Metropolitan Transportation Authority

MetroTrans

Mobile Communication System

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[Note: This 160-page manual has been shortened and scrubbed so I could use a portion in my portfolio.]

Document History

Date	Version Number	Comments
February 2007	1.0.0	First draft, prior to stakeholder review
April 2007	1.0.1	Second draft, after first review; expanded Sections 7 and 8; added info about the power supply.

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[This TOC has been removed – the original TOC was 9 pages long.]

Appendix Index

[Appendix diagrams cannot be included.]

Glossary

APC	Automatic Passenger Counter, a device that uses an infrared sensor to 'count' passengers entering and exiting a bus
BIOS	Acronym for Basic Input Output System, the Read Only Memory that contains the most basic routines to interface with hardware
Band	The spread of a range of frequencies used for a given purpose, e.g. the width of individual channels allotted to data transmission
CAD	Computer Aided Dispatch
Communica-tions Link	A circuit that is used to send and receive information from a remote location
Coverage	The amount of area where a radio system will provide communications
DAS	Digital Audio Switch
Data911	1. The company that manufactures the Mobile Data System, adopted by MTA as part of the MetroTrans system 2. The Data911 display (or touchscreen), which is a component of the Mobile Data System
EMR	Emergency
ESN	Electronic Serial Number
Fixed	Also called Fleet; these large buses have fixed routes and schedules
PRCC	Paratransit Radio Control Center
Full-duplex	Allows transmission to take place in both directions simultaneously
Group	*Radio units* can be put into groups to allow *group calls* to take place. The maximum number of groups permitted is dependent on the number entered on the Fleet record.
Group call	A call involving more than two *radio unit* users simultaneously. A *group call* may be a local *Site* group call, for which all users are controlled by the same *Site*.
GUI	Graphical User Interface
Half-duplex	When transmission can take place in either direction, but only one direction at a time
Ident	An acronym used in the MPT 1327 standard referring to the least significant bit of a unit or group identity
LAN	Local Area Network
LCD	Liquid Crystal Display
LDT	Line Dispatcher Terminal

LMR	Land Mobile Radio system
MAP 27	MAP = Mobile Access Protocol; MAP 27 is a data communication standard
MPT	*Ministry of Posts and Telecommunication*, the radio/telephone regulatory agency based in the UK
MPT 1327	A *radio unit* Signaling Standard (or Protocol) for trunked private land mobile radio systems.
MPT 1343	A radio interface specification (or fleet numbering Protocol) for commercial trunked networks operating in Band III, sub-bands 1 and 2
MDC	Mobile Data Computer, the part of the MDS that contains the computer motherboard and hard drive
MDS	Data911 Mobile Data System, which includes the computer (MDC) and the touchscreen
MST	Multi Segment Transmission, a text transmission composed of 4 SSTs
NC	Normally Closed (relay switch status)
NDD	Network Dependent Data
NIC	Network Identity Code
NMT	Network Management Terminal
NO	Normally Open (relay switch status)
Node	An abbreviation for *Network Node*. The central electronics controller for the Tait Trunked Radio system. The *Node* maintains *registration* and *validation* databases – all calls are logged by the *Node*.
Node Box	Used to run the *Node* software. It processes the requests from the *Sites* for *inter-site* or *inter-node* calls, communicating with them through the MPT protocol.
NPD	Non-Prescribed Data Call – In-band data signaling of a non-MPT format which requires the use of an audio channel
PA	Public Address, i.e. PA Amp and PA System
PABX	Private Automated Branch Exchange
PSTN	Public Switched Telephone Network
PTT	Press to Talk
Queuing	Waiting in sequence for a resource to become available. When a call is attempted and a channel is not available, the call is placed in a queue until a channel becomes free.
RCC	Radio Control Center
Regional Node	*Regional Nodes* handle inter-site calls and connect to *PABX* and *PSTN* lines. Although capable, the MTA system does not utilize a Regional Node.

RF	Radio Frequency
RFID	Radio Frequency Identification, used in contactless fare transactions
RSAS	Radio SoundBlaster Audio Switch, I/O Box function
RX	Radio Receiver
SB	Sound Blaster, considered the industry standard in PC audio
SBAMS	Sound Blaster Audio Mute Sense, I/O Box function
Short data message	Messages that carry more data than a status message, but still do not require an audio channel; user data is contained in the signal
SIC	System Identity Code
SIO	Serial Input/Output
Site	A radio repeater location
SST	Single Segment Transmission, a text transmission of up to 25 bytes (24 characters)
Status message	Short signaling messages that carry only a number between 0 and 31. Because of the brevity of the message, no audio channel is used.
SVC	Service
TaitNet	A generic name given to Tait Electronics Ltd trunked network equipment
Transmitter	The equipment used to produce and modulate radio frequency current.
Thermistor	A combination of the words thermal and resistor. A thermistor is a resistor used to measure temperature changes.
Trunking	Applies to a radio communications network and describes a method used to dynamically share a number of communications channels among a large number of users.
TX	Radio Transmitter
UI	User Interface
WAN	Wide Area Network
Wi-Fi	Wireless fidelity - the IEEE 802.11 standard that denotes a Wireless LAN
WLAN	Wireless Local Area Network

