to analyze activity and performance.
Data Intervals	Historical data is stored in time-based intervals. For each interval type, the oldest interval in storage is removed as a new interval is added to storage. The timed intervals are defined as follows: • Every 15 minutes for 100 intervals (approximately one day; zone level only). • Hourly for 241 intervals (approximately 10 days; system and zone level). • Daily for 62 intervals (approximately 2 months; system and zone level). • Monthly for 36 months (3 years; system and zone level).
Accessing Data/Data Exporting	Users can utilize the Report Scheduler window to schedule zone-wide and system-wide reports to occur at specified times, with an output to a printer or data file. Reports can be exported to one of the following formats: • Comma Separated Values (CSV). • HTML. • Adobe Portable Document Format (PDF). • Extensible Markup Language (XML).
Data Storage	Statistics are aggregated into detailed and summarized reports on both an individual zone and system-wide basis; they are available on an hourly basis for 10 days, daily for 62 days, and monthly for 1 year.

Radio Control Manager

The Radio Control Manager (RCM) is used primarily by dispatchers to monitor and manage radio events, issue and monitor commands, and make informational queries of the system database. The RCM runs on a local PC client and, depending upon the configuration in the Provisioning Manager (PM), can access multiple zones. Features and benefits are outlined in Table 4-6.

Table 4-6: Radio Control Manager Features and Benefits

Feature	Benefit
Radio Commands	• Regroup. • Cancel Regroup. • Selector Lock. • Cancel Lock. • Regroup and Lock. • Cancel Regroup and Lock. • Selective Inhibit. • Cancel Inhibit. • Storm Plan.
Status Commands	• Radio check. • Snapshot. • Zone Status.

Feature	Benefit
Events	ĩ Emergency Alarms. ĩ ChangeMe Requests. ĩ Status Events.
Reports	The RCM Reports tool is used to create, view, print, schedule, and export standard reports from RCM. These reports use a common format so the data can be used in spreadsheets. The report information reflects the actual RCM server database information, except the Emergency Alarms. RCM Reports enables you to present and analyze data showing RCM activity on the system.

Zone Watch

ZoneWatch is a performance management tool that has customizable displays and grids to monitor real-time communications activity in a single zone (Figure 4-9). The information displayed can help system managers become proactive in making better resource planning decisions, such as when additional channels need to be added.

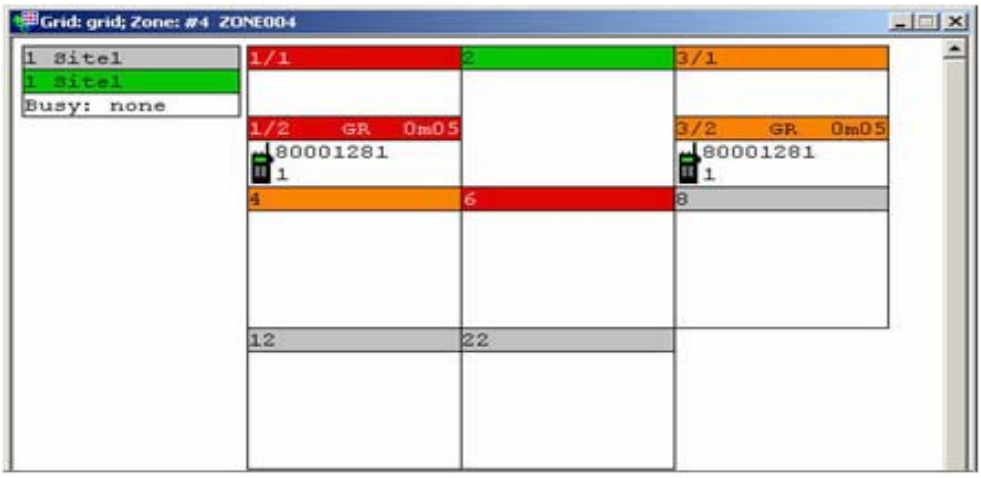


Figure 4-9: Sample ZoneWatch Screen

ZoneWatch also receives fault information related to repeater sites, console sites, and the zone controller from the UEM. ZoneWatch is used to monitor call traffic and allows the system manager to organize displayed information using various criteria.

Single Site View, Channel View, and Multisite view display all important radio call information. This provides the manager with insight about radio call activity, channel usage activity, and busy activity, to more efficiently manage the radio system.

4.2.1.5 System Structure and Components

Understanding the ASTRO 25 Core and Components

Motorola's ASTRO 25 has a solution for all public safety organizations. Rather than providing out-of-the-box technology, ASTRO 25 offers several features to customize cutting-edge, industry standard communication tools for your organizational needs.

Beginning with your Master Site and Network Transport Subsystem, ASTRO 25 can be configured in Trunking or Conventional Sites. With Motorola's ASTRO 25, you have access to the very best in communications technology to improve efficiency and ensure the safety of your users.

The system is comprised of:

- Master Site (DEM).
- Network Transport Subsystem.
- ASTRO 25 Sites.
- System Components.

4.2.1.5.1 Master Site (DEM)

Call Processing & System Management

MAINTAIN CONSTANT COMMUNICATION BETWEEN ALL SITES & NETWORK

The master site is the central point for all system traffic in each ASTRO 25 zone. Call processing and system management occur at the master site. The Voice and Data call processing for each zone is performed by the redundant Zone Controllers. The Zone Controllers maintain constant communication between the RF Sites, Simulcast Sites and Network Management (NM) sub-systems via the Network Transport Subsystem.

A zone has a master site that contains the computing backbone for that zone. The master site contains all the components necessary for controlling calls within a zone and for communicating with other zones to manage InterZone calls in a multi-zone system. In addition, the master sites provide the hardware and software components that are used for Network Management and system configuration.

All the components that communicate over Ethernet are connected through a central switch called the master site Ethernet LAN switch. This switch provides two separate internal LANs which are integrated to provide redundant links for critical network traffic.

The zone controller is used to process system-wide commands and handle call processing and mobility management functions for the system. In systems like San Francisco's with two zone controllers, there is a connection from each zone controller to the LAN switch and a direct connection between the two zone controllers. The LAN switch connection allows each zone controller to communicate with the gateway routers/Core Gateways.

Network Transport Subsystem

The ASTRO 25 transport core is engineered to meet the performance requirements of a real-time system transporting voice, call control, network management, and ancillary network services. The Transport Network is a closed network. Only Motorola-supplied equipment, applications, and services can be used on the core and site networks.

IP encapsulation across the customer-provided backhaul network is used to transport Radio Network Interface (RNI) traffic. In addition, Quality of Service (QoS) can be used to distribute voice packets to provide a constant and steady delivery of packets from the source to the destination.

Ethernet Switch

The Enterprise Ethernet Switch (LAN Switch) is used to aggregate all the Ethernet interfaces for all servers, clients, and gateways.

Core Gateway

The core gateway interfaces to the core LAN, providing layer three routing and protocol conversion between the core IP devices and the remote site IP devices.

Site Gateway

The site gateway interfaces to the remote site LAN via one Ethernet connection, and provides layer three routing and protocol conversion between the remote site IP devices and the core site IP devices.

Redundancy

To ensure system availability, the Transport Network provides:

- Redundant Ethernet switches.
- Redundant routers.

4.2.1.5.2 ASTRO 25 RF Sites

ASTRO 25 RF sites provide communications for radio users and dispatch operators on the ASTRO 25 network. RF Sites may include ASTRO 25 repeater sites, simulcast cells, and ASTRO 25 conventional channel sites.

The RF Site types applicable to this system design are described briefly in this section.

ASTRO 25 Repeater Site

An ASTRO 25 Repeater Site (Figure 4-10) consists of a single site with up to 28 channels and two site controllers (in a redundant configuration), which can be standalone or housed in a GTR 8000 Expandable Site Subsystem (ESS).

UP TO 28 CHANNELS AND 2 SITE CONTROLLERS MANAGED FROM A SINGLE LOCATION

The GTR 8000 Expandable Site Subsystem in a repeater site is set up in a single trunked site, with one active control channel and a number of voice channels at the site. If packet data services are supported at the site, a number of voice channels can be configured with packet data channel capability. Voice traffic is routed from each of the base radios to the system for distribution to other sites and is repeated by the base radios to support other local subscribers. However, data traffic is routed to the GCP 8000 Site Controller. The site controller routes these packets upstream to the zone controller for further processing and routing.

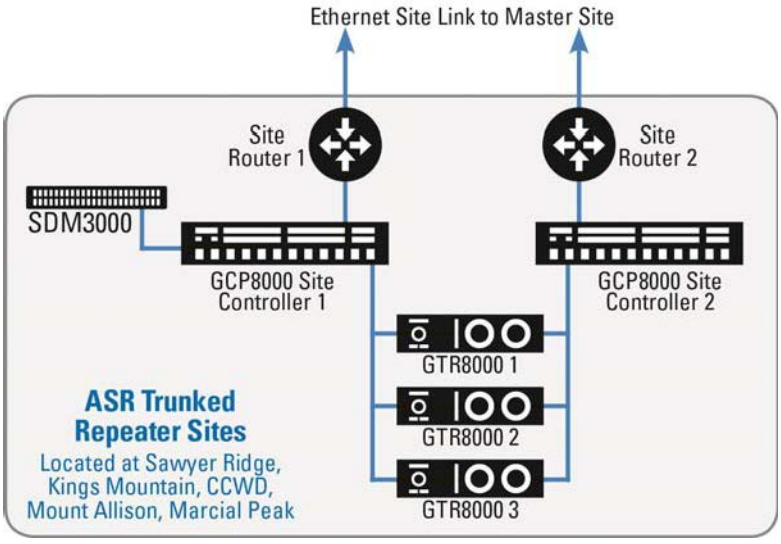


Figure 4-10: ASTRO 25 Repeater Site

The ASTRO 25 Repeater Site consists of the following components, described in the Component Descriptions section of this System Description:

- GTR 8000 Expandable Site Subsystem (ESS):
  - GTR 8000 Repeater/Base Radio.
  - GCP 8000 Site Controller.
  - Radio Frequency Distribution System (RFDS).
- GGM 8000 Site Gateway.

Simulcast Sites

A simulcast land mobile radio system provides continuous coverage over a large geographic region using a single set of frequencies. Simulcast solutions extend a system's RF coverage, especially in areas where available frequencies are limited, and in areas where physical barriers (e.g., mountains and buildings) can cause reduced signal coverage.

IMPROVED COVERAGE, EFFICIENT USE OF FREQUENCIES & SIMPLIFIED RADIO OPERATIONS

Trunked simulcast was developed by Motorola to meet the needs of users who were outgrowing their single-site radio systems. Simulcast offers the following advantages:

- ***Improved Coverage***—One radio site may not provide the coverage necessary for the application in question. Simulcast expands the coverage area by expanding the number of radio sites without adding additional frequencies.

- ***Efficient Use of Frequencies***—Adding sites typically requires more frequencies. In a simulcast system, the same frequencies are used at every site in the system. This makes very efficient use of the available spectrum.
- ***Simplified Radio Operations***—Because the simulcast architecture operates like a single-site system, operations are simplified and radios are easy to use.

The ASTRO 25 simulcast infrastructure consists of a central simulcast prime site and up to 32 distributed simulcast remote sites, each with up to 30 channels (Figure 4-11). The prime site acts as a control and digitized audio center for the simulcast subsystem. Audio is routed to the prime site from each simulcast remote site. To ensure that the best audio from the simulcast receivers is processed, a voting comparator selects the best signal.

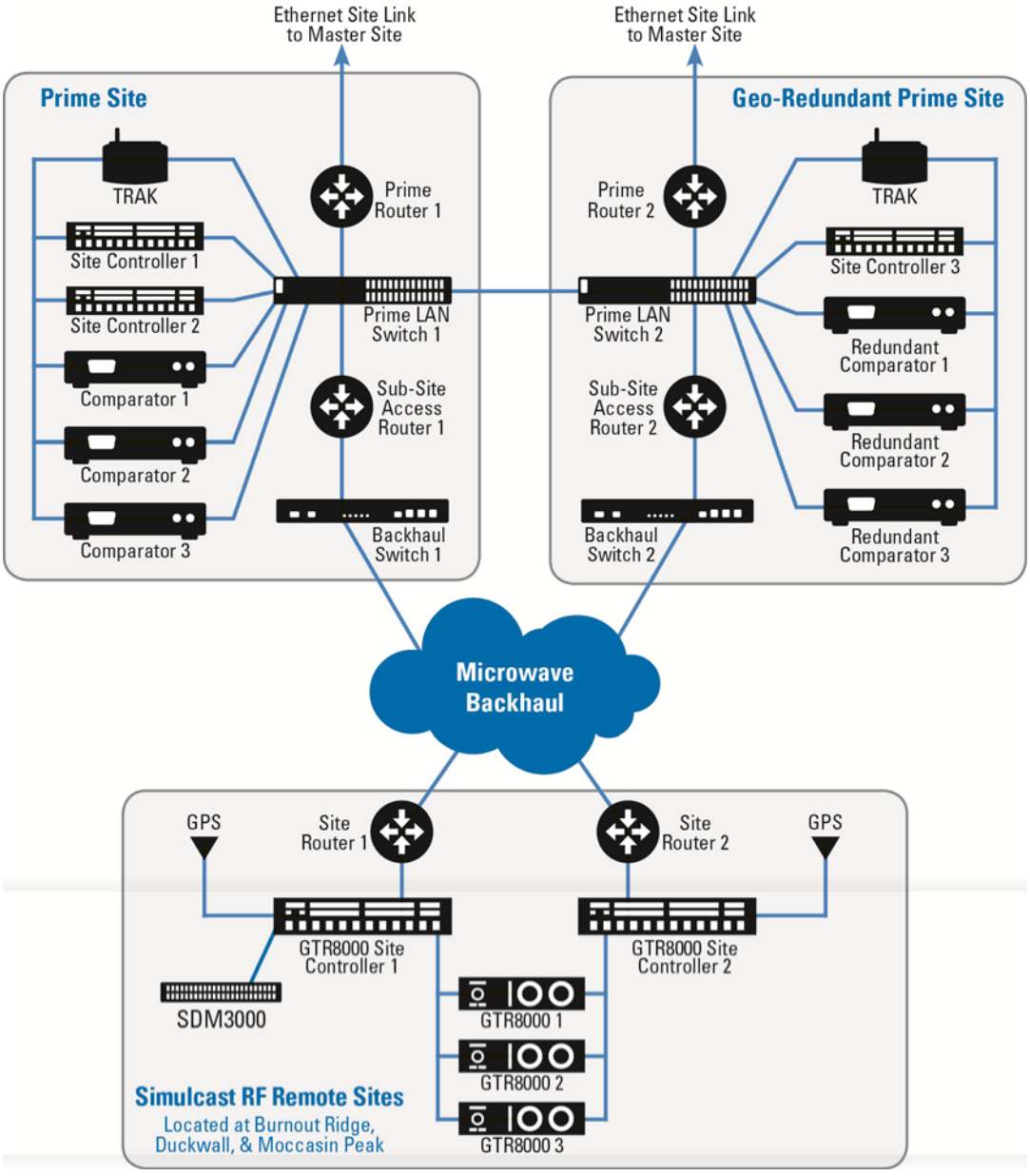


Figure 4-11: SFPUC ASTRO 25 Simulcast Prime System

The prime site contains the prime site simulcast controller, simulcast comparators, and networking equipment to interface to the remote simulcast sites. The simulcast RF transmitters and receivers are located at the simulcast remote sites. These sites simultaneously transmit identical information from each site to the radios. The receivers at these sites receive the audio from the user radios, and pass the audio back to the prime site for voting. Audio and site control comes from the prime and master sites. Equipment at a simulcast remote site includes a simulcast base radios, fault management equipment, and networking equipment to interface to the prime site.

Simulcast Prime Site

The ASTRO 25 Simulcast Prime Site consists of the following components, described in the Component Descriptions section of this System Description:

- GCP 8000 Site Controller.
- GCM 8000 Comparator.
- GGM 8000 Site Gateway.
- TRAK 9100 Simulcast Site Reference.
- Sub-site Access Router.
- Prime Site Ethernet Switch.
- Sub-site Ethernet Switch.

Simulcast Remote Site

The ASTRO 25 Simulcast Remote Site consists of the following components, described in the Component Descriptions section of this System Description:

- GTR 8000 Expandable Site Subsystem (ESS):
  - GTR 8000 Repeater/Base Radio.
  - GPB 8000 Site Controller and GPS Signaling
- GGM 800 Site Gateway.
- Radio Frequency Distribution System (RFDS).

ASTRO 25 Conventional Sites

ASTRO 25 systems are multifunctional communications systems which provide capabilities for trunked-only, trunked and conventional, and conventional-only operations. ASTRO 25 conventional systems with IP connectivity to dispatch and RF sites allow for the expansion of the system to include conventional sites.

A CUSTOMIZABLE PLATFORM FOR YOUR RADIO COMMUNICATIONS NEEDS

Today's conventional systems meet Federal mandates for narrowbanding, interoperability, and IP connectivity. They enable features such as text messaging and end-to-end encryption that help first responders do their jobs safely and effectively. To answer the needs of agencies that are ready to modernize their conventional radio systems, Motorola offers a selection of conventional solutions that are sized right, priced right, and future ready.

The ASTRO 25 core provides a platform to manage the entire network. It supports users communicating across analog, mixed mode, and P25 digital RF channels. Motorola offers choices in core configurations scalable to fit agencies of all sizes. On an IP-based network, the central core server provides call management between conventional stations and console positions. New functionality, including fault management and security, also resides in the core.

The ASTRO 25 platform supports a wide range of channel types and coverage methodologies, giving customers maximum flexibility to integrate different types of equipment. Customers can select the channel and coverage types and price points to meet their needs.

Channel Types:

- Analog 4-wire.
- Mixed Mode—Analog/P25 Digital.
- P25 Digital V.24.
- P25 Digital over Ethernet.

Coverage Types:

- Repeater.
- Voting.
- Multicast.
- Simulcast.

An ASTRO 25 IP core provides a full-featured suite of system management applications to monitor, manage, and configure elements across your entire radio system, including the ASTRO 25 Conventional Channels. Centralized management helps you fine-tune network performance, minimize costly field visits, and keep the system running with minimal effort from your administrative staff. This has a big impact on your total cost of ownership, helping you get the best return on your investment.

4.2.1.5.3 Components

Each site type in an ASTRO 25 system contains various components. Components included in this system design are described in this section.

GTR 8000 Expandable Site Subsystem

The GTR 8000 Expandable Site Subsystem (ESS) enclosure can contain GTR 8000 base stations, site LAN switches, and GCP 8000 controllers, along with a Radio Frequency Distribution System (RFDS), depending on your configuration needs.

Voice traffic is routed from each of the site base stations to the system for distribution all sites associated with the call. Benefits of the ESS include:

- Integrated design provides a smaller footprint at the site.
- Front/top access design and minimized cabling reduces install and service labor.
- Increased power supply redundancy through common power bus.

GCP 8000 Site Controller

The GCP 8000 Site Controller (GCP 8000) is the control interface between the transmitter/receiver subsystem and the Zone Controller. The GCP 8000 Site Controller comprises redundant site controller modules; one site controller module acts as the active module, and the second module acts as a standby. The redundancy minimizes the possibility of a single point of failure at the site.

The GCP 8000 provides the following functions:

- Manages the channels to maximize throughput and channel availability.
- Administers registration and context activation requests.
- Monitors base stations and RF distribution equipment and interacts with the MOSCAD site device manager to facilitate centralized alarm and control monitoring.

- Provides redundant site control.
- Enables redundant site link routing for patch redundancy.
- Acts as the network hubs for the sites.

Additionally, the GCP 8000 provides the following functions at the simulcast site:

- Provides a time and frequency reference signal to the base stations, maximizing frequency stability and allowing for further site separation in a simulcast configuration.
- Provides IP simulcast capability, enabling true end-to-end IP connectivity in a simulcast configuration.

GCM 8000 Site Comparator

The GCM 8000 Comparator ensures the broadcast of the best possible voice signal by combining the best parts of a single signal that has been received by multiple sites in a Multisite (simulcast) system.

The comparator features a digital voting methodology: Frame Diversity Reception. The comparator selects the data frame or signals with the lowest Bit Error Rate (BER) and forwards it. By using the best pieces of each input signal, the result is the best possible composite signal.

GTR 8000 Site Repeater/Base Radio

The GTR 8000 Base Radio consists of a transceiver module, power amplifier module, fan module, and power supply. The transceiver module includes the functionality for the exciter, receiver, and station control. The base radio software, configuration, and network management, as well as inbound/outbound traffic handling, are performed through this transceiver module. On-board serial and Ethernet ports are located on this module for local servicing via CSS. The power amplifier module amplifies the low-level modulated RF signal from the transceiver module and delivers the amplified signal on the path to the transmit antenna. The power supply module supports the transceiver and power amplifier modules, and can also provide auxiliary power to a connected site controller or Receive Multicoupler/Low Noise Amplifier (RMC/LNA).

Radio Frequency Distribution System

The Radio Frequency Distribution System (RFDS) provides interconnect between the base radios and antennas, allowing for a completely contained and more compact installation footprint. For the transmitters, this can include isolators, combiners, TX filters, diplexers, and power monitors.

RF Site Gateway

The Site Gateway provides an interface that handles all of the IP Network Management traffic between the Core Site and the RF Site. The Site Gateway provides the following:

- Media conversion—the gateway converts Ethernet to the selected transport medium.
- Traffic prioritization—the gateway applies a prioritization marking to the packets leaving the site.
- Fragmentation—the gateway fragments large IP packets per industry standards.

Site LAN Switch

The site LAN Switch provides a LAN interface for site equipment and a LAN port for the site gateway. Through the switch, the service technicians gain access to service the site, and also access the system's Graphical User Interface (GUI).

TRAK 9100 Simulcast Site Reference

The TRAK 9100 Simulcast Site Reference is a GPS-based frequency and time reference. The TRAK frequency reference provides the simulcast system 1 PPS (Pulse per Second), 5 MPPS, and 1 PPS + 5 MPPS composite signals. These signals are used to synchronize the transmission of a simulcast system to improve overall performance and coverage.

This unit provides a high-level redundancy, including redundant GPS receivers, backup rubidium standard, and redundant power supplies.

Sub-Site Access Routers

The sub-site access routers, located at the prime site, provide the IP network routing interfaces between the prime site and all of the sub-sites. In the single sub-site link configuration, two sub-site access routers are deployed in a cooperative WAN routing arrangement for T1/E1 subsystems. In the dual sub-site link configuration, two sub-site access routers each serve as the endpoint for one of the sub-site's WAN links. The sub-site access routers support T1, FT1, E1, FE1 and Ethernet sub-site links.

Note that the total number of access routers utilized at a trunking IP multi-site subsystem depends on the number of sub-sites. IP multi-site subsystems with 15 or less sub-sites require two access routers. Subsystems with more than 15 sub-sites, however, require two access router pairs (i.e., four access routers) where each access router pair can support up to 16 sub-sites.

Prime Site Ethernet Switches

Two paired Ethernet switches form the prime site LAN in an IP multi-site subsystem. They are paired for redundancy so if one of them fails, half of the hosts (site controllers, comparators) on the LAN are still connected to a working Ethernet switch. In addition to these switches, a third Ethernet switch is required for IP multi-site subsystems equipped with more than 15 sub-sites. For this configuration, all four access routers will have their LAN 2 ports connected to the third Ethernet LAN switch (crossover Ethernet cable is no longer utilized). It should be noted that although the third switch provides additional available ports, these ports should not be utilized for devices affecting critical services (e.g., comparators).

In the dual prime site link configuration, there are two prime site routers, each of which is attached to a different prime site LAN switch. This ensures that if either switch fails, there is still a path to a prime site router for connectivity to the master site.

Sub-Site Ethernet Switches

There may be either one or two Ethernet switches at the sub-site to form the sub-site LAN. In a single sub-site link configuration, only one switch is used unless a second switch is needed to provide enough port capacity for all of the hosts at the sub-site. In a dual sub-site link configuration, two switches are used so that there is no single point of failure for the sub-site's entire IP network.

4.2.2 MCC 7100 Solution Overview for SFPUC

Motorola's dispatch solution for SFPUC is our MCC 7100 Dispatch Console, offering IP-based seamless connectivity between SFPUC dispatch operators and field personnel.

The MCC 7100 Dispatch Console will provide SFPUC with a scalable, flexible system architecture, sophisticated network management and security, and an easy migration to future capabilities.

At the Moccasin dispatch, Motorola has included the firewall and proxy server. This will provide SFPUC with the ability of locating dispatch position equipment outside of the dispatch network.

Cost Savings and Ease of Use

The MCC 7100consoles are designed to help reduce the total cost of owning an IP-based, feature-rich dispatch system without compromising quality and reliability. Specific benefits of the MCC 7100 consoles include the following:

- The intuitive, easy-to-use Graphical User Interface (GUI) **enhances dispatchers' efficiency and accuracy**.
- Robust API **allows CAD systems to have complete access to console status and features** for further improvements in efficiency and accuracy.
- **Software-based upgrades** facilitate system and feature expansion.
- Console **configuration is performed at centralized Network Management clients**, and **changes are automatically distributed**, which saves valuable technician and administrator time.
- Offers **robust service logs that contain real-time information** to facilitate maintenance activities.
- Consoles within the ASTRO 25 dispatch site are **integrated into the ASTRO 25 fault management system**, which uses industry-standard event monitoring protocols, resulting in fewer dispatch site visits.
- **Flexible bandwidth requirements** minimize operating costs for remote console sites.
- **Conventional audio can be transported over the IP network**, which eliminates the need for channel banks or a separate circuit-switched network.
- A tiered licensing model offers a **scalable approach to audio capacity needs**.

MCC 7100 Console Configuration for the SFPUC

The SFPUC system offers SFPUC Eleven (11) total MCC 7100 Dispatch Consoles at four different locations to interface with the San Francisco ASTRO 25 system and communicate on the SFPUC sites (Figure 4-12). Table 4-7 outlines the number of consoles and their location.

Table 4-7: Console Operators and Their Locations

Number of Operator Positions	Location
3 MCC 7100	El Camino Real
2 MCC 7100	PUC
5 MCC 7100	Moccasin Dispatch (3 Power, 2 Water)
1 MCC 7100	Kirkwood Power House

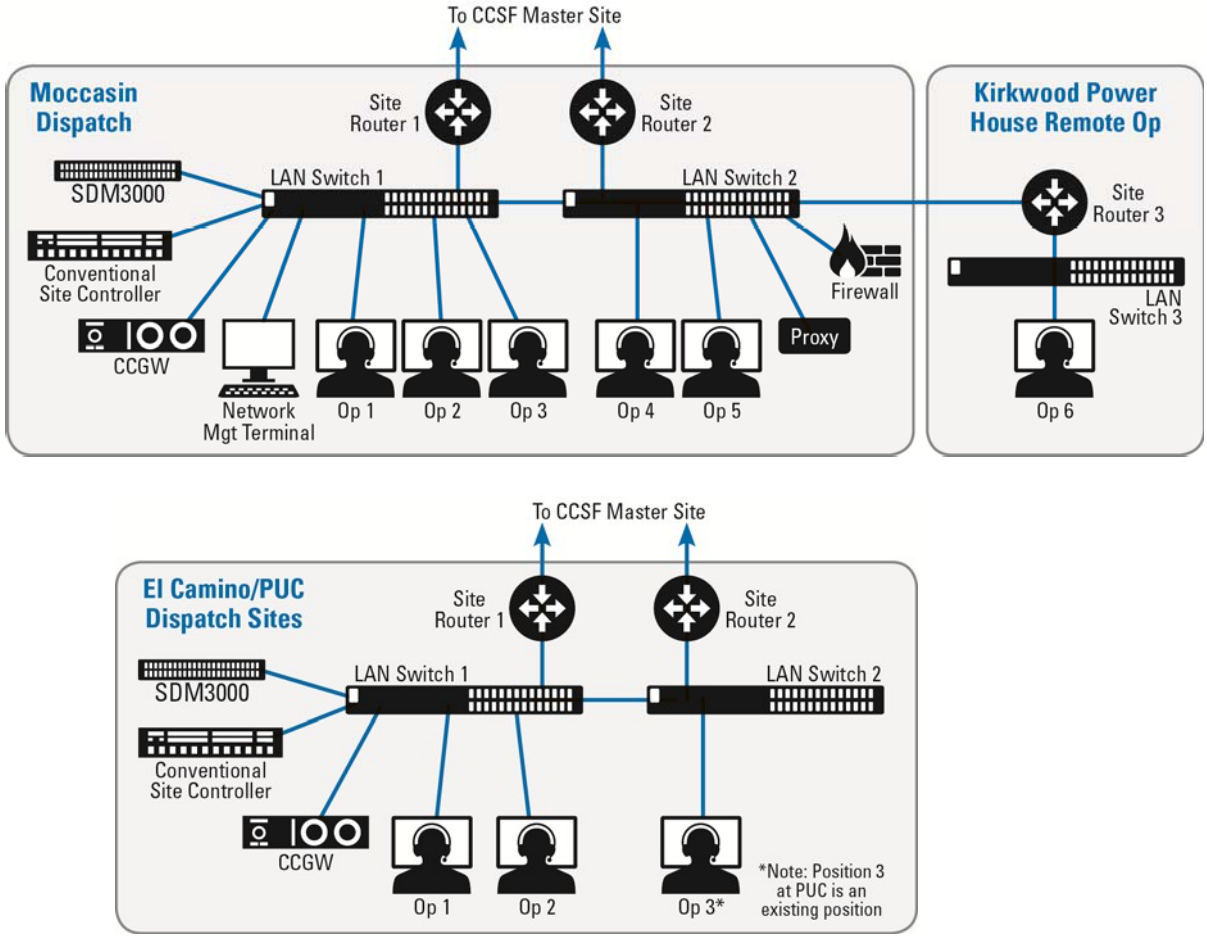


Figure 4-12: Radio System Infrastructure with Motorola MCC 7100 Consoles Block Diagram

4.2.2.1 The MCC 7100 Dispatch Experience

The MCC consoles offer SFPUC state-of-the-art communications, console management and configuration functionality, dispatch operation, and communications security.

The SFPUC system also offers SFPUC the capability to maintain both audio and data recording of the calls made on the communications system.

4.2.2.1.1 Interoperability Features

ASTRO 25 is specifically designed around APCO P25 standards. All voice messages are digitized, all Land Mobile Radio (LMR) system features are compliant with P25 standards, and the system uses the P25-defined, 9600-bps control channel format for all control channel

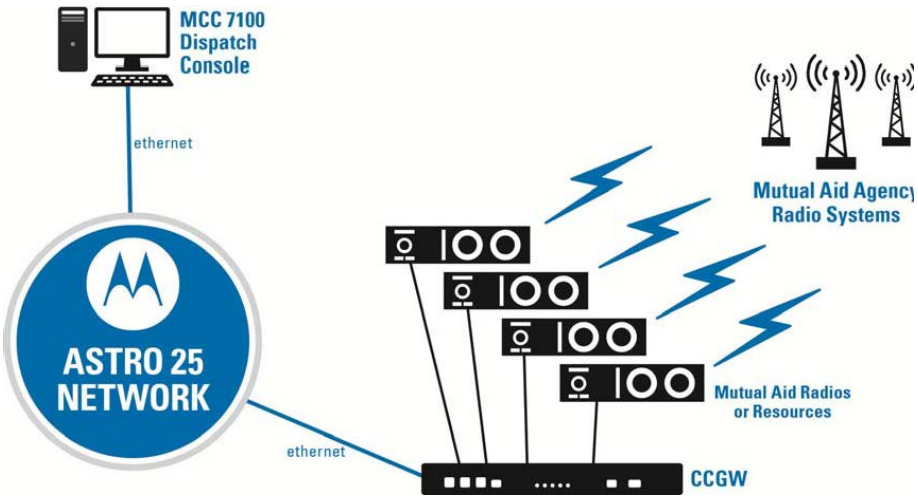
commands. As part of ongoing enhancements to this solution, Motorola has joined and actively participated in the P25 interoperability committee to ensure continuously improving interoperability with the radios of other P25 vendors. ASTRO 25 is also fully Common Air Interface (CAI) compliant.

MUTUAL AID INTEROPERABILITY OFFERS FLEXIBILITY AND FUTURE EXPANSION.

l Gateway (CCGW) forms the bridge between the MCC7100
radio network and conventional radio resources, including
ner to patch together conventional radio resources and
as situations dictate. Each GGM 8000-based CCGW can
eight V.24 ports, plus 10 IP-based Mutual Aid channels.
er site for seamless communications with various agencies.
r console
to the MCC 7100consoles. CCGW interfaces can be
here is network connectivity back to the Zone Core.
dded anywhere on the LMR IP network as requirements change.

Figure 4-13 is an example of Mutual Aid conventional radios connected on the system through CCGWs.