1 Overview

1.1 Introduction to MTA

The Metropolitan Transportation Authority (MTA) is a multi-modal transportation organization that provides a full line of transportation services to more than a million people living in five northern Utah counties. Founded in 1970, MTA services include Fleet Bus, Paratransit, Light Rail, Commuter Rail and Transit Police.

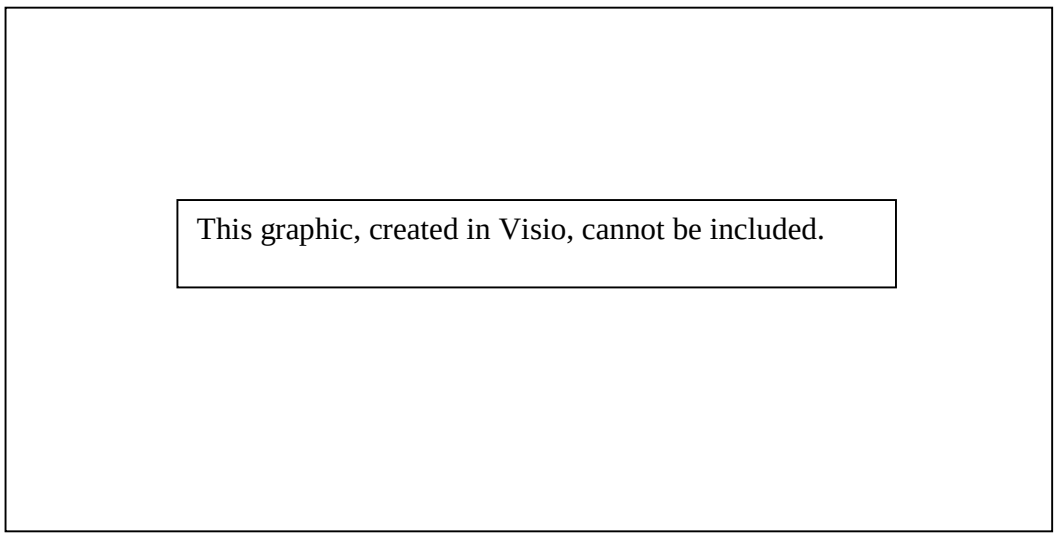
The MTA service area stretches over 100 miles north to south and 50 miles east to west. The service area includes seven maintenance facilities and three dispatch centers. Fleet and Paratransit Buses operators use the MetroTrans System to communicate with dispatchers and supervisors.

1.2 Introduction to MetroTrans

The MTA MetroTrans System was designed *by* MTA employees *for* MTA employees. MTA improved its award-winning transportation service by developing the MetroTrans mobile communication system, which integrates radio, computer and GPS systems to offer state-of-the-art communication among dispatchers, operators and supervisors.

1.2.1 MetroTrans Bus Configuration

The following graphic shows the MetroTrans components installed in MTA bus.



The MetroTrans System allows bus operators to determine the priority level for any Request to Transmit (RTT) messages and for RCC personnel to control radio traffic.

1.2.2 MetroTrans System Bus Components

In MTA buses, the MetroTrans System includes the following main components:

- Radio and antenna
- Wi-Fi communication system
- Mobile Data System
- Radio Interface Box
- Global Positioning System receiver

1.2.2.1 Trunking Radio Communication System

Large organizations that establish their own dedicated radio network typically select a trunked radio scheme because trunked systems offer wide-area dispatch, an economical infrastructure, and the ability to make private calls. Trunking offers an efficient and effective use of the radio spectrum. Trunked radio systems offer features like emergency and priority call management, status messaging, dynamic regrouping of users, and data/text messaging.

MTA buses, along with mobile and handheld radios used by MTA personnel, communicate through a trunked radio system. Learn about MTA's trunked radio system in Section 2, Trunking Radio System, and in Section 3, Trunking Radio Sites.

1.2.2.2 Wi-Fi Communication System

'Wi-Fi' refers to a wireless local area network (WLAN) that is based on IEEE 802.11 specifications. The Wi-Fi standard was developed for use by mobile computing devices, such as laptop computers, and for VoIP (voice over Internet protocol) phone access. (Note: The MetroTrans system does not utilize the VoIP capability at this time.)