Figure 4-13: Mutual Aid Components



Integration with the ASTRO 25 Network

THE MCC 7000 SERIES CONSOLES' IMPROVED USE OF BANDWIDTH ENSURES THAT EMERGENCY CALLS WILL MAKE IT THROUGH TO THE DISPATCH OPERATOR, REGARDLESS OF SYSTEM TRAFFIC.

atch Console will be seamlessly integrated into San Francisco's
out interface boxes, digital voice gateways or backroom
ated mission critical network. This tight union between radio
tch console equipment has several operational benefits to

ch substantially reduces the amount of space needed for backroom
activity is performed over IP. The physical space needed to
7100 console position is comparable to that required for a personal

enefits of the MCC 7100's seamless integration to the ASTRO 25

Table 4-8: Benefits of Seamless Integration of the MCC 7100 IP Console with San Francisco's ASTRO 25 Network

Feature	Benefit to SFPUC
Tight coordination between the IP network and IP console eliminates the potential for audio degradation.	Subscribers and console operators will be able to communicate without loss of information.
Emergency calls are prioritized for successful delivery regardless of network traffic.	Console operators will always be able to hear emergency calls from users in the field.
Inherent access to all system resources within the network provides dispatch priority to reach any user	Console operators will always be able to reach out to users in the field.
Rapid call set up times and quality of service, regardless of the size of the system.	The ability to scale the system to handle future capacity, while maintaining efficient dispatch operations.
True end-to-end encryption capable from the subscriber to the console operator position, enhancing operational security	Assurance that sensitive, private communications will remain secure, from the user in the field to the console dispatch operator.
Improved bandwidth efficiencies reduce transport costs.	Ongoing cost savings for SFPUC.

Connection to ASTRO 25 System

Details on the connectivity between the MCC 7100 dispatch console and the ASTRO 25 system are described below.

Dual Site Link

The MCC 7100 console site for SFPUC is remote from the core site and is provided with redundant site links to provide path diversity. The console site has two logical connections to the core site with each connection using a different core router. Each console site gateway provides an interface that handles all of the IP Network Management traffic between the MCC 7100 console center and San Francisco's ASTRO 25 system core site. The site gateways fragment

large IP packets according to industry standards, prioritize packets, and convert Ethernet data to the desired transport medium.

LAN Switches

The redundant site LAN switches provide LAN interfaces for dispatch site equipment and LAN ports for the link to the core site. Through the switches, service technicians can access the system's configuration manager and service the equipment.

Supported Console Deployment Sites

The MCC 7100 console can be deployed at the following sites:

- A console site inside the ASTRO 25 Radio Network Infrastructure (RNI).
- A conventional subsystem site inside the RNI.
- A customer network with access to the RNI through the Control Room Firewall.
- A public network (Internet) with access to the RNI through the Control Room Firewall using a VPN firewall on SFPUC's network.

Advanced Conventional

This feature, included on the SFPUC consoles, provides the dispatch operator the ability to control ASTRO 25 conventional channels and/or MDC 1200 channels.

Agency Partitioning

With Agency Partitioning, SFPUC agencies will gain the interoperability benefits of being on the same system with San Francisco, be able to leverage cost savings in the maintenance of a shared system, and still maintain control of their own console configurations, channels, and encryption keys when applicable.

The Agency Partitioning feature enables SFPUC's system administrators to control who has access to functionality for the console network as a whole. It controls access for conventional RF channels, trunking talkgroups, auxiliary I/Os, pre-programmed pages, encryption keys, and configuration data. Agency Partitioning helps keep an agency's resources available for its users, while preventing unauthorized people from accessing or modifying the network configuration.

Conventional Base Station Interfaces

The MCC 7100 consoles are capable of accessing and controlling analog and digital conventional base stations through the use of conventional channel gateways (CCGW). This capability lowers SFPUC's cost of ownership in two-ways:

- It uses the same transport network, reducing the requirements for dedicated backhaul.
- It reduces the hardware requirements for interoperability, lowering fixed network equipment costs.

The dispatch console processes audio received from the station, and controls various features on the stations, such as frequency selection, private line selection, and repeater on/off.

4.2.2.1.2 Console Operations

The MCC 7100 dispatch console is designed to provide mission-critical audio between the dispatch console and users in the field. It is optimized for real-time audio, prioritizing emergency calls over other traffic, minimizing voice queuing, and transmitting calls in 450 milliseconds or less.

Using robust error mitigation to maintain call quality, even when the system is heavily loaded,

the MCC 7100console reduces communication errors that may force dispatch console operators to repeat their transmissions.

Dispatch Interface

The MCC 7100 console's graphical user interface (GUI) optimizes user efficiency. It is designed to display the maximum number of resources a dispatch operator is able to easily view and control. SFPUC can customize the MCC 7100 GUI by agency or by individual user to meet their dynamic needs and requirements.

Elite Dispatch Graphical User Interface

An example of the MCC 7100 GUI is shown in Figure 4-14.

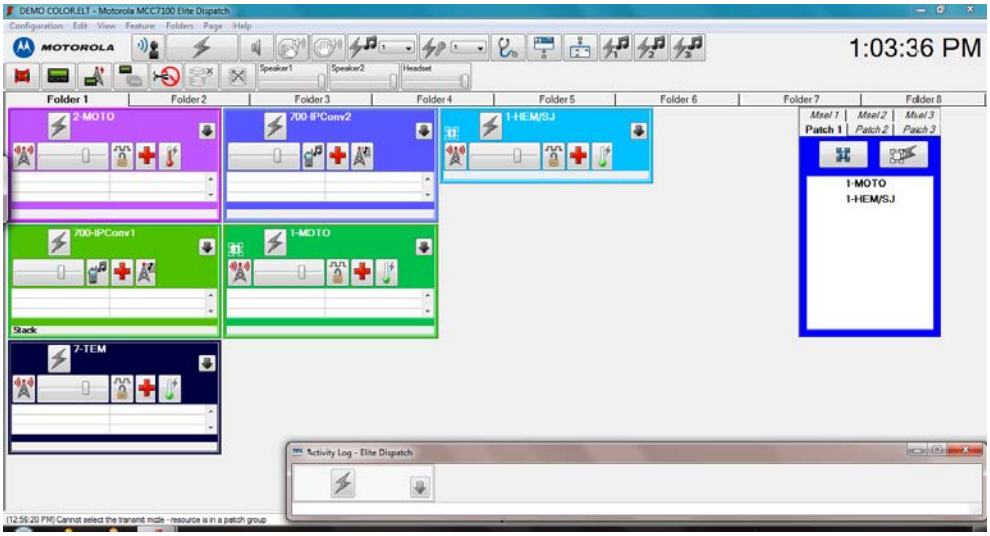


Figure 4-14: The MCC 7100 GUI delivers critical real-time information is delivered to the console operator when and where they need it.

Based on operator preference, the MCC 7100GUI can be customized to show details of trunked and conventional RF channels on a per-channel basis. Various controls can be highlighted, such as patch status, frequency select, coded/clear select, and individual volume control. Per- channel controls can be fully or partially shown, or hidden to save space on the screen. Busy dispatch operators can respond to a missed call by simply clicking on an entry in the Activity Log. The number of calls and call information displayed in the Activity Log is customizable to suit the needs of the user. The status of auxiliary inputs and outputs can be conveniently interpreted from the GUI with the use of familiar graphical icons, such as a door shown open or closed.

Standard Radio Transmission and Reception

A typical MCC 7100 console has two speakers, one for selected audio and the second for all remaining unselected audio. Additional speakers can be added to the console, allowing dispatch operators to configure a specific speaker for a set of designated audio sources. This simplifies multitasking between multiple audio sources, allowing flexibility in the way the audio is presented to the dispatch operator.

Receiving Calls from the Field and Other Dispatch Operators

Dispatch operators have great flexibility as to how to hear calls from field radio users and other dispatch operators. Each console dispatch operator can define his or her own audio reception profile. They can select a single conventional audio source to be heard on a selected speaker ("Single Select"). The dispatcher can also define groups of radio resources that can all be heard on a selected speaker ("Multi-Select").

Initiating Calls to the Field and Other Dispatch Operators

The dispatch operator has several different ways of initiating a call. In most circumstances, a "General Transmit" is appropriate. With the general transmit, the dispatch operator selects a resource on the console and activates the transmission through a footswitch, headset transmit button, or a microphone transmit button.

If the dispatch operator needs to quickly transmit on a resource, they use the "Instant Transmit" function, which activates the resource regardless of whether it is selected. To prevent accidental activation of "Instant Transmit," it can be limited through an "Instant Transmit Safety Switch," which must be pressed prior to activation of "Instant Transmit."

Making Calls to the Field and Other Dispatch Operators

The dispatch operator can transmit audio in different ways, depending on who they need to speak with and how important that communication is. Essentially, they can make calls to all users listening to a specific conventional radio resource. When multiple resources are required, the operator can select additional conventional channels as needed for the call using the multi-select feature.

The MCC 7100 console enables dispatch operators to make private calls to individual field radio users or dispatch operators. Once this private call is established, it can be patched in with another resource at the dispatch operator's discretion.

Controlling Console Audio

The MCC 7100 consoles offer the operator several different ways of controlling or muting the audio on their console. The operator can change the audio volume of any specific resource routed to a selected speaker and, if they desire, can mute and un-mute all non-selected resources on the console ("All Mute") for 30 seconds.

The console enables the dispatcher to transmit on a resource while receiving audio from other resources. It also can prevent acoustic feedback when a co-located operator position transmits by muting the transmitting operator position's audio on a shared resource.

Controlling Network Audio

Dispatch operators can control the audio on the ASTRO 25 network. Using the console, the operator can enable or disable radio users in order to compartmentalize traffic, reduce interruptions, and maintain communications between dispatch and the field. When this function is enabled or disabled, all dispatch consoles with this resource assigned are updated with the current status of the feature. This feature can be controlled from any dispatch console.

Based on operator preference, the MCC 7100 GUI can be customized to show details of RF resources on a per-channel basis. Various controls can be highlighted, such as patch status, frequency select, coded/clear select, and individual volume control. Per-channel controls can be fully or partially shown, or hidden to save space on the screen. Busy dispatch operators can respond to a missed call by simply clicking on an entry in the Activity Log. The number of calls and call information displayed in the Activity Log is customizable to suit the needs of the user.

The status of auxiliary inputs and outputs can be conveniently interpreted from the GUI with the use of familiar graphical icons, such as a door shown open or closed.

Emergency Radio Transmission and Reception

As part of a mission-critical communications network, the MCC 7100 console facilitates immediate prioritization and resolution of emergency communications between SFPUC dispatch and their field personnel. This enables dispatch operators and field personnel to focus on their job, not their equipment—especially during critical situations.

When a field user or another dispatch operator initiates an emergency call, the console emits both visual and audible indications ("Emergency Alarm"). The operator can then "recognize" the emergency call, which ends the audible emergency indication and notifies all console operators that the emergency is being addressed ("Emergency Recognize"). The audible emergency indication may also be muted by a console operator without recognizing the emergency alarm ("Mute Tones at a Single Op"). When an emergency is over, the dispatch console user can end the Emergency Alarm. The emergency mode remains active on the initiating radio unit until it is ended (reset) by the radio user.

Emergency Alarms

The MCC 7100 dispatch console is capable of monitoring radio subscribers for user initiated emergency activations. On subscriber radios that are equipped and programmed to transmit an emergency alarm, the MCC 7100 console detects that this emergency has occurred and displays the emergency on operator positions that are preprogrammed to receive the emergency notification.

Operator positions can be programmed to either receive the emergency or to completely ignore it. In the event of an emergency condition from a radio user, all programmed consoles will give both an audible and visual indication of the event. The dispatch operator can then silence the emergency leaving the visual indication on the screen indicating information on the initiating radio allowing the call to be handled and dispatched appropriately. Once an emergency is received all programmed operator positions will give the audible and visual indication of the event. Any one of these operator positions has the ability to silence the emergency at only their position or for all operator positions on the system.

In the event that all channels are busy at the RF site receiving the emergency, that event is automatically given a Priority Level 1. This is the highest priority possible, putting the emergency call at the top of any busy queue. The emergency call will be given the next available voice channel at that site bumping all non-emergency calls in the queue.

Receiving an Emergency Call

When a field user or another dispatch operator initiates an emergency call, the console emits both visual and audible indications ("Emergency Alarm"). The audible indication works to alert the dispatch operator that an emergency is underway; the visual indication directs the dispatch operator's attention to the specific resource on which the emergency call is being made. The dispatch operator can immediately reserve a voice channel for the duration of the emergency.

The audible indication for an emergency is generated at the maximum level of the received audio, regardless of what volume the console has set that resource to. This is to ensure that the console operator does not miss the call. When the emergency call has been acknowledged, the volume for that resource is returned to its previous level.

Responding to an Emergency Call

When a console operator wishes to respond to an emergency call, they can bypass the standard console interface to auto-open a quick list, which contains specific controls for recognizing an emergency call, initiating an emergency call, and ending an emergency call ("Auto-Open of Quick List"). The operator can then "recognize" the emergency call, which ends the audible emergency indication and notifies all console operators that the emergency is being addressed ("Emergency Recognize").

The audible emergency indication may also be muted by a console operator, without recognizing the emergency alarm ("Mute Tones at a Single Op"). This would be used in a situation where one agency is monitoring a channel that belongs to another agency. If an emergency alarm comes in on the second agency's channel, the first agency could mute the tones at their dispatch consoles without having to wait for the second agency to recognize it.

Ending an Emergency Call

When an emergency is over, the dispatch console user can end the Emergency Alarm. The visual indication on the console GUI is removed, and the console informs the other operator positions that the emergency is over ("Emergency End/Knockdown").

The emergency mode remains active on the initiating radio unit until it is ended (reset) by the radio user.

Radio Patch Control

MCC 7100 console users can patch communication between radio users that are normally unable to communicate with each other due to different features, programming, or even different frequency bands. A patch group is a group of linked resources that can both receive messages from a console and transmit to all other members of the patch group. The MCC 7100 supports a maximum of four active patch groups.

Setting up a Standard Patch

A dispatch operator can set up a standard patch between conventional RF and other audio resources. After the patch is created, the dispatch console transmits all audio on one resource to all other resources in the patch group.

Patched radio users see the ID or alias of the other patched radio(s) on trunking resources, as opposed to that of the console, provided that the radio subscriber is capable of displaying IDs. This minimizes confusion and the need for the dispatch operator to intervene in the call. Patches are automatically re-established if interrupted so the MCC 7100 user can concentrate on continuing operations.

Pre-Defined Patches

Patches can also be predefined, and be automatically re-initiated each time a dispatch console computer is restarted ("Patch Auto-Start").

Using Multi-Select

The Multi-Select feature allows a dispatch console to define groups of selected radio resources. When a Multi-Select group is opened, all of the resources in the group are simultaneously selected. Resources can be added or removed from a Multi-Select group while it is open or closed.

The Multi-Select feature:

- Selects multiple resources simultaneously.
- Defines and stores groups of resources so that multiple resources can be conveniently selected and deselected.

Call Management and Control

Automatic Prioritization of Calls

Calls on the MCC 7100 console are prioritized through a transmission hierarchy. Calls from primary supervisors take priority over those from secondary supervisors, which in turn take priority over non-supervisors. Instant Transmit or All-Points Bulletin (APB) transmissions, regardless of whether they are from a supervisor, will take priority over general or patch transmissions.

Multiple dispatch console operators can be designated as primary supervisors on the same system, which is useful when multiple agencies share one system, each with their own primary supervisor.

Console supervisors have the capability to disable and enable operator console functionality as necessary.

Standard Call Indications

The MCC 7100console indicates the availability of any given resource, whether or not it is being transmitted on at the moment. It will also give an inbound call indication that provides the console operator with a visual cue of audio activity on a radio resource. This functionality makes it easy for an operator to see at a glance what the status of a resource is at any moment.

Resource Identification

To identify a resource, the console reads its unit ID, a string of digits that uniquely represent that resource. The console makes it easy for operators to read unit IDs by replacing them with user-friendly 16-character aliases. These aliases, which are defined during the configuration of the console system, can replace the unit IDs of the following resources:

- Conventional Channel Resource.
- Conventional Channel Frequency Selection Control.
- Conventional Channel PL Selection Control.
- Unit ID.
- Aux I/O Resource.

The unit ID can appear in a received call stack, the three-line display, the resource header, and the activity log window. The unit ID of a parallel dispatch console is also displayed on the dispatch console when the parallel dispatch console transmits on ASTRO 25 conventional radio resources which are common to both consoles.