In MTA buses, the Mobile Data Computer uses the Wi-Fi connection to upload software upgrades from the network server and to download accumulated data at the end of a shift. However, the bus can only establish a Wi-Fi network connection when it is within 50 meters of a MTA business unit.

Learn more about how the MetroTrans System uses the MTA Wi-Fi network in Section 5.8, Wi-Fi Network.

1.2.2.3 Mobile Data System

The Data911 Mobile Data System contains three components:

- The mobile computer, referred to as the MDC
- The touchscreen display, situated in front of the bus near the operator
- The filtered 12V power supply

Bus operators use the touchscreen display to interface with the Mobile Data Computer. Through the MDC, the RIB (radio interface box), and the Tait radio system, the computer sends short data messages from the operator to the dispatcher.

In addition, dispatchers can send data messages to operators; these messages appear on the touchscreen display. Learn more about the Mobile Data System in Section 6, Mobile Data System and Section 7, MDC System Diagnostics.

1.2.2.4 Radio Interface Box

On MTA buses, the MetroTrans System requires a Radio Interface Box. MTA communications engineers designed and constructed the I/O Box to interface between the Mobile Data System and peripheral equipment, such as Tait radio, PA system, Emergency alarm, GPS and fare box.

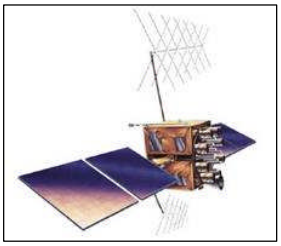
RIB components and interfaces include:

- The interface between the Mobile Data Computer and the Tait radio system
- A GPS receiver
- Power and audio control for the P/A system, microphone and handset
- Power supply connectivity
- A USB interface board
- An SIO Controller (Serial In/Out)

Learn more about the RIB in Section 8.1, Radio Interface Box.

1.2.2.5 Global Positioning System

Global Positioning System (GPS) receivers offer accurate time; they also function as a means of determining location. MTA adopted a GPS receiver system to facilitate a faster response to bus operator and dispatcher needs. The GPS receiver, located in the I/O Box, continually sends bus location information to the MDC. This system allows dispatchers to request the location of a specific bus.



In the Mobile Data System, the Reliability feature utilizes GPS reception and the time-points database installed on the MDC. For more information about Reliability, see Section 6.4.4.1, Reliability Setting. Learn more about bus GPS systems in Sections 7.1.2 and 8.1.3.3.

1.2.2.6 Other Components

Other MetroTrans System components that are part of the bus installation include:

- EMR – Refers to the Emergency Switch on the floor that can be used to send a silent emergency alarm to dispatchers at the control center (refer to the 'Silent Emergency Switch Flowchart' in **Appendix F**)
- P/A – The Public Address System on buses, used to make announcements to all passengers, using either a lapel microphone or hand microphone (Paratransit buses, which are much smaller than Fixed Route buses, do not have PA systems)
- Power Supply –Each bus MetroTrans System is powered by a 12-Volt dc ATX power supply, which keeps the MDC operational within input of 6-18 volts
- Radio Handset – The radio handset installed in buses looks much like a telephone handset. Bus operators can use the handset (and radio) to communicate with dispatchers by depressing the handset 'press to talk' (PPT) button in the middle of the handset

  Note: For ease of use, MTA engineers designed and built a custom cradle and hook switch mechanism so that bus operators could easily answer an incoming call while operating the bus.

A detailed look at how these MetroTrans System components operate and how they are interconnected, see Section 8, MetroTrans System – Interface and Control.

1.2.3 Radio Control Center and Computer Aided Dispatch

The Radio Control Centers provide communications support services for:

- Fixed route buses in the counties serviced by MTA
- Bus maintenance
- Fixed route operations supervisors, engineers and staff

The Flex Radio Control Center (FRCC) provides similar communications support for Paratransit (Flex route) buses and vans.

1.2.3.1 Dispatchers

Dispatchers in the radio control centers utilize UTA's Computer Aided Dispatch (CAD) system, which visually displays traffic flow, bus locations, and messages from mobile computers. MTA's custom MetroTrans Computer Aided Dispatch (CAD) system was designed in-house. This system provides voice and data communications to all Fixed Route and Paratransit buses and vans, along with mobile and handheld radios. This state-of-the-art communication system allows dispatchers to quickly and efficiently communicate with bus operators, supervisors, and MTA security officers.

The Radio Control Centers and the Computer Aided Dispatch system are discussed in Section 9, Radio Control Centers, and Section 10, Computer-Aided Dispatch.