Call Alerting

When an operator needs to reach a radio user or dispatch operator and they are not near their radio or console, the dispatch operator can “page” the unattended radio or console through a series of beeps and an indication of the sender’s ID. When the radio user or dispatch operator becomes available, they will see the unit ID of the calling dispatch operator’s console or radio ID, and be able to return the call. Additionally, a Call Alert can be used to trigger an activity. For instance, a Call Alert may cause a vehicle’s horn to sound and its lights to flash. The console operator can even send a call alert to a user who is involved in voice and data communications over the network.

4.2.2.1.3 Console Logging

The MCC 7100 dispatch console system provides several different features to SFPUC to log audio on the system. These include the Long-Term Logging Port at each position, the Instant Recall Recorder included with the dispatch consoles, logging ports on the Conventional Channel Gateways, and the ability to interface to the Industry Standard IP Loggers.

Long Term Logging Port

Long term audio recording is used to record a portion of the inbound and outbound audio present on a specific dispatch console. These recordings are typically archived for long-term storage, and provide a historical record of the radio communications made at a given dispatch console.

The long-term logging port allows an external logging recorder to be connected to a dispatch console. The audio that appears on this output is configurable, but is typically the audio that was transmitted and/or received at that dispatch console.

The long-term logging port can be configured to log any combination of the audio sources listed below:

- Audio received from the currently selected radio resources (note that the level of this audio is not affected by either the individual volume setting of the radio resource or the master volume control on the speaker or headset jack).
- Microphone audio being transmitted to the currently selected radio resources by this dispatch console user.
- Microphone audio being transmitted to unselected radio resources by this dispatch console user.
- Any tones generated by the dispatch console that appear in its speakers (trunking tones, emergency tones, etc.).
- Tones generated by an external paging encoder.

Note that this output may be used with an instant recall recorder, as well as a long-term logging recorder.

Instant Recall Recorder

The Instant Recall Recorder (IRR) is designed to record incoming radio audio on the dispatch PC. The amount of audio recorded is configurable and is kept on a first in first out basis.

Conventional Channel Gateway

The Conventional Channel Gateway (CCGW) is used to connect to conventional resources. Each CCGW interface also includes a logging port for capturing the audio that was sent and received on that resource.

4.2.2.1.4 Console System Security

The MCC 7100 dispatch console enables end-to-end encryption from the operator position to the ASTRO 25 network, so that at no point will communications be undermined by unencrypted transmissions. Each dispatch operator will be able to fully participate in secure communications while being confident that sensitive, vital information will not be heard by unauthorized individuals.

Secure Access to the Console

To use the dispatch console, an operator must enter a valid radio system user account name and password. The dispatch console validates that information with the radio system's network manager and allows the user to access only the resources for which the user has access rights. This also applies to third-party applications that use the dispatch console's API.

Secure Communications at the Console

The console itself encrypts and decrypts radio voice messages. Thus, radio voice messages are encrypted end-to-end, from the field radio user to the dispatch console. The console operator can

choose whether or not to encrypt their transmissions on a particular trunked resource. Console operators can interface with agencies that have different encryption configurations without any manual intervention or delay. The MCC 7100 console can support up to 60 calls simultaneously, using up to four different algorithms and multiple encryption keys.

To help reduce potential errors when managing encrypted communications, the MCC 7100 interface provides alerts when the console mode does not match that of a received call, and when a patch or multi-select group is being set up between a mix of clear and secure channels.

4.2.2.1.5 Console Configuration and Management

The MCC 7100 console system is configured and managed by the same configuration manager, fault manager, and performance reporting applications as the radio system. The user can define exactly which resources are available and how they are presented to the dispatch console user. This provides SFPUC with a single point for configuring and managing the entire ASTRO 25 system, including the dispatch consoles. Changes are automatically distributed throughout the system. This centralized approach saves valuable time and effort for system administrators and technicians, and reduces the errors that can occur when radio IDs and other data are entered at multiple locations.

In addition, call traffic and performance reports for each console can be generated from the system's network manager. This enables administrators to quickly and easily ensure optimal effectiveness and efficiency.

4.2.2.2 MCC 7100 Dispatch Console Component Description

This section discusses the various components that make up the MCC 7100 Dispatch Console system. These components are connected together and to the rest of the ASTRO 25 system on an IP network via console site routers and switches. The MCC 7100 Dispatch Console functions as an integrated component of the total radio system, fully participating in system level features such as end-to-end encryption and agency partitioning.

Since the network is IP-based, the system's interfaces and components can be distributed physically throughout the network. Logging components can be centrally located at the zone core or distributed at console sites. CCGWs can be located at conventional-only RF sites, at trunking RF sites, the Core site, or at console sites with conventional stations. Aux I/O Servers can be placed anywhere in the zone, closest to where they are needed.

Components described below are included in this system design.

4.2.2.2.1 Operator Position Components

MCC 7100 operator positions connect directly to the radio system's IP transport network without gateways or interface boxes. Audio processing, encryption, and switching intelligence for dispatch are performed within each software-based operator position, without additional centralized electronics.

Personal Computer (PC)

The MCC 7100 Console is supported on a Motorola certified workstation running Microsoft Windows 10 OS (64 bit) SPI. These workstations are available through Motorola and are also recommended for use with the MCC 7100 Proxy Software.

Motorola has included a 19" Flatscreen monitor with each dispatch position.

MCC 7100 Operator Accessories

The MCC 7100 Dispatch Console also supports commercially available accessories. These accessories: USB connected Microphone, USB Headset, and USB Footswitch have been tested for reliable performance with high quality audio.

The USB Audio Interface Module (AIM) is an external device that you connect to the MCC 7100 Dispatch Console. It functions as an interface between analog devices and the console position and as a general-purpose input/output module. The USB Audio Interface Module supports audio routing between the dispatch operator and Motorola-standard peripherals. The USB AIM connects to the MCC 7100 Dispatch Console with a USB cable.

Audio Interface Module (AIM)

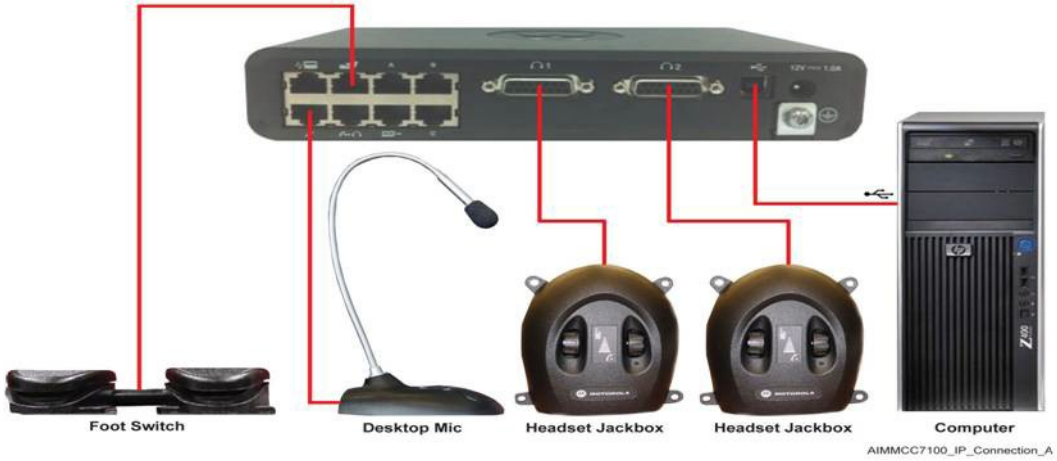


Figure 4-15: Audio Interface Module

The AIM supports standard Motorola operator accessories (Figure 4-15):

- Footswitch - USB Kinesis two pedal footswitch.
- Desktop Gooseneck Microphone - USB SHURE Desktop Microphone:

– Desktop Microphone is a set of three parts: 12” neck Hyper, Angled Desktop Gooseneck Base, XLR to USB Adapter.

– The SHURE Microphone does not have PTT in the base. PTT is accomplished using the headset PTT, Mouse, Touch-screen or footswitch.

- Headset Base with PTT—Plantronics USB Headset base with PTT (limit one per console). Quick-disconnect top is ordered separately.
- USB Hub—Cables to Go 7-Port USB 2.0 Hub.

4.2.2.2.2 Instant Recall Recorder (IRR)

Figure 4-16: Sample IRR Screen Shot

The IRR allows a dispatch operator to record radio transmit and receive audio (Figure 4-16). Recorded calls include the following call types:

- Inbound audio from the currently selected channels.
- Outbound audio from the microphone to the selected channels.
- Outbound audio from the microphone to the selected channels.
- Tones generated by the dispatch console that appear in the speakers of the dispatch console.

One IRR is required per console position. Features of the MCC 7100 IRR include:

- Save and forward audio files.
- Configurable storage of up to 4 GB.
- Automatic purge of the oldest record.
- Variable speed replay.

Note: The IRR records radio audio only, it does not record telephone audio.

4.2.2.2.3 Reserved

4.2.2.2.4 Conventional Channel Gateway Equipment

Conventional Channel Gateways (CCGWs) are used to interface analog and ASTRO 25 conventional channels to the ASTRO 25 radio system infrastructure. CCGWs provide 4-wire analog interfaces for analog channels and V.24 and IP digital interfaces for ASTRO 25 conventional channels. The platform that is hosting a CCGW may be solely dedicated to that task or it may also be used as a console site router or an RF site router, provided the WAN link is not redundant.

The enhanced GGM 8000-based CCGW is available for interfacing to conventional channels. The enhanced CCGW can support combinations of analog, MDC 1200, ACIM Link, digital and mixed mode channels simultaneously. Low density and high density versions of the enhanced CCGW are available. Motorola has included High Density CCGWs for the SFPUC system.

- The low density version contains four analog ports and four V.24 ports plus an Ethernet port. Up to eight conventional channels can be connected to the analog and V.24 ports. The eight channels can be mixtures of analog, MDC 1200, ACIM Link, digital or mixed mode. In addition to the eight channels connected to ports, up to 16 IP-based channels can be supported. This brings the total number of channels supported on the low density version to 24.
- The high density version contains eight analog ports and eight V.24 ports plus an Ethernet port. Up to 16 conventional channels can be connected to the analog and V.24 ports. The 16 channels can be mixtures of analog, MDC 1200, ACIM Link, digital or mixed mode. In addition to the 16 channels connected to ports, up to 16 IP-based channels can be supported. This brings the total number of channels supported on the high density version to 32.

Analog Configuration

The enhanced GGM 8000-based CCGW provides two sets of ports that are used with analog channels. One set (called the Analog Ports) contains the analog inputs and outputs for the channels along with a COR/Coded/Clear input and a PTT Relay output. The other set (called the Supplemental I/O Ports) contain analog logging recorder outputs and various inputs that can be

used with the analog channel.

Each analog port contains the following inputs and outputs:

- **2-Wire Input/Output**—When the channel is configured for 2-wire operation, this input/output is used to send console transmit audio to the channel and to accept radio audio from the channel.
- **4-Wire Input–**—When the channel is configured for 4-wire operation, this input is used to accept radio audio from the channel.
- **COR or CIU Coded/Clear Input**—If the channel is configured for clear (non-secure) operation with COR (Carrier Operated Relay), then this input is used to accept the COR output from the channel. When used as a COR input, the input uses contact closure detection.
- **PTT Relay Output**—The PTT relay output provides a relay contact closure capable of supporting up to 1 Amp at 24 volts DC.
- **VOX and COR Operation**—A clear (non-secure) analog port must be configured to support either VOX or COR operation. The CCGW will not pass audio to the dispatch consoles or logging recorders unless there is an active VOX or COR condition.
- **LOBL (Line Operated Busy Light) Detectors**—The LOBL detector on the 2 or 4 wire inputs can be used to detect when a parallel non-MCC 7100 dispatch console is transmitting on the channel via tone remote control.
- **AGC, DLM and Fixed Gain Operation**—When configured for AGC operation, the gain of the audio input is constantly adjusted to provide a constant output level to the dispatch consoles and logging recorders. When configured for DLM operation, the gain of the audio input is constantly adjusted to provide a constant output level to the dispatch consoles and logging recorders. When configured for fixed gain operation, the gain of the audio input is fixed and does not change. The enhanced GGM 8000-based CCGW provides four (low density version CCGW) or eight (high density version CCGW) ports containing supplemental I/Os which can be used to provide additional functionality on analog channels:
- **LOBL (Line Operated Busy Light) Input**—The LOBL input provides an alternative method to the software LOBL detector for detecting when a parallel non-MCC 7100 dispatch console is transmitting on an analog channel. This input can be configured for either voltage operation or contact closure operation.
- **High Speed Mute Input**—When the mute input is active, all audio at the configured audio input(s) will be muted.
- **Analog Logging Output**—The analog logging output provides 600 Ohm balanced analog audio consisting of the summed transmit and received audio from the channel connected to the paired analog port.
- **Coded/Clear Call Input**—The coded/clear call input provides certain legacy analog secure conventional channels a means of informing the MCC 7100 dispatch consoles about the mode (coded or clear) of a call.

V.24 Configuration

The enhanced GGM 8000-based CCGW provides four (low density version) or eight (high density version) V.24 ports to which ASTRO 25 conventional channels may be connected. The

V.24 ports on the CCGW are connected to the V.24 ports on the base station or comparator. The V.24 ports are also used for the ACIM link connections to consolettes.

Mixed Mode Configuration

Both the low density and high density versions of the enhanced GGM 8000-based CCGW support mixed mode channels. These channels are shared between digital radio users and analog radio users. When a digital call is generated either by the MCC 7100console or a radio user, the V.24 port provides the digital voice path to and from the radio system. Mixed mode operation does not use an IP link for digital audio routing. For analog radio calls, the 2 or 4 wire ports provide the analog voice path, while the V.24 ports will provide control and signaling information for the channel.

IP Conventional Gateway

Both the low density and high density enhanced GGM 8000-based CCGWs can support up to 16 G-Series-based ASTRO 25 conventional channels via the radio system's IP network. The IP interface uses the same Ethernet cable that the enhanced CCGW uses for everything else. The 16 IP-connected channels are in addition to any analog or V.24 channels that may also be connected to the enhanced CCGW.

Conventional Site Controllers

The GCP 8000 is equipped with a single controller module. The GCP 8000 is capable of supporting the full set of dispatch consoles, archiving interface servers, and conventional gateways. The GCP 8000 can only be located at the Core site. The GCP 8000 is responsible for:

- Fault management for the GCP 8000.
- Processing conventional call requests from the conventional gateway or from the console.
- Assigning the multicast groups for conventional calls.
- Issuing a call grant to the requestor.
- Issuing a beginning of mobile transmission to the consoles (with alias information).
- Arbitration between multiple radios and/or consoles vying for the same channel.
- Processing an end of call.
- Acknowledge subscriber signaling calls (e.g. emergency).
- Distributes subscriber signaling to affiliated consoles.
- Other conventional voice call processing.

4.2.2.2.5 System Components Required for Functionality Outside of the ASTRO 25 Network

The following components are used for MCC7100 operation outside the RNI.

- PRX7000 Console Proxy Software.
- Control Room Firewall.
- Connecting Console "Link-Op".

It is recommended that a pre-planning document be prepared prior to install of an MCC 7100 console being deployed outside the RNI. The document should identify the IP addresses assigned to any device that will communicate with the ASTRO 25 network.

PRX 7000 Console Proxy Software

An installation of PRX 7000 Console Proxy Software is required at the Console site when MCC 7100 IP Dispatch Consoles are deployed outside the ASTRO 25 Network (RNI).

The PRX 7000 Console Proxy delivers the following functionality:

- Converts multicast audio packets used in the ASTRO 25 network to unicast audio packets used on the customer network.
- Keeps track of remote connections into the ASTRO 25 Network with a limit of 10 connections per Proxy.
- Can be used by administrator to prevent a device from establishing a connection by setting up a “Black List” for lost or stolen devices.

Control Room Firewall

The Control Room Firewall is installed at the Console Site to allow secure communications with outside networks. The Firewall requirement is necessary only when the MCC 7100 Console is intended for use outside of the RNI. To facilitate this communication and eliminate any conflict between the customer (CEN) IP addresses and the ASTRO 25 RNI IP addresses, the firewall is configured for Network Address Translation (NAT) functionality.

Multiple control room firewalls may be installed in an ASTRO 25 system; one at each console site. Redundant firewalls at the same console site are not supported in the MCC 7100. If the Control Room firewall fails then connection for the Remote Consoles will be lost.

Connecting Console “Link-Op”

The “Link-Op” is the first dispatch console at a console site that registers with the system and assigns a resource. This behavior is inherent in all console application software and no user-intervention or configuration is required. A “Link-Op” must be an MCC 7100, an MCC 7500 Console, or an AIS.