1.2.3.2 Mobile Communication

Mobile and handheld radios from Tait Electronics complete the MTA radio system by offering an easy, efficient way for supervisors and other MetroTrans stakeholders to communicate with radio control centers and with each other. In an emergency, dispatchers use mobile radios to contact individuals they cannot locate by landline. Learn more about MTA's mobile and handheld radios in Section 4.3, Mobile and Handheld Radios.

1.2.4 MTA Vehicles

At present, the MTA fleet has 640 buses, 55 light rail cars and 50 service vehicles. To facilitate communication and operator assistance, MTA has three dispatch centers.

1.2.4.1 Fixed Route Buses

Currently, MTA has 520 Fixed route buses operating in five counties (Weber, Davis, Salt Lake, Utah and Tooele) in northern Utah. Each Fixed route bus contains the MetroTrans System. Because MTA has five types of Fixed route buses, the bus radio and MDS mounting configurations differ, but the systems operate the same way.

1.2.4.2 Flex (Paratransit) Route Buses

Paratransit is a demand-responsive transportation service. Paratransit services are characterized by the flexible routing and scheduling of relatively small vehicles that provide shared-occupancy, personalized transportation on demand.

At MTA, the Paratransit service is referred to as the 'Flex' service because of the flexible routes and schedules available through Paratransit services. Currently, MTA maintains about 90 Flex buses. Although most MTA Flex routes are handled by small buses, some of the routes utilize vans.

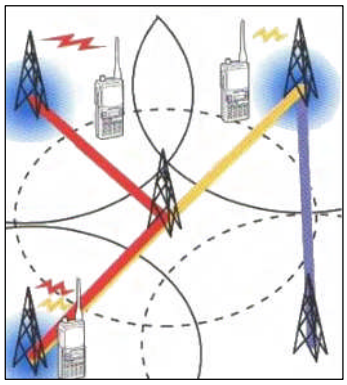
1.2.4.3 Staff Vehicles

Over 40 MTA staff cars, vans and trucks, including radio and bus maintenance vehicles, are equipped with mobile radios. In addition, some supervisors and maintenance personnel also have handheld radios.

2 Trunking Radio System

To facilitate inexpensive yet dependable mobile communication throughout the service area, MTA adopted a digitally controlled trunking radio system. All voice channels for MTA buses and mobile and handheld radios are linked in a trunking networked configuration so that all radio channels at each site are accessible to all services on a priority-of-call basis.

2.1 How Trunking Works



Basically, trunking permits a large number of users to share a relatively small number of communication paths - or trunks. Since MTA has close to a thousand radios, counting handhelds, MTA needed to find an affordable way for all radios to communicate within the five counties of northern Utah. A trunking radio network offers MTA the affordability, flexibility and reliability needed for their communication system.

In a trunking radio system, all radio communication individuals and groups have access to the same pool of shared radio channels. Trunking systems depend on the probability that the number of individuals or groups concurrently requiring communications is less than the number of radio channels in the pool. The trunked radio system has performed well for MTA's bus, mobile and handheld radio users.

2.1.1 Trunking System Channels

When a user keys the radio to transmit, the trunking system automatically assigns the first available radio channel to the call. The trunked radio system intelligence takes care of guiding the users to a free channel.

2.1.1.1 Availability

Essentially, all channels are available to all users. No channel stays unused when a need for communication exists. Channel selections are made by the site control module for local calls and the central controller (or Node) for inter-site calls. The trunking controller immediately allocates a free channel when requested. Channel assignment is automatic and is transparent to individual users.

Queue times are usually short, and when a free channel is available, calls are set up automatically.

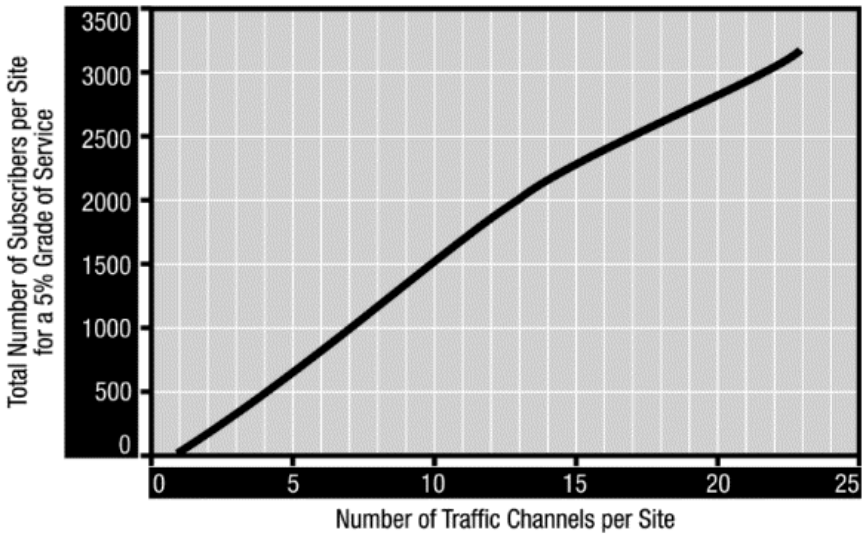
2.1.1.2 Privacy

In a trunked radio communication system, users only hear the conversation intended for them because they have exclusive use of the channel. Since communication in a trunked radio system happens on an arbitrary channel selected by the system, it becomes difficult for unauthorized users to monitor the voice communication of a particular group of users.