The “Link-Op” is in control of the active link between the console site and the zone controller or site controller. A connecting console acting as a “Link-Op” need not be actively staffed, but must be in continuous operation.

If the “Link-Op” goes offline or down, the system immediately re-establishes a new “Link-Op”—assuming there are multiple consoles at the console site. If no additional consoles are available, then remote consoles depending on that “Link-Op” will cease until “Link-Op” connection is restored.

The Connecting Console “Link-Op” is located inside the ASTRO 25 RNI along with a PRX 7000 Console Proxy at a traditional console site or conventional subsystem site. The Connecting Console can be deployed on any desktop or laptop computer meeting minimum specifications.

- Either an MCC 7100 or MCC 7500 Console located inside the ASTRO 25 RNI can be used as a “Link-Op.”
- An MCC 7100 IP Dispatch Console located outside the ASTRO 25 RNI cannot be used as a “Link-Op.”
- The “Link-Op” at one console site cannot be used as the active link for another console site.
- An MCC 7500 Console that is used as a “Link-Op” can also act as host for the PRX 7000 Console Proxy Software.

Customer-Supported Components

The following customer-supported components are required for MCC7100 operation outside the RNI.

Domain Controller

SFPUC will have to set the group policies for the MCC 7100 dispatch console users. This will allow the MCC 7100 dispatch console software to operate properly. The customer should import the User Policy and Group Policy into the Customer Network Domain Controller from the Windows Supplemental CD. This requires running additional script on the Domain Controller that replaces place holder values with actual domain values.

DNS Server

The Domain Name Server (DNS) contains a database of network hostnames and their associated IP addresses for Intranet resources connected to the Intranet.

The MCC 7100 Dispatch console will download console configuration data from the LDAP (Lightweight Directory Access Protocol) Server in the ASTRO Network. MCC 7100 dispatch consoles located inside the RNI will resolve host names to IP addresses by querying the DNS Server inside the ASTRO RNI. For MCC 7100 dispatch consoles located outside the RNI, the customer network IT administrator will have to add entries for the ASTRO devices that the MCC 7100 dispatch console will communicate with. The IP plan that is generated during the preplanning stage will be used and the information will be entered in the customer DNS.

DHCP Server

The Dynamic Host Configuration Protocol (DHCP) server assigns an IP address to a computer from a defined range of numbers configured for a given network. The DHCP server in the customer network should be configured to assign a static IP address for each MCC 7100 dispatch console installed in the CEN or connecting to the ASTRO RNI through the CEN. This allows the firewall to be configured for a one to one NAT (Network Address Translation) for each MCC 7100 dispatch console located in the CEN.

No CEN/Transport Network Elements

If SFPUC does not have network management elements, then a local host file must be populated with the ASTRO Element FQDN (Fully Qualified Domain Name) and CEN IP address.

Virtual Private Network (VPN)

The Virtual Private Network server supports a secure connection for the remote console to connect through to the Customer Enterprise Network (CEN) and from there into the ASTRO 25 network.

Network Requirements

Network requirements for MCC7100 operation outside the RNI are detailed in Table 4-10.

Table 4-10: Network Requirements

Requirement	Specification
Network Connection Requirements	The MCC 7100 IP Dispatch Console uses wired (Ethernet) or wireless broadband (e.g. 4G, Wi-Fi) networks to establish voice
Bandwidth requirements	35 kbps per channel: 175kbps for a 5 stream dispatch console and up to 700 kbps for
Network jitter allowed	131ms. max
Dropped packets allowed	1% packet loss max

Maximum delay	Latency between the console site where proxy is to be installed and the core—lowest latency site link to

4.2.2.2.6 Licensing

There are three types of licenses available for the MCC 7100 console, capacity licenses, the PRX 7000 proxy license, and operational licenses.

Radio Resource Capacity Licenses

A radio resource capacity license is needed for each MCC 7100 Dispatch Console. A radio resource capacity license defines the number of simultaneous voice streams a given console can use. Feature Licenses.

A feature license may be needed for each MCC 7100 Dispatch Console depending upon the desired feature. At this time only the MCC 7100 Integrated IRR requires a feature license.

PRX 7000 Proxy License

The Proxy License allows connectivity with MCC 7100 Dispatch Consoles deployed outside of the ASTRO 25 Network. A Proxy license is required for each proxy being deployed.

Operational Licenses

An Operational License grants the user a right to use designated operational features Operational licenses are delivered with the MCC 7100 Dispatch Console software and do not require Internet access or separate activation to function.

4.2.3 Subscriber System Description

4.2.3.1 Subscriber Radios

To satisfy the requirements for RFP section 4.18 Radio Requirements, Motorola is providing our APX 1000+ Portable Radio. For the mobile radio requirements, Motorola is providing our APX 1500 and APX 4500 mobile radios.

Motorola has also included the APX 7500 Consolette, DVRS, and MCD5000 Deskset.

To keep the SFPUC subscriber fleet programmed and up to date, Motorola has included our APX Radio Management software.

The APX line of Project 25 portable and mobile radios delivers exceptional performance by combining advanced voice and data technology with legendary Motorola quality. To develop the APX platform, Motorola's product engineers met with personnel from public safety and law enforcement agencies to identify and design the specific functionality essential for critical communications. Through that research and collaboration, every feature and function in APX portable and mobile radios has been designed with its users in mind—from its rugged, easy-to-operate form factor to the loudest, clearest audio.

4.2.3.1.1 APXTM 1000+ Project 25 Portable Radio

The APX 1000+ provides a complete and complementary look and feel to the APX family of P25

TDMA radios. With a two-microphone design to reduce background noise and excellent RF coverage, the APX 1000+ is engineered to give SFPUC the smallest P25 Phase 2 capable radio on the market today. Engineered with a simplified control top to ensure ease of use, the APX 1000+ is the ideal solution for local government and public works users who require quality P25 functionality.

The APX 1000 is an easy-to-use, reliable radio designed to keep radio users connected, providing them with P25 radio communications while adhering to a budget SFPUC can afford. It provides users with a customizable radio in a simple, compact design, with the versatility to suit any type of radio user and the attributes of a high-quality Motorola portable radio.

Figure 4-17: APX 1000+ Model 3.5

The APX 1000+'s customizable feature set will provide SFPUC users with efficient communications while keeping costs down. Some of its standard features and benefits are identified below:

- **Improved Efficiency and Safety**—Supports Integrated Voice and Data (IV&D) capabilities to enhance the efficiency and safety of SFPUC's users through various data applications (Including Over-the-Air Programming (POP25) and Text Messaging).
- **Economical Communications**—A reliable, simplified, and fully customizable P25 radio made to give your users the functionality they need within SFPUC's budget. The APX 1000 portable radio operates on both Project 25 Phase 1 and Project 25 Phase 2 TDMA. It can also operate on analog and Project 25 conventional systems, and supports a variety of software capabilities and feature sets.
- **Excellent Audio Qualities**–Coordination and communication efforts are intelligible in high-noise environments. Dual-sided two-microphone noise canceling technology ensures clear audio. An AMBE digital voice vocoder provides unmatched speed and voice quality, while reducing costs by requiring less data, memory and power consumption.
- **Uncompromising Design**–The smallest, most durable P25 Phase 2 TDMA-capable radio available with an LCD high-contrast color display, making it comfortable to carry and read in all kinds of light.
- Meets all applicable MIL-STD-810C, D, E, F and G standards for withstanding dust, heat, shock, and drops, making it the most reliable portable radio in any situation.
- **Simplified Controls**—The multifunction knob provides ease of use by combining volume,

channel, and ON/OFF settings in one. Radio profiles can automatically adjust audio levels. Its Text Messaging feature offers both freeform and preset messaging features, maximizing efficiency and discretion.

The APX 1000 comes in three different base configurations, and can be further customized to meet the needs of SFPUC. These models include:

- Model 1.5 (Display and backlit keypad with 3 softkeys).
- Model 2 (Display and 4-direction navigation key with home & data buttons).
- Model 3 (all features listed above with a full keypad).

4.2.3.1.2 APX™ 1500 Project 25 Mobile Radio

Durable and compact, the APX 1500 mobile is a budget-friendly, P25 Phase 1 and Phase 2 solution that provides seamless
interoperability and extended range. The APX 1500 is engineered so that SFPUC's personnel can be connected wherever the mission takes them. With its compatible APX O2 Control Head, rugged construction, and easy installation, the APX 1500 is the ideal solution for users who require quality P25 functionality in a compact, cost-effective mobile radio.

The APX 1500 is a cost-effective, reliable mobile radio for local government and public works customers whose primary users include utility, rural public safety, and transportation departments that need to communicate with first responders.

The APX 1500's customizable feature set will provide SFPUC users with efficient communications while keeping costs down. Some of its standard features and benefits are identified below:

- **P25 and Legacy Interoperability** - Available in 700/800 MHz, VHF, UHF R1 and UHF R2 frequency bands, and compatible with both P25 Phase 1 and Phase 2 infrastructure, the APX 1500- seamlessly unifies public works and public safety personnel so they can interoperate effectively in the moments that matter.
- **Ergonomic Controls** - The compatible O2 Control Head with color display is easy to read and operate in all lighting conditions, from bright sunlight to dark streets. Intelligent lighting notifies users when the radio receives a call, an emergency arises, or when they are out of range. Enlarged multifunctional knobs allow radio users to easily adjust talkgroup and volume settings while wearing bulky gloves.
- **Easy to Install** - The APX 1500's simplified dash mount design makes installation quick and easy, fitting into the existing XTL™ footprint so you can reuse mounting holes and cables. This design also allows the reuse of mounting holes and cables, making installation easy and reducing costs.
- **Ruggedized Construction**—Uncompromising durability and world-class quality enables the APX 1500 to withstand wet, dusty, and hazardous conditions. Its IP56 durability rating is the highest level of certification for mobile radios, and it meets applicable MIL-STD 810C, D, E, F, G standards.
- **Included options to Meet Radio Users' Needs**—The APX 1500 is compatible with the following advanced features and data applications:), Text Messaging, , and GPS Outdoor Location Tracking. The GPS location tracking feature is enabled on the radio and sends information to the City of San Francisco's Location Server. A separate 3rd party application is needed to graphically display the coordinates on a computer.

4.2.3.1.3 APX™4500 Project 25 Mobile Radio

The APX 4500 brings together powerful technology in a compact, rugged, budget-friendly mobile radio, providing seamless, secure interoperability to a wide variety of agencies and users. By providing a wide range of budget-friendly configuration features, the APX 4500 offers the functionality and security required by public works, public safety, and mission critical first responders. Its compatible APX O2 Control Head, easy installation, and durability ensure that users can safely and effectively complete the mission at hand.

Figure 4-19: APX 4500 Mobile Radio

Motorola's APX 4500 offers a sophisticated feature set that meets the needs of public servants, including utilities and public works personnel, public safety, and first responders, while being easy on agency budgets. Some of its standard features and benefits are identified below:

- **P25 and Legacy Interoperability** - Available in 700/800 MHz, VHF, UHF R1 and UHF R2 frequency bands, and compatible with both P25 Phase 1 and Phase 2 infrastructure, the APX 4500 seamlessly unifies public works and public safety personnel so they can interoperate effectively in the moments that matter.
- **Ergonomic Controls** - The compatible O2 Control Head with color display is easy to read and operate in all lighting conditions, from bright sunlight to dark streets. Intelligent lighting notifies users when the radio receives a call, an emergency arises, or when they are out of range. Enlarged multifunctional knobs allow radio users to easily adjust talkgroup and volume setting while wearing bulky gloves.
- **Easy to Install** -The APX 4500's simplified dash mount design makes installation quick and easy, fitting into the existing XTL™ footprint so you can reuse mounting holes and cables. This design also allows the reuse of mounting holes and cables, making installation easy and reducing costs.
- **Ruggedized Construction–**—Uncompromising durability and world-class quality enables the APX 4500 to withstand wet, dusty, and hazardous conditions. Its IP56 durability rating is the highest level of certification for mobile radios, and it meets applicable MIL-STD 810C, D, E, F, G standards.
- **Included Options to Meet Radio Users' Needs**—The APX 4500 is compatible with the following advanced features and data applications: Text Messaging,

4.2.3.1.4 APX 7500 Project 25 Consolette

The APX 7500 Consolette (Figure 4-20) provides a low-cost, mid-power wireless dispatch solution as an ideal complement to a modern P25 dispatch center. Equipped with leading edge P25 Phase 1 & Phase 2 TDMA technology and multiband interoperability, the APX 7500 Consolette can also be used as an emergency backup station when infrastructure is offline, or for wireless access to different system types for increased interoperability between agencies.

The APX 7500 Consolette' s flexible design will allow SFPUC to utilize it for local control, remote control via a desksset, or for dispatch control.

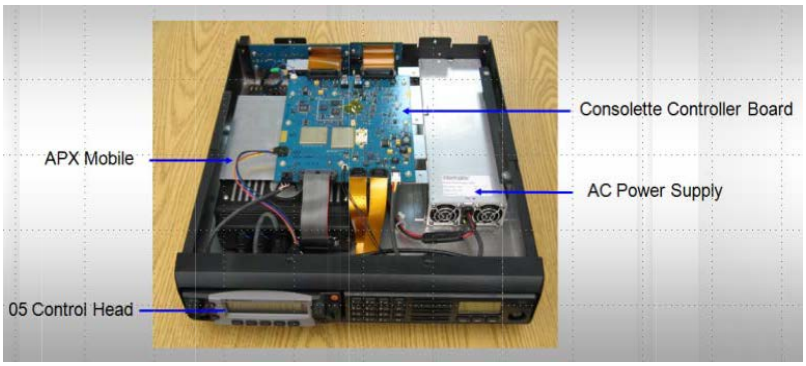


Figure 4-20: APX 7500 Project 25 Consolette

The APX 7500 Consolette' s dual-band P25 operation and compatibility with legacy systems ensures that communications are clear, continuous, and coordinated across multiple users, agencies, and systems. Some of its standard features and benefits are identified below:

- **Multiband Operation in One Radio**–The APX 7500 Consolette delivers the convenience of two radios in one while maintaining APCO TIA receiver specifications. With the APX 7500, personnel can use one consolette to communicate and provide dispatch operations across multiple digital and analog networks that operate in any two of the following frequency bands: 700/800 MHz, VHF, UHF R1 and UHF R2.
- **Included Options to Meet Radio Users' Needs**—The APX 7500 is compatible with the following advanced features and data applications:, Text Messaging, and ADP Encryption Software Options.

4.2.3.1.5 DVRS

The P25 Digital Vehicular Repeater System (DVRS) allows Portable Subscriber Units (PSU) to be used in areas where only Mobile Subscriber Unit (MSU) coverage is available and PSU coverage is either intermittent or nonexistent. Installed in the trunk of a car, fire truck, armored vehicle, ambulance or configured as a Transportable or Fixed mount DVR, the DVRS extends radio communications when the PSU users are outside of the vehicle, inside a nearby building or in any PSU marginal coverage areas.

The same PSU is used to communicate directly with the system as well as through the DVRS. Whenever system radio coverage is not available, the PSU users can switch to a DVRS channel and communicate via a nearby active DVRS.

The P25 DVRS can also be used in Cross-Band Systems, where all Portable Radio Coverage is provided via the DVRS. The most typical Cross-Band DVRS scenario is when the entire portable radio coverage is provided via DVRS.

The P25 DVR is a versatile, full duplex digital repeater, designed to be seamlessly interfaced to a Remote Mount APX 6500 or APX 7500 mobile. The DVRS is controlled from (and its status is displayed on) the MSU Control Head and is equipped with all necessary filtering for interference-free operation.

4.2.3.1.6 MCD 5000 Deskset

Ideal for dispatch environments, back-up sites, alternate locations, special events, and call monitoring, the MCD 5000 Deskset is a powerful and easy-to-deploy VoIP solution. An IP-based desktop console, the MCC 5000 Deskset provides digital control to a variety of Motorola two-way radios, allowing the deskset to perform all the functions that can be performed using the radio control head.

Each MCD 5000 Deskset can connect to a single radio device and allows independent control of that radio resource for the dispatch operator. The MCD 5000 can also be networked together with multiple radios and multiple Desksets. Several accessories are available for the MCD 5000 including headsets, foot pedals, and external microphones. The unit includes logging recorder outputs for connection to the logging recorders at the dispatch centers.

The MCD 5000 Deskset is ergonomically designed with an intuitive layout and an adjustable viewing angle for both occasional and constant everyday use. The large and easy-to-read color LCD screen gives at-a-glance access to critical information including messages, channel status and names, and emergency and user IDs. The programmable softkeys can be customized to the unique needs of users for quick control of the standard functions of each radio.