2.1.1.3 Number of Subscribers

Fewer channels are needed in a trunked radio system, reducing the cost of licensing spectrum and reducing hardware costs. For MTA, this meant they could support a large number of subscribers with less radio spectrum than other radio systems required, and yet still maintain a high grade of service to subscribers.

The graph below shows the total number of subscribers that can be supported per traffic channel on a trunked site with a 5% grade of service. A trunking site with one control channel and five traffic channels can therefore support a total of 575 subscribers with a 5% grade of service*****, as illustrated in this chart from TaitNet.



***** Grade of service measures the probability that a subscriber will be queued for more than a defined amount of time. In graph above, the time has been defined as 20 seconds, so a 5% grade of service means that only 5% of subscribers may have to wait 20 seconds (or more) for their calls to be connected.

2.1.2 Microprocessor Role

Trunking in radio systems became possible with the introduction of the microprocessor. The application of this technology made it possible to bring enough computing power to mobile and portable radios, as well as the trunking controller of the system.

The microprocessor allows the system controller to be the heart of the trunking system. The controller is the housekeeper of all activity within the trunking radio system.

2.1.3 Advantages over Conventional Radio

The key reason for adopting trunking technology is that it massively increases the productivity and usefulness of a multi-channel mobile radio system. Many radios can be handled per channel. During heavy traffic periods, several hundred radios may be able to share a multi-channel system without chaos.

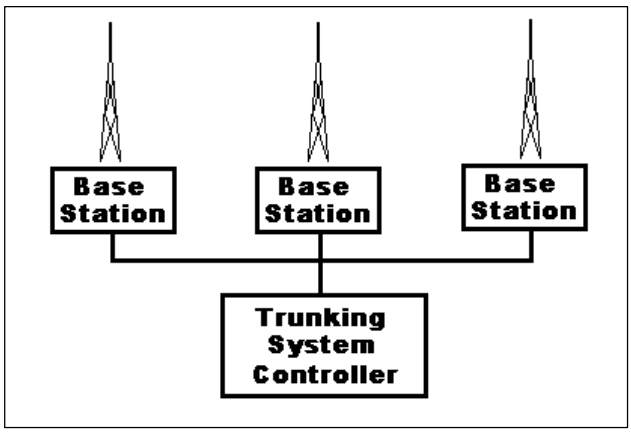
Additional advantages of a trunked radio system over a conventional radio system:

1. Trunked calls take place in private, and once a call is completed, the channel is returned to the pool.
2. Sharing channels increases the availability of airtime to all users.
3. Calls are more private because only the units in the call know which channel was allocated for the call.
4. Trunked systems use the available channels more efficiently; if a channel is free, then it will be allocated to a call.
5. Because channels are used more efficiently, people don't have to wait as long for a free channel.
6. Fewer channels can be used for the same number of users, which reduced the hardware cost per user.
7. Trunked systems offer emergency and priority call management, status messaging, dynamic regrouping of users, and data/text messaging.

2.1.4 Communications Protocol

A communications protocol is the set of standard rules for data representation, signaling, authentication and error detection required to send information over a communications channel. An example of a simple voice communications involves a radio dispatcher talking to mobile stations. Basically, following a communication protocol means following certain rules so that the system works properly.

Protocol MPT1327 enables stations to communicate over wide areas and allows for communication among numerous facilities.



Generic MPT 1327 System

2.1.4.1 MPT 1327 Protocol

MPT 1327 is an industry standard, possibly the most widely used trunking radio format in the world. MPT 1327 is a signaling standard for trunked private land mobile radio. England's Department of Trade and Industry published the first draft of the MPT 1327 open standard in 1986, in response to the need for a more efficient and effective use of the radio spectrum.

This standard is efficient in spectrum use, while offering security and verification, mobile data communications, system administration, and seamless multi-site roaming. Covering frequencies between 60 and 960 MHz, no other protocol allows this kind of versatility in the economy of scale inherent in MPT 1327.

Because MPT 1327 is an open standard with few patent restrictions, its adoption is attractive to manufacturers and users alike.

Features and Advantages of MPT Trunking

MPT Features	Advantages
Fast call set-up times	Less waiting
World-wide acceptance	Known technology, reference sites
Caters for small to large networks	Flexible and upgradeable
Frequency transparent	Can choose best available frequency
Established technology, since 1986	Proven reliability
Non proprietary protocol	Choice of supplier
Uses free channels efficiently	Cuts user waiting time
Fewer channels required	Hardware cost per user is less
Dedicated channel per call	Higher level privacy
Electronic Serial Number checks	Security
Provides a data medium	Can use text messages
Billing	Record keeping, customer charging
Supports a multiple of call types	PSTN, data, groups

2.1.4.2 MAP 27 Standard

Mobile Access Protocol (MAP) 27 is a standard that specifies the interface between mobile radios and data terminal equipment. That is, the MAP 27 data transfer protocol defines the standard for data exchange by connecting an external terminal (like a PC) with an RS-232C interface. This type of communication requires installation of a control interface on the radio unit.

By installing suitable application software on the mobile computer, users can enter and transfer data over the trunked radio system in a 'user friendly' manner.

The MAP 27 standard includes procedures for sending:

- Status messages (numbered between 0 and 31) on a control channel
- Short data (up to 24 ASCII characters) on a control channel
- Extended data (up to 100 ASCII characters) on a control channel
- Standard packet-switched data (with a defined bit rate of 1200 bit/s) or non-prescribed data (NPD) on a dedicated voice channel

MTA communications engineers designed and built an I/O Box (or Radio Interface Box) to interface between the mobile computer and the radio system in MTA buses. To learn more about the I/O Box, see Section 8, Radio Interface.

2.1.4.3 MPT 1343

This standard is a fleet numbering system that MTA opted not to use.

2.1.5 Public Telephone Connections

Common usage of trunked radio communication involves mobile-to-PSTN / PABX calls as well as mobile-to-mobile traffic.

The MPT 1327 standard offers digital signaling and advanced features, including:

- Wide range of call types (i.e. private, conference, emergency, broadcast)
- Ability to place and receive telephone calls through a PABX or PSTN
- Connection with an existing conventional network

The message trunking scheme assigns an analog voice channel for the call duration. Each subscriber radio is allocated a unique ESN number that can be individually verified for system control and subscriber management.

2.1.6 TaitNet System

By choosing the open standard MPT 1327 system, MTA could purchase equipment from a number of suppliers. MTA communication developers selected Tait Electronics of New Zealand as the radio system provider because Tait offered the advantage of being a one-stop-shop supplier of trunked radio equipment. The TaitNet system is the central infrastructure and control equipment for the wide area trunked radio network that is utilized by MTA's MetroTrans system.

The first true MPT 1327 operational system in London used Tait software, hardware and RF modules. For information about Tait radios and the MTA radio communication system, see Section 4, Radio Communication System.

2.1.7 MTA Trunked Radio Sub-systems

The MTA radio system has four subsystems. Each subsystem provides a unique service for the departments they serve.

- **Sub-System One** – The MetroTrans System was designed in-house by MTA employees and is used by Fleet and Paratransit buses, along with radio and maintenance supervisors. This system is discussed in detail in this document.
- **Sub-System Two** – This conventional radio system was designed in-house by MTA employees and is used exclusively by MTA TRAX. This system will be covered in a separate document.
- **Sub-System Three** – This conventional radio system designed in-house by MTA employees and is used exclusively by MTA Commuter Rail. This system will be covered in a separate document.
- **Sub-System Four** – This radio system is a mixture of Tait trunked radio and UCAN trunked radio used by the MTA Transit Police. This system will be covered in a separate document.

2.1.8 Radio System Benefits for MTA

Radio is a great communication system to adopt when cost is a significant consideration. Radio is probably the most practical method of communication for people or moving vehicles on land or sea, in the air or outer space.

The MPT 1327 trunked radio system offers effective and efficient communication for a transportation organization like MTA, including:

- Efficient radio communications over a large geographic area
- Cost effective infrastructure that allows both voice and data on the same system
- Ability to organize radios into private one-to-one, fleet and groups calls
- Capacity for future expansion to accommodate additional users
- Virtually free calling for lower operational costs

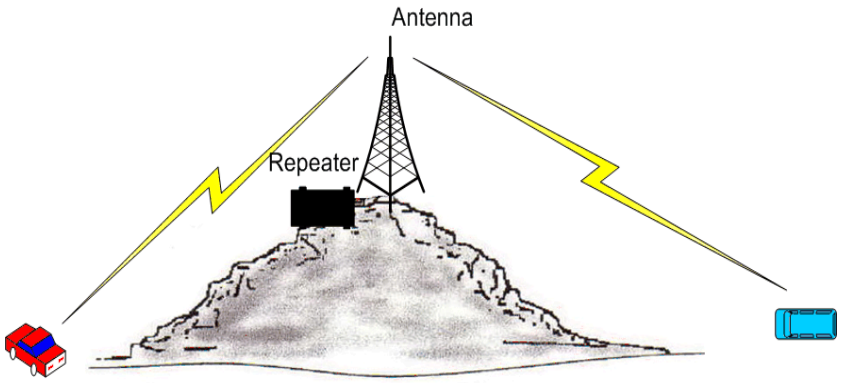
2.1.9 Communication Department Website

For use by department personnel, the Communications Department posts MetroTrans and TaitNet Radio System information on the Communication Department website.