Figure 4-21 and Table 4-11 shows the MCD 5000 and primary functions.

Figure 4-21: Example of the MCD 5000 Backup Dispatch Deskset

Table 4-11: Primary Functions

No.	Item	Description
1	Handset	For audio transmit and receive, with a microphone in the mouthpiece and an audio speaker in the earpiece and a built-in PTT.
2	Internal Speaker	For hands-free public audio receive.
3	Internal Microphone	For hands-free audio transmit.
4	Transmit button	For transmitting on the radio channel.
5	Transmit LED	Indicating that the MCD 5000 Deskset is transmitting on the radio channel.
6	Busy LED	Indicating that another MCD 5000 Deskset is using the radio channel.
7	Receiver Indicator	Indicating that the MCD 5000 Deskset is receiving on the radio channel.
8	Volume Control	Increases or decreases received audio volume for the handset, speaker phone, or headset (depending upon which is currently active).
9	All Mute Button	Toggles the mute on or off, allowing the user to mute all received audio. Pressing any button will remove the MCD 5000 Deskset from “All Mute” state. Internal red LED indicates “All Mute” is turned on.
10	Speaker Button	Toggles the internal speaker on or off allowing the user to turn on the internal speaker as additional audio source to the headset or the handset. The Speaker Button operation has a corresponding indication LED. Internal green LED indicates the internal speaker is turned on.
11	Navigation Keys	For browsing through menus.
12	Emergency Button	For activating an Emergency Outbound function from the MCD 5000 Deskset.
13	Menu Button	Toggles upper soft keys between “MCD 5000 Deskset Home Screen” and “Emulated Radio Screen.”
14	LCD Display	For displaying: digital radio messages or test and configuration messages, radio icons, soft keys, and VU meter readings.
15	Radio Soft Keys (Radio Function Buttons)	Radio programmable buttons or radio soft keys buttons.
16	Mode Up and Mode Down Buttons	For moving up and down through the MCD 5000 Deskset or radio menu or modes, channels, or functions that appear on the LCD display.

17	Keypad	For emulating the keypad of the radio and entering numbers to operate the MCD 5000 Deskset functionality.
18	Base Intercom Button & LED	Toggles the Base Intercom on or off. Base Intercom Button allows direct communication between parallel MCD 5000 Deskset users that are connected to the same radio in the system without transmitting over the radio channel. The Base Intercom button has an internal LED. The green LED indicates incoming transmission and red LED indicates outgoing transmission.

4.2.3.1.7 APX Radio Management

Motorola has included the Radio Management license on the Subscriber Radios to be incorporated into the Radio Management system currently being deployed by the City of San Francisco.

Radio Management is a software tool that provides basic fleet mapping and asset management capabilities for ASTRO® Digital APX radios in the field. Radio Management allows for viewing, editing, sorting, grouping and filtering of ASTRO® Digital APX radio's identity and system information.

Radio Management can help reduce fleet programming time and improve overall radio asset management. Radio Management allows:

- Sharing of a code plug template across multiple radios.
- Automatically applying template changes to effected radios.
- Advanced scheduling of programming jobs.
- Configuration changes from multiple CPS RM client locations.
- Programming setup to occur at remote locations.
- Programming support for Programming Over IP.
- Radio management (RM) consists of an RM Client, RM Server, Job Processor and a device programmer.
- The RM Client provides the radio managers a unified view into their radio fleet from a single dashboard by having the radio management user interface integrated into the CPS (Customer Programming Software).
- The City and County's RM Server provides radio managers with flexible features for managing radios, templates, codeplug data and programming jobs via hardware or cloud based database.
- The Job Processor is responsible for preprocessing of programming jobs by validating and transforming template and radio data into a format that can be written to the radio.
- The Device Programmer performs read and write jobs to the APX Radios.
- In order for Radio Management to work all radios must be software release 7.12, version R08.02.00 and later.

4.2.3.2 Coverage

Motorola's 800 MHz system for SFPUC meets the requirements of the RFP.

The system is designed for a DAQ of 3.4 and 90% reliability of the SFPUC Service Area. The system is also designed so that the loss of any single site will not result in the loss of coverage

greater than 10% percent of the entire covered area.

Motorola has provided the following information only maps to illustrate the coverage modeling provided by the SFPUC system. The Coverage Acceptance Test Plan is detailed in the SOW Appendix F.

- Portable On-Street Inbound.
- Portable On-Street Outbound.

SFPUC has requested a design to provide in-building coverage within the Watershed cottages, and in-building coverage for the critical facilities. For the different building types, Motorola selected those most closely resembling the buildings requiring in-building coverage in selecting the losses to model the in-building coverage. Actual measurements may be taken during the project to modify the losses within the critical buildings.

As can be seen from these maps, and the table below, many of these critical locations are covered by the SFPUC system. To augment the coverage, Motorola is providing the following system additions:

- Conventional Site at SVWTP.
- Conventional Site at Intake Radio Site.
- Simulcast Repeater site at Poopenaut Pass.

As noted in Table 4-12 and Table 4-13, these sites provide augmented coverage at the O'Shaughnessy Dam, in the area surrounding the Sunol Valley Water Treatment Plant, and at the Kirkwood and Holm Power Houses.

As can be seen in the following tables showing the Mobile coverage provided by the SFPUC system with the mobile antenna elevated at 25 feet, the remaining Watershed Cottages are covered in this scenario. This makes them candidates for a Fixed DVRS solution. The Fixed DVRS solution places a conventional repeater at the location that is connected to a mobile radio communicating on the P25 trunked system, effectively tying the conventional repeater into the system and extending coverage to the areas in and around the Watershed cottages. Motorola will install Fixed DVRS repeaters at the following Watershed Cottages:

- San Antonio Reservoir.
- San Andreas Cottage.
- Sawyer Camp Cottage.
- Upper CS Cottage.
- Pulgas Water Temple.

Table 4-12 and Table 4-13 show how the in-building coverage will be accomplished by Motorola:

Table 4-12: How the in-building coverage will be accomplished

Critical In-Building Location	4 dB In-Building Coverage by System	Mobile Coverage with Elevated Antenna by	9 dB In-Building Coverage by System
San Antonio Watershed		X	
Sunol Maint. Yard	X	X	
Calaveras Substation	X	X	X
San Antonio Pump Station	X	X	
Alameda East Cottage		X	

Fremont/Irvington Cottage	X	X	X
SVWTP		X	
Calaveras Watershed	X	X	
N San Andreas Cottage		X	
San Andreas Cottage	X	X	
Davis Tunnel Cottage	X	X	
Sawyer Camp Cottage		X	
Pilarcitos Cottage		X	
Lower CS Cottage	X	X	
Crystal Springs Reservoir/Upper CS Cottage		X	
CS Cottage	X	X	X
Pulgas Water Temple		X	
O'Shaughnessy Dam			
Kirkwood Powerhouse			
Holm Powerhouse			
Moccasin Powerhouse and Yard		X	X
Warnerville Substation		X	X
Tesla Water Treatment Facility		X	X
Thomas Shaft Water Treatment Facility		X	X
Harry Tracy Water Treatment Plant		X	X
Millbrae Corporation Yard		X	
City Distribution Division		X	X
Lake Merced Pump Station		X	X
SFPUC Headquarters		X	X

Table 4-13: How the in-building coverage will be accomplished

Critical In-Building Location	9 dB In-Building Coverage by	9 dB In-bldg. Coverage	9 dB In-Building Coverage by
San Antonio Watershed			
Sunol Maint. Yard	X		
Calaveras Substation	X		
San Antonio Pump Station	X		
Alameda East Cottage	X		
Fremont/Irvington Cottage			
SVWTP	X		
Calaveras Watershed			
N San Andreas Cottage			
San Andreas Cottage			
Davis Tunnel Cottage			
Sawyer Camp Cottage			
Pilarcitos Cottage			
Lower CS Cottage			
Crystal Springs Reservoir/Upper CS Cottage			
CS Cottage			
Pulgas Water Temple			
O'Shaughnessy Dam		X	
Kirkwood Powerhouse			X
Holm Powerhouse			X
Moccasin Powerhouse and Yard			
Warnerville Substation			
Tesla Water Treatment Facility			
Thomas Shaft Water Treatment Facility			
Harry Tracy Water Treatment Plant			
Millbrae Corporation Yard			
City Distribution Division			
Lake Merced Pump Station			
SFPUC Headquarters			

Per the RFP requirement in Section 4.5.1, provided below in Table 4-14 is a list of all of the technical parameters used to produce the predicted in building coverage maps. Motorola has not included the Receive Signal Levels as this parameter is unclear. The Receive signal level will vary depending on location of subscriber relative to the site. If SFPUC will provide additional details on what is desired regarding this specification Motorola will happily supply the information.

Table 4-14: Technical parameters used to produce the predicted coverage maps

SFPUC COVERAGE TECHNICAL PARAMETERS									
PROPAGATION MODEL	OKAMURA 2								
LOGNORMAL FADING STANDARD DEVIATION	5.5 DB								
PORTABLE PARAMETERS	ASTRO IMBE VOCODER, RECEIVE AT HIP LEVEL, TRANSMIT AT HEAD LEVEL, 1/4 WAVE ANTENNA								
MOBILE PARAMETERS	ASTRO IMBE VOCODER, 1/4 WAVE ANTENNA ON GLASS,								
SITE	**COORDINATES**			**TX ANTENNA SYSTEMS**			**RX ANT SYSTEM**		
	LAT (N)	**LONG (W)**	**ERP (DBM)**	**HT (FT)**	**LINE LOSS (DB)**	**ANT GAIN (DBD)**	**HT (FT)**	**LINE LOSS (DB)**	**ANT GAIN (DBD)**
SAWYER RIDGE	37-34-27.31	122-25-22.86	53.8	48	5.7	9.5	60	7.3	9.5
KINGS MOUNTAIN	37-26-9.8	122-19-12.5	52.2	150	6.8	9	160	7	9
MT. ALLISON	37-29-58	121-52-21	52.1	160	6.9	9	195	4.3	9
MARCIAL PEAK	37-38-9.6	121-37-21.5	53.9	40	3	9.5	40	3	10.4
ACITD									
CCWD	37-39-9.07	121-28-41	53.3	100	6.2	9.5	100	6.2	10.4
MOCCASIN PEAK	37-48-18.5	120-19-40.66	53.3	6.2	100	9.5	90	6.2	9.5
DUCKWALL	37-58-7.3	120-7-11.5	53.2	60	5.8	9	60	5.8	9
BURNOUT RIDGE	37-55-54	119-55-4	51.9	180	7.1	9	180	7.1	9
POOPENAUT PASS	37-54-13	119-49-59	53.1	70	5.9	9	70	5.9	9
SVWTP	37-32-14.6	121-51-22.73	53.7	60	5.8	9.5	60	5.8	9.5
INTAKE RADIO SITE	37-52-3	119-58	27.7	60	5.8	9	60	5.8	9

UHF System

Motorola did evaluate the potential for a UHF system by running coverage maps and also performing a frequency search. While it does appear at this time that there are potential UHF candidate frequencies for a UHF system, Motorola has concerns with the viability of such a system. Recent experience with UHF spectrum on a public safety trunked system has shown that interference is common. Any move toward a UHF system would require a full spectrum analysis, including spectrum fingerprinting, to ensure the viability of the selected spectrum for use.

4.2.3.3 Capacity Analysis

Motorola ran a loading and capacity analysis for the SFPUC system design for the SFPUC based on the requirements in the RFP Sections 4.4, 4.11. Based on the information used in the simulation, Motorola can guarantee that the system as designed will meet the SFPUC loading requirements listed in the RFP.

The loading and capacity requirements that Motorola took into account were:

1. The traffic study will take into account for 125 users active across the entire system. The 125 users takes into account for the 25% growth expected.
2. GOS of the system was to be no higher than 5% GOS.
3. Request of GPS location polling every 5 minutes.
4. The Talkgroups matched what were received in the Questions_Answers document.

Motorola made the following assumptions regarding the SFPUC loading and capacity analysis.

- All talkgroups used the same loading characteristics. The message length to be 9 seconds and arrival rate of 1 second.
- Assumed each talkgroup operated in their region.
- With three regions assumed for uniform user distribution in each region, approximately 41 users in each of the three regions.
- In each region, users were uniformly distributed across the coverage in each given region.
- For this simulation, assumed that each regional talkgroups operated in its own region. No migrations of talkgroup were simulated.
- 100% users were FDMA. Additional capacity would be realized with the TDMA design provided.
- Motorola will revise this analysis during the project as additional information becomes available.

4.2.4 Asset Management (Included)

The city of San Francisco has just completed the purchase of a Motorola Asset Management solution as part of the City's P25 System. Motorola has included licensing on this system to include the SFPUC system components.

In a typical communications system environment, an organization uses multiple sources of data storage for the tracking of various communications assets. This method of tracking information can lead to missing or incomplete data, duplication of data, and offer difficult means for accessing the critical information. Motorola's Asset Management offering allows the management of this information to be handled in a web-based commercial off-the-shelf (COTS) product.

Motorola's Asset Management solution is unique in that it offers some distinct benefits to SFPUC in the following areas:

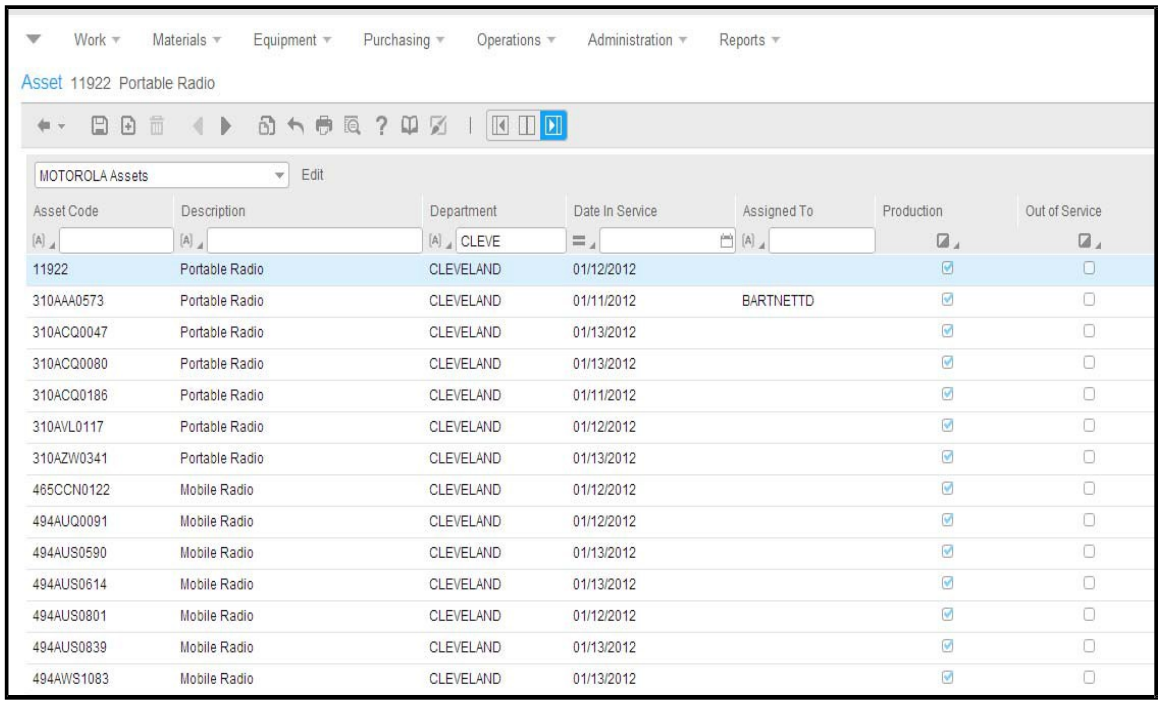
- The cloud-based SaaS (Software as a Service) offering is secure, flexible, configurable and scalable which offers SFPUC an easily accessible and easily supported long-term solution.
- The system is easily configured. This means that the asset tracking data and processes can be updated through the application's configuration settings rather than custom code development.
- This solution easily allows customers to migrate any existing Access or Excel data into the application through the various migration tools provided with the new software. This capability is critical because it greatly reduces the risk of lost data, re-entry of data, or the costly expense of data conversion services.
- The application can be expanded as asset management needs change. With so much inherent functionality, organizations can add assets, department, users, security, and more with simple configuration items.
- The solution is integrated with Motorola's internal ordering, maintenance, and support systems. Likely the most beneficial advantage of Motorola's asset management system is the integration of Motorola's core systems to the customer's asset management environment. This groundbreaking functionality automatically transfers customer's equipment data with Motorola's Order, Configuration, Installation, and Support Systems.