3 Trunking Radio Sites

To afford radio communication over the large mountainous area covered by MTA, the MetroTrans System utilizes various radio towers situated on mountain peaks and hilltops in the region.

At each radio site, all radio channels are shared by the ParaTransit and Fixed route buses as well as MTA mobile and handheld radios. This section includes information about each radio tower site.



3.1 Radio Site Systems

Each radio site consists of base station repeater equipment through which the network's radios talk to each other. Each site has several channels; each channel consists of a transmitter and a receiver operating on a defined frequency pair.

Each site needs an antenna sub-system that may include combining or multi-coupling equipment. The network is controlled and monitored with the network management terminal (NMT). Read about the NMT in Section 5.4, Network Management Terminal.

3.1.1 Site Equipment

Battery-backed RAM provides data storage at each site. The RAM stores information about the radios allowed on the site and legitimate registrations. The RAM should retain data for about a month without external power.

Each radio site consists of the following assemblies:

- Control Channel Module (CCM)
- Receiver
- Transmitter
- PSU (power supply unit)
- Equipment rack

The CCM, receiver, transmitter and PSU modules fit into slots in the equipment rack. The transmitter may consist of a single module (when lower power is sufficient) or separate exciter and power amplifier (when high power is needed).

3.1.2 Radio Sites

Multiple radio sites, located on strategic mountain peaks, handle the MTA broad service area. These radio sites are numbered 1 through 7.

Site 1 – Z Peak
Site 2 – X Peak
Site 3 – Y Peak
Site 4 – B Peak
Site 5 – Darwin Ridge
Site 6 – Mountain Peak
Site 7 – Edgar Ridge

3.1.3 Site Channels

MTA has 23 radio channels, which are distributed among the sites according to expected traffic use.

Although a radio site can have up to 24 channels, one of these channels must be a control channel (CC). One channel at each site functions as a control channel, and its channel control module (CCM) provides the trunking intelligence for that site.

A channel can operate in one of three ways:

- Control channel – handles the communications involved in setting up and clearing down calls involving radio units registered at the site
- Local traffic channel – handles local calls registered at the site in question
- Inter-site traffic channel – handles inter-site calls as well as local calls. Inter-site calls proceed from a CCM at one site, via the node, to a CCM at another site

3.1.3.1 Control Channels

The control channel on each site is usually the first RF channel at the site. It consists of a shelf containing a channel control module, a receiver and a transmitter, accompanied by a power supply. The CC processes all call requests to and from radios, coordinating the calls and message packets sent to and from bus operators, dispatchers, and staff.

When bus operators use the MDC to send a short message to dispatch, the message contains the bus radio ID. In response, the control channel:

- Checks the bus number against a list to determine if it is allowed to communicate with the specific site
- Locates an idle channel within its pool of channels
- Broadcasts an outbound message packet to dispatch via the backhaul

3.1.3.2 Control Channel Modules

Each channel has a control channel module (CCM), which provides MPT 1327 signaling to and from the radios as well as control messaging on the site bus.

The CCM carries out the following functions:

- Controls and monitors the receiver and transmitter. The CCM for the control channel communicates with the mobile radios to set up calls.
- Switches the audio signals, which can come from the channel receiver or from the inter-site line to the DAS port at the node, sending them to the appropriate destination(s).
- Provides a four-wire 600-ohm termination for audio lines. The signal level can be adjusted to the values required (MTA's in-house standard is 0 db).

3.1.3.3 Voice Channels

Each site has from one to five voice channels for use by MTA. At each site, the CC:

- Handles voice communication between radios by assigning channels
- Prioritizes voice communication and handles a radio queue when required

3.1.4 Repeater Systems

A repeater transmitter-receiver combination is used to increase the coverage area of a mobile radio system. The repeater ensures more reliable performance in areas where signals are reflected or attenuated by terrain.

Go to this page on the Department website to open the list of 900 MHz radio channels and repeaters available for the MetroTrans System: _____

3.2 Radio Coverage

MTA radio communication sites offer overlapping coverage.

3.2.1 Permissions Template

Radio Shop technicians install a permissions template in each MTA radio. This template limits radio communication to specific radio communication sites.