For the reasons stated above and coupled with the fact that Motorola's radio asset management solution can be accessed over the Internet and can be made available to users outside of your organization (if necessary), makes this system the right choice to address both current asset tracking needs as well as future goals surrounding radio asset management and maintenance activities.

The screen shots below represent a description and typical configuration of a **communication infrastructure asset management deployment**. These screen shots are meant to give real-world examples of how information can be organized for an organization's asset management initiative and to provide a better understanding of Motorola's asset management offering in a web-based environment. Details of the information being displayed are provided for each screen shot.

Organized Asset Tracking

The List View screen of the application displays the available assets that an organization desires to track in the system and allows for convenient searching with pick-list or free-form text functionality (Figure 4-22). Portable radios are shown as an example. It also serves as the screen where the user can sort or filter on the different types of assets that are being tracked. All columns in the result set may be resized or ordered by the user. Using the query functionality, the information on this list view may be modified to contain different fields as needed. Tabs in the upper left portion of the screen provide further detail for the selected asset such as comments, history, warranties, and related documents.



Asset Code	Description	Department	Date In Service	Assigned To	Production	Out of Service
		CLEVE				
11922	Portable Radio	CLEVELAND	01/12/2012		☑	☐
310AAA0573	Portable Radio	CLEVELAND	01/11/2012	BARTNETTD	☑	☐
310ACQ0047	Portable Radio	CLEVELAND	01/13/2012		☑	☐
310ACQ0080	Portable Radio	CLEVELAND	01/13/2012		☑	☐
310ACQ0186	Portable Radio	CLEVELAND	01/11/2012		☑	☐
310AVL0117	Portable Radio	CLEVELAND	01/12/2012		☑	☐
310AZW0341	Portable Radio	CLEVELAND	01/13/2012		☑	☐
465CCN0122	Mobile Radio	CLEVELAND	01/12/2012		☑	☐
494AUQ0091	Mobile Radio	CLEVELAND	01/12/2012		☑	☐
494AUS0590	Mobile Radio	CLEVELAND	01/13/2012		☑	☐
494AUS0614	Mobile Radio	CLEVELAND	01/13/2012		☑	☐
494AUS0801	Mobile Radio	CLEVELAND	01/12/2012		☑	☐
494AUS0839	Mobile Radio	CLEVELAND	01/13/2012		☑	☐
494AWS1083	Mobile Radio	CLEVELAND	01/13/2012		☑	☐

Figure 4-22: List View Screen

Tracking Attribute and Status Changes on Assets

The Record View Screen of the application gives users a detailed look at any specific asset in a tabular format (Figure 4-23). It includes data fields, which lists asset details (attributes) of the specific asset. This, like all forms, is a configurable screen where the fields can be moved, hidden, added, made required, and protected by the configuration manager. This allows organizations a great deal of flexibility in how asset information is stored in the system.

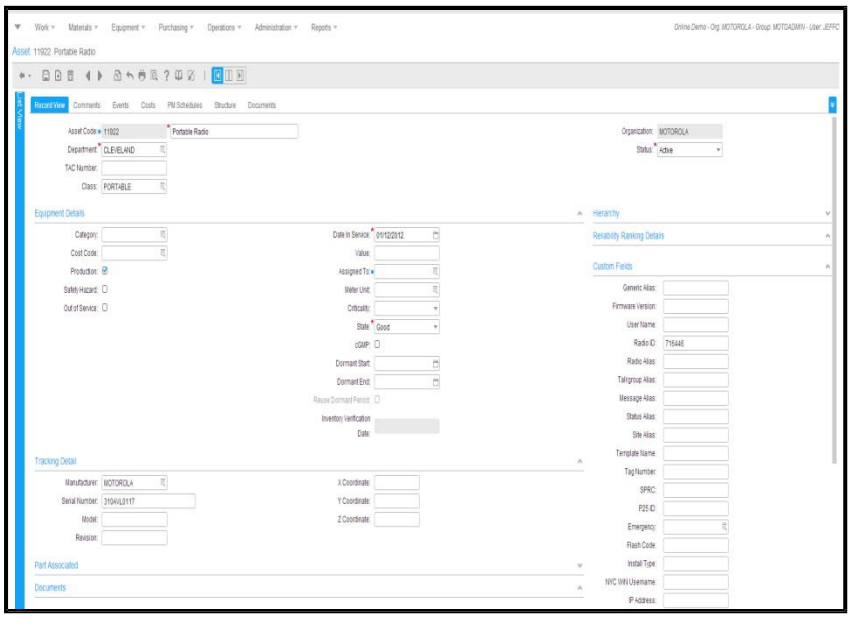


Figure 4-23: Record View Screen

The Record View Screen allows users the following functionality:

- Provides a quick and effective way for your team to track an asset's status and location.
- Maintain and track an unlimited amount of information on a specific asset or group of assets.
- Assign assets to individuals, organizations, or locations.

Organized Asset Structure

The Structure tab offers users a hierarchical view of equipment being tracked (Figure 4-24). The system is unique in the fact that there is an unlimited number of "levels" that an administrator may create in order to meet the needs of both large and small organizations. The hierarchy is completely user-defined and flexible for any future changes that may need to occur.

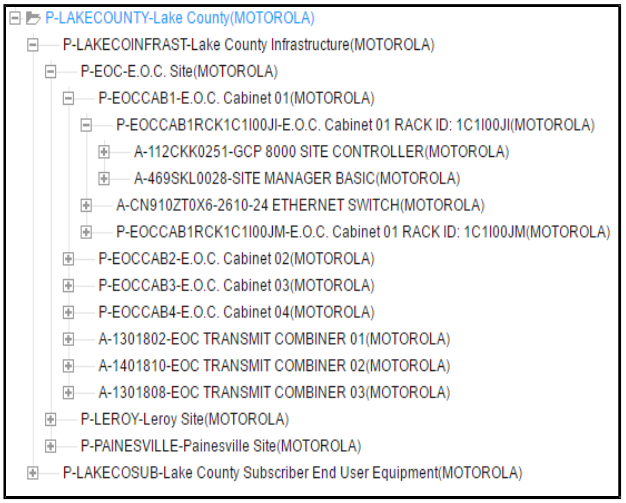


Figure 4-24: Structure Tab

The Structure tab provides users of the system with robust asset management capabilities including:

- Efficient movement or relocation of assets through click-drag-drop technology.
- Cost and other reporting "roll-up" throughout every level of the hierarchy.

Dashboard

The offering also allows users and administrators to get an overall view of performance-related activities. KPIs (Key Performance Indicators) display a graphical depiction of KPI status based on user-specified parameters (Figure 4-25). An organization can utilize this functionality by defining the important performance metrics required and can utilize the dashboard to assess how the team is performing in a variety of asset tracking areas.

Figure 4-25: Key Performance Indicators

Reporting

The Advanced Reporting web architecture provides anytime access to users throughout an organization. The solution's familiar browser-based user interface facilitates greater productivity by encouraging user adoption. What's more, both the interface and level of reports can be tailored to all levels of users—from novice to advanced—putting critical information in the hands of the right decision-makers in a matter of minutes. Anything, from Inventory Quantities to Equipment Locations can be filtered, organized and exported to Excel. This ability extends the reach and power of the system beyond the licensed users to include "non-users". With this insight, customers have the tools needed to make faster, smarter business decisions that make an impact when and where it matters most.

4.2.5 Backhaul Design

The state-of-the-art microwave network for SFPUC has 10 sites and 8 Hot Standby microwave hops consisting of the following products:

- Nokia 9500 Microwave Packet Radio Transceiver (MPT).
- Nokia Microwave Service Switch 8 (MSS-8).

The network consists of linear hot standby microwave hops as shown in Figure 4-26. It will utilize Nokia's 9500 MPR MPT-HC-HQAM transceivers. Nokia's HQAM radios allow the customer to maximize the useful over-the-air bandwidth by using higher modulation schemes (QAM). The 9500 MPR is a 100% packet technology which offers further operational simplicity when compared to hybrid microwave systems which are less efficient and require the use of both packet and TDM networking technology to create a microwave network.

The design utilizes the number of sites needed to implement the SFPUC system and incorporate

these links into the existing city of San Francisco network and the existing Hetch-Hetchy microwave network providing end-to-end communications from the city out to the Hetch-Hetchy region.

The links include:

- Foresthill to Sawyer Ridge.
- Sawyer Ridge to Kings Mountain.
- Kings Mountain to Mt. Allison.
- Mt. Allison to ACITD.
- ACITD to CCWD.
- CCWD to Pelican.
- Moccasin Peak to Duckwall.
- Duckwall to Intake Radio Site.Motorola will add a Microwave hop to Poopenaut Pass from one of these sites, at no cost to the SFPUC.

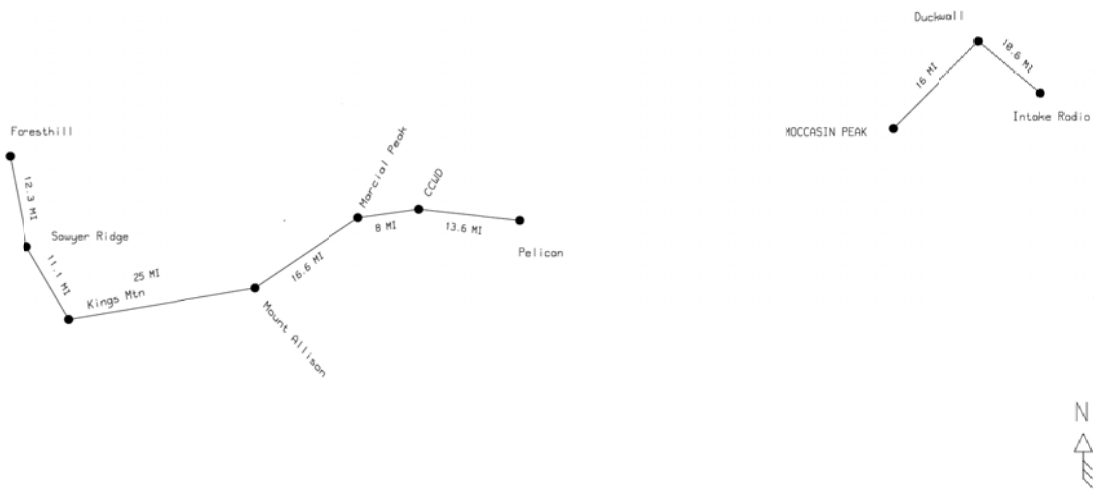


Figure 4-26: SFPUC Microwave Network

All RF paths will be designed using the 11 GHz frequency with 30 MHz channels. Each path was design with a 99.999% availability for 109 Mbps. While the RFP requirements in Section 4.4 specified only a 99% reliability, Motorola and Nokia felt that a higher, 99.999% reliability more closely aligned with the type of system and the users proposed for its use.

Motorola has included the SNMP licenses for the UEM to allow the SFPUC microwave components to be managed by the San Francisco UEM system, integrated into a single location for SFPUC. During the design review phase of the project, this UEM subsystem can be expanded to include existing SFPUC facilities.

Table 4-15 below, summarizes the microwave configuration. The one exception is the Pelican tower will utilize an Outdoor Configuration due to the distance of the tower from the site.

Table 4-15: 9500 MPR Architecture for SFPUC MW Network

Path	Topology	Freq	Channel BW	BW, Mbps	Availability	Configuration n
Foresthill to Sawyer Ridge	1+1 HS	11 Ghz	30 Mhz	109 Mbps	100.00%	Indoor
Sawyer Ridge to Kings Mountain	1+1 HS	11 Ghz	30 Mhz	109 Mbps	100.00%	Indoor
Kings Mountain to Mt. Allison	1+1 HS	11 Ghz	30 Mhz	109 Mbps	100.00%	Indoor
Mt. Allison to Marcial Peak	1+1 HS	11 Ghz	30 Mhz	109 Mbps	100.00%	Indoor
Marcial Peak to CCWD	1+1 HS	11 Ghz	30 Mhz	109 Mbps	100.00%	Indoor
CCWD to Pelican	1+1 HS	11 Ghz	30 Mhz	109 Mbps	100.00%	Indoor
Moccasin Peak to Duckwall	1+1 HS	11 Ghz	30 Mhz	109 Mbps	100.00%	Indoor
Duckwall to Intake Radio	1+1 HS	11 Ghz	30 Mhz	109 Mbps	100.00%	Indoor

The Poopenaut hop from one of the other sites will be added during design. ACTID hop needs to be redesigned.

4.2.5.1 Site Configuration

All sites will be equipped with Nokia 9500 MPR indoor microwave systems using Multi Service Switch 8 (MSS-8) indoor unit and MPT-HC-HQAM transceiver.

Figure 4-27 and Figure 4-28 show 9500 MSS-8 and MPT-HC-HQAM Transceiver.

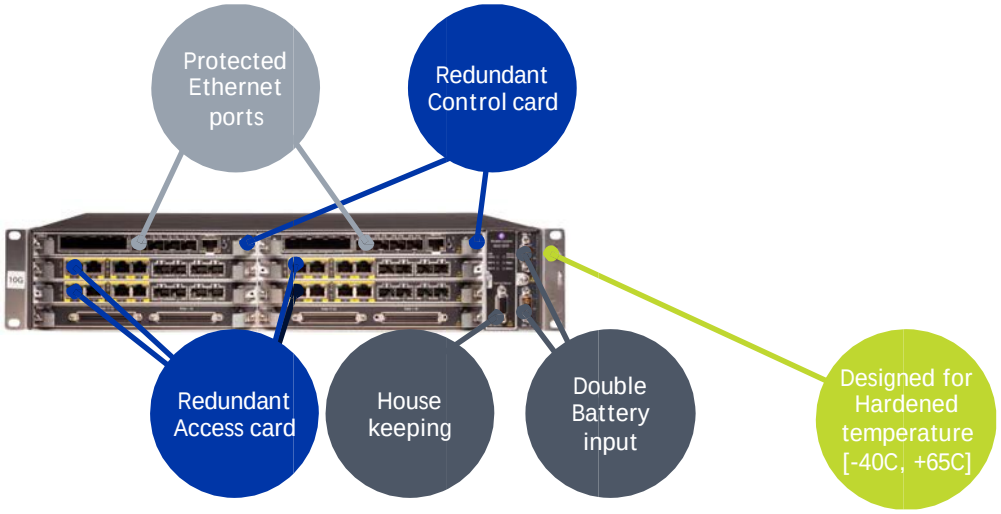


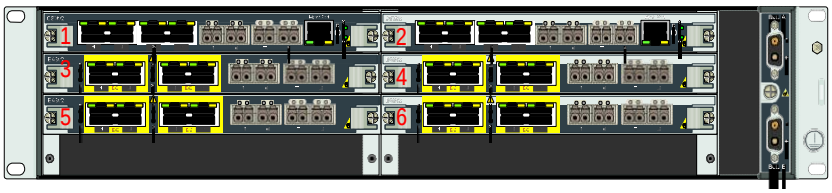
Figure 4-27: MSS-8 Shelf

Figure 4-28: MPT-HC-HQAM Transceiver

Each indoor MSS-8 shelf is configured with redundant CorEvo controllers and Ethernet Access Switch (EASv2) modules to prevent a single point of failure.

The Control and Switching Module (CorEvo) performs all supervisory functions for the 9500 MPR MSS-8 and switches Ethernet packets from peripherals to radio cards. The CorEvo consists of microprocessor and Ethernet switch circuits.

Figure 4-29 shows a MSS-8 shelf equipped with redundant CorEvo controllers and four EASv2 modules.



1,2 Redundant CorEVO
3,4,5,6 EASv2 Modules

Figure 4-29: MSS-8 Shelf (Shown as example, site configurations will vary)

4.2.5.1.1 9500 Microwave Packet Radio (MPR)

The 9500 Microwave Packet Radio (MPR) is a microwave digital radio that supports PDH, SONET and packet data (Ethernet) for migrating from TDM to IP. 9500 MPR operates in the RF bands from 6 GHz to 38 GHz. **Packet radio means that all the transmitted traffic is Ethernet traffic**.

The 9500 MPR provides a generic, modular IP platform for multiple network applications (including 2G/3G/HSDPA/WiMAX backhauling to Metro Ethernet areas) to accommodate broadband services. The 9500 MPR radio family supports low, medium, and high capacity applications using North American data rates, frequencies, channel plans, and tributary interfaces.

The traffic is transmitted via Native Ethernet traffic.

In case of PDH or SONET traffic, the traffic is packetized into Ethernet frames and sent to the L2 Ethernet Switch to be distributed to the different microwave transceivers, according to the Ethernet Switch configuration.