3.2.2 Vote Now Map

'Vote Now' messages instruct radios to vote on which repeater site has the greater signal strength: the current control channel or the control channel specified in the message. If the other control channel is significantly stronger, Tait radios attempt to register with it.

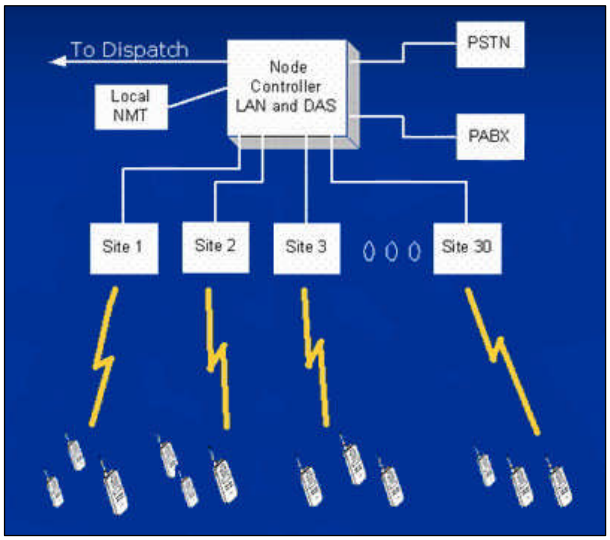
This can improve the efficiency with which roaming radios acquire a new control channel. Both the sites and the radios on the network have to be configured to enable Vote Now messaging. See MTA's 'Vote Now Map' in **Appendix A**.

3.3 Radio System Backhaul

[The rest of this section, which contains details about each site, has been removed.]

4 Radio Communication System

Because TaitNet trunked networks have a modular design, they can easily be expanded, like adding channels to a site and sites to a node. Refer to the expanded description of the trunked radio network in Sections 2 and 3.



Tait radios work well with the MetroTrans System because of their adaptability and expandability. Consultants from Tait Electronics worked with MTA engineers to create the mobile communication system envisioned by the MTA communication design team.

4.1 Radio Communications

In principle, radio communications is a relatively simple process. At the transmitting end, the information is modulated on a local radio frequency and an antenna radiates the signal carrying the information. On the receiving end, the signal is picked up by another antenna, where it is fed to a receiver and demodulated.

Professional mobile radio systems feature:

- Point to multi-point communications
- Push to talk, release to listen (half-duplex)
- A single PTT button press opens communication on a radio frequency channel
- Closed user groups
- Use of VHF or UHF frequency bands

4.1.1 Radio Registration with CC

When a trunked radio (bus, mobile or handheld) is turned on, the radio immediately starts searching through frequencies (‘hunting’) for a Control Channel (CC).

4.1.1.1 Hunting

The radio hunts through frequencies called the ‘Normal Hunt List’. By default, when a trunked radio is switched on, it tries to communicate with the last known CC. Radios may be programmed to ‘prefer’ some channels over others; the radio may also be barred from a particular channel. These parameters are established in the NMT and the template that is installed in the radio (by Radio Shop technicians) before the radio is set in use.

Mobile and handheld radio screens flash ‘S’, ‘SVC’ or ‘Service’ while the radio ‘hunts’ for a control channel. This message stops flashing when the radio locates a CC.

Bus radios also hunt for a CC when the ignition is turned on, but the Data911 touchscreens display the information differently. Learn more about radio registration on the Mobile Data System in Section 6.3, MDC Start-Up Screens.

4.1.1.2 Registration

After the radio locates a CC, the radio automatically requests registration. If permitted, the radio ‘registers’ with the CC at that radio site. After registration, the system knows where to find that particular radio. Then, when a call is set up, the radio switches to the voice channel designated for that call, and the MPT number and the staff/radio number are sent to the Node.

When a MTA radio moves between coverage areas, it automatically changes its site registration as needed to maintain good signal strength. As the radio registers with the new site, this deregisters the previous site.

4.1.2 Semi and Full Duplexing

A radio system that uses repeaters must be a duplex system. Full-duplex radio systems provide separate talk paths (frequencies) for transmitting and receiving. Most calls on the MTA radio system are half-duplex. These calls work much like calls on walkie-talkies, where information flows in only one direction at a time. Half-duplex systems use separate frequencies for transmitting and receiving, such that each party can either speak or listen, but not both at the same time.

Full duplex is available for PSTN and PABX calls as an option on Tait T7000 radios.

4.2 MTA Radio System

The MetroTrans bus configuration diagram (shown here and in Section 1) illustrates the relative position of the radio, MDC, RIB Box, Data911 touchscreen and other components in a MTA bus.

MTA buses utilize 900 MHz radios