In case of native Ethernet traffic, the traffic is sent directly to the Ethernet Switch, managed according to the configuration of the Ethernet Switch and then sent to the different microwave Transceivers, always according to the configuration of the Ethernet Switch. The L2 Ethernet Switch is inside the CorEvo unit.

The packetizer/depacketizer is inside a PDH or SONET unit, depending on the type of traffic. The 9500 MPR employs innovative solutions as shown in Figure 4-30 below.

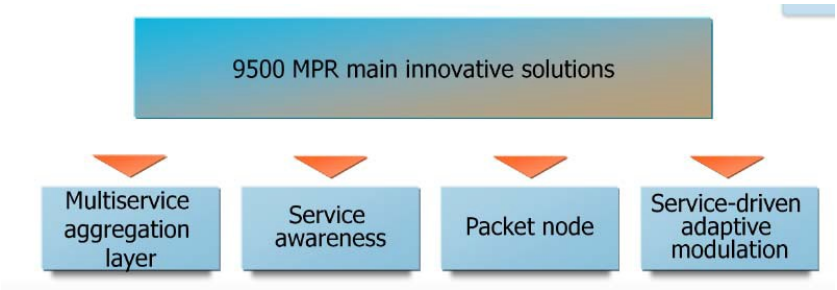


Figure 4-30: 9500 MPR innovative solutions

Multiservice aggregation layer: the capacity of using Ethernet as a common transmission layer to transport any kind of traffic, regardless of the type of interface. Ethernet becomes the convergence layer.

Service awareness: traffic handling and quality management, queuing traffic according to the type of service assigned, regardless of the type of interface.

Packet node: no service aggregation limits with all traffic aggregated in packets, in terms of capacity, type of service requirements, and type of interface.

Service-driven adaptive modulation: fully exploit the air bandwidth as a whole by changing the modulation scheme in accordance with the propagation availability and by allocating transport capacity, discriminating traffic by different services, possible only in a packet-based environment.(Figure 4-31).

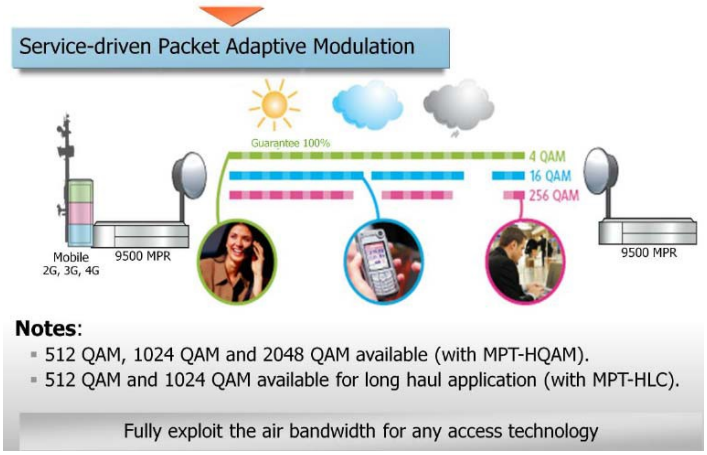


Figure 4-31: Service-driven adaptive modulation

The 9500 MPR node is available in the following architecture:

Split Mount:

- Full Indoor

Radio I/O Configuration:

- MSS-8.

The number of indoor transceivers (called MPT) depends on the radio directions to be implemented in the radio station and on the radio protection scheme. The maximum number of MPT is 24.

Included MPT:

- MPT-XP-HQAM.

Security

The most flexible security design combines the inherent security capabilities of the Nokia 9500 MPR platform with a sound security policy and security framework. For maximum security that cannot easily be circumvented, solutions can use individual link identifiers, secure protocols support such as SFTP.

HTTPS, SSH, and SNMPV3 management traffic encryption and validation, and authentication and authorization mechanisms.

SNMP operating mode (SNMPv3 support)

The SNMP operating mode of the NE can be set using the WebEML or the web interface.

The following SNMP operating modes are supported:

- SNMPv2: Only SNMPv2 or v1 managers can access the NE. This is the default operating mode.
- SNMPv3: Only SNMPv3 managers can access the NE.

SNMPv3 addresses security problems by adding two new features on top of the existing SNMPv1 and SNMPv2 network management protocols:

- Authentication using hashing and time stamps.
- Confidentiality using encryption.

SNMPv3 is based on the following:

- The User based Security Model (USM), which provides strong user authentication, data integrity, privacy (encryption) and time stamp management (timeliness).
- The View base Access Control Model (VACM), which provides a mechanism for managing what information is available to users.
- Authentication is provided using the HMAC-MD5-96 standard authentication protocol. The SNMP operating mode is stored in permanent memory on a Flash card.

SSH and SFTP support

9500 MPR supports the client-server model for SSH. The server mode is enabled at startup and cannot be disabled. The operator can open up to five simultaneous SSH sessions. The client mode is supported only for file downloads using SFTP.

FTP or SFTP can be used to download software. When SFTP is used, the server host key fingerprint must be provided during download initialization. FTP is the default protocol selection. To initiate an SFTP session, the user must have either administrator or craftsperson privileges.

4.2.5.1.2 Microwave Service Switch (MSS-8)

The MSS-8 houses equipment that supports 10 Gb/s packet switching, synchronization, protection switching, provisioning, and alarm management. Two Core slots support either one Core card in unprotected configuration or two Core cards in protected configuration. Six transport slots support any mixture of unprotected and/or 1+1 EPS protected transport cards. MSS-8 shelf (2RU) supports up to 24 unprotected links or up to 12 protected links or a mix of them (Figure 4-32).

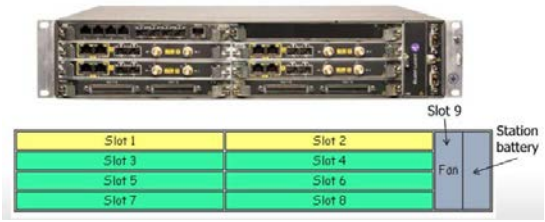


Figure 4-32: Microwave Service Switch (MSS-8)

The MSS-8 shelf houses the following cards:

Core Card:

- Core-E—Enhanced Control and Switching Module.

CorEvo

- P32E1DS1—DS1/E1 PDH card.
- P2E3DS3—DS3 PDH card.
- SDHACC (OC-3/STM-1)—OC-3/STM-1 SDH card.
- P8ETH (EAS)—Ethernet Access Switch card.
-

EASv2—Ethernet Access Switch Card

- MPTACC (RADIO)—MPT Access card.
- MOD300 (RADIO)—Modem card.
- AUX—Auxiliary card.
- Power Injector card.
- Power Converter.
- Fan.

MSS-8 slots allocation:

- Slot 1 is dedicated to the CorEvo Main unit.
- Slot 2 is dedicated to the CorEvo Spare unit.
- Slots 3–8 are universal slots and can be used for transport and radio units.
- Slot 9 is reserved to the Fan unit.

The MSS-8 operates on -48 VDC (-40.8 to -57.6 VDC) dual feeds input power. Each MSS-8 shelf requires two power cables to provide fused power backup in case of a blown fuse or bad Cable/connection to the MSS-8 shelf. The A-side power connection of the MSS-8 shelf should be fused through the A-side of the fuse panel. The B-side power connection of the MSS-8 shelf should be fused through the B-side of the fuse panel.

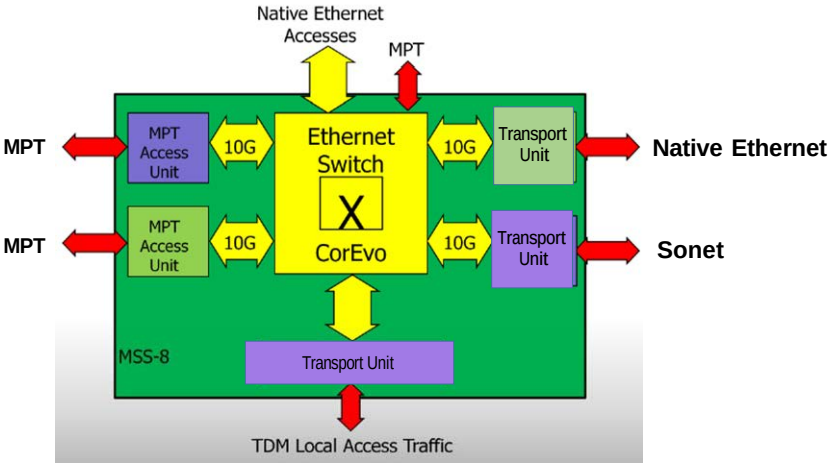


Figure 4-33: MSS-8 Architecture

As shown in Figure 4-33, the MSS-8 manages multiple transport units of different type. For example, TDM local access, Ethernet, radio interfaces towards MPTs and to connect each of them to the Ethernet switch inside the CorEvo. The interconnections between the transport units and the CorEvo unit takes place on the MSS-8 backplane, which has a 10G capacity.

4.2.5.1.3 CorEvo

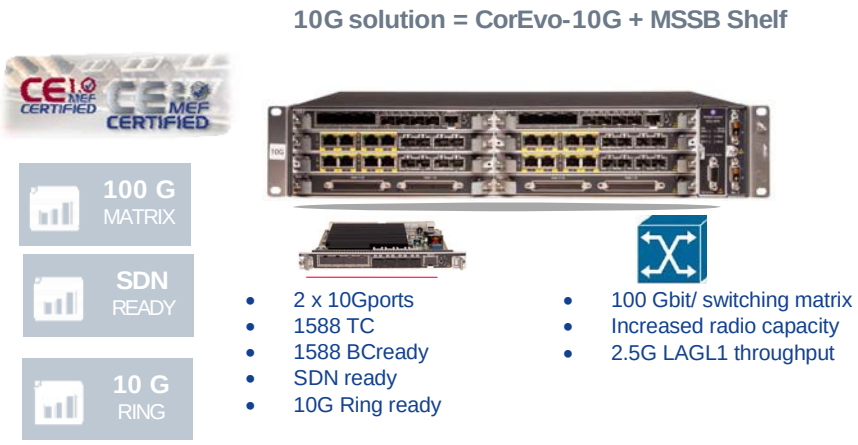
The CorEvo card provides eight user Ethernet interfaces, up to four 10/100/1000BaseT electrical Ethernet interfaces, up to four optical SFP Ethernet interfaces, the local WebEML interface, and local debug interface (Figure 4-34).

The CorEvo card has two roles, main and spare. The main CorEvo performs key node management, control functions, provisioning, configuration management, and cross-connection matrix. The matrix is a standard Ethernet switch based on VLAN. The card also houses a plug in flash card which stores node configuration and license data. The spare CorEvo card is included, provides aggregate traffic and control platform protection. The following CorEvo is available:

- **CorEvo-10G.**

CorEvo-10G is the **FIRST 10G** capable system on the microwave market. It offers 100Gb/s switching matrix, MEF 2.0 certified, 1588 TC/BC/OC and SDN ready. It supports two 10 Gbps ports and 2.5G LAG throughput.

Figure 4-34: CorEvo



The CorEvo-10G unit (Figure 4-35) provides the key node management, control functions, and Ethernet User traffic management by performing the following macro functions:

- MSS Controller to manage all the peripheral units. MSS has one-layer control architecture implemented by a microprocessor acting as Equipment Controller and Physical Machine Controller.
- Layer-2 Ethernet Switch performing Cross-Connect function between all the peripherals and Ethernet ports. The switch assures to the system a complete interconnection between all the boards connected into MSS node.
- Clock Reference Unit (CRU) with main function to generate the Network Element Clock.
- Ethernet interfaces (10M/100M/1G/10G) can be used or used as user interfaces or used to connect up to 6 MPT (Outdoor unit).
- The CorEvo-10G unit embeds a microSD card, which among other things stores the terminal SW configuration and the Node license.
- CorEvo-10G provides HW support for 10Gbps user interfaces, 10Gbps ring, 1588v2 on path support, and enhanced Ethernet features.

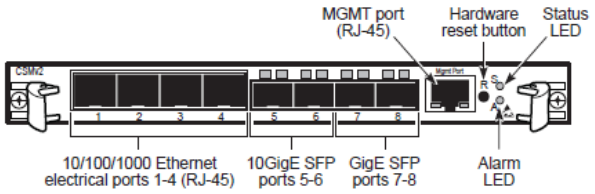


Figure 4-35: CorEvo-10G

The CorEvo unit provides the following hardware support:
Based on packet technology with eight GbE serial internal interfaces between CorEvo and peripherals (jumbo frames 9728 bytes allowed):

- 4x10/100/1000 Ethernet electrical embedded interface (RJ45): port #1 to port #4.

- 2x10G SFP optical interface with speed up to 10 Gb/s: port #5 and port #6.
- 2x1000 SFP optical interface with speed up to 1 Gb/s: port #7 and port #8.

Port #1 through port #4 support interconnection directly to MPT-HC/HCHQAM/XP/XP-HQAM. **Port #7** and **port #8** support interconnection directly to MPT-HC/HC-HQAM/XP/XP-HQAM and MPT-HL/HLC.

The CorEvo module uses Sync In/Out Small Form Factor Plug-in (SFP) to provide dedicated Sync ports. The Sync In/Out SFP provides both Sync-In and Sync-Out ports. The SFP can be installed in ports 7 and 8 of a CorEvo module. Figure 8 shows Sync In/Out SFP.

With the Sync In/Out SFP installed (Figure 4-36), the CorEvo can provide a reference clock according to any of the following:

- 2.048 MHz, electrical levels according to G.703, clause 13.
- 5 MHz, + 6 dBm ± 1.5 dBm into 50 ohm, sine-wave.
- 10 MHz, + 6 dBm ± 1.5 dBm into 50 ohm, sine-wave.
- 1.024 MHz, electrical levels according to G.703, clause 13 with the following exception:
    - timing scaled from 2.048 MHz to 1.024 MHz.

Figure 4-36: Sync In/Out SFP

4.2.5.1.4 EASv2 Card

Provides up to eight ports for customer Ethernet traffic or for the connection to an MPT transceiver.

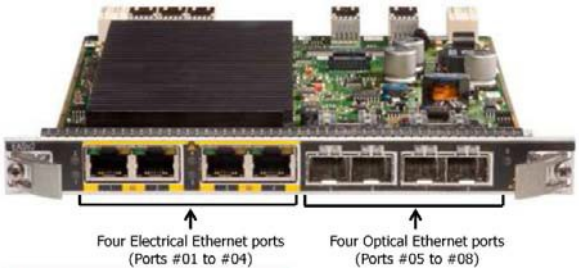


Figure 4-37: EASv2

The EASv2 unit (Figure 4-37) supports the following traffic external interfaces:

- Port #1 to port #4: Ethernet 10/100/1000 Base-T
- Port #5 to port #8: Ethernet SFP 1000 Base-X optical

Microwave Packet Transport (MPT)

MPT contains not only the transceiver section but also the modem section. MPT is performing the following main five functionalities:

- Data interfaces and RPS protection.
- Framing, QoS and modem functions with an integrated microprocessors capable to manage the antenna pointing and local management signal.
- RF and IF functionalities.
- Separation of radio TX and RX signal with diplexing functionalities.

The diplexer is internal or external depending on the frequency. The following MPT is included:

- MPT-HC-HQAM

4.2.5.1.5 MPT-HC-HQAM

The Nokia 9500 Microwave Packet Radio (MPR) family includes a range of Microwave Packet Transport (MPT) units for shorthaul applications. These MPT units operate in the standard frequency bands and are designed to provide high-capacity reliable backhaul for Land Mobile Radio systems. The MPT-HC-HQAM units combined with the 9500 MPR Microwave Service Switch (MSS), set the standard for delivering fast, efficient wireless transmission links with flexible networking and simple operations.

The MPT-HC-HQAM is a radio that uses Hierarchical Quadrature Amplitude Modulation (HQAM), which uses higher-order modulation to maximize spectral efficiency over a microwave communications channel. It also employs packet compression mechanisms, which reduce the overhead introduced by a frame or packet structure to help increase in spectral efficiency in a full packet-based environment.

HQAM formats increase the density of modulation symbols in a transmitted constellation. For example, 512-state quadrature amplitude modulation (512QAM) and 1024QAM formats provide a combined sequential gain of about 25% in useable traffic capacity compared to 256QAM. And 2048QAM and 2096QAM formats deliver an additional 15% capacity gain over 512QAM and 1024QAM.

Packet compression acts on the protocol overhead portions of IP packets. Fields belonging to Ethernet, Multiprotocol Label Switching (MPLS), IP and TCP/UDP are compressed before transmission and rebuilt at the receiving end of a microwave link. This reduces the number of bits sent across the link, improving capacity for services and applications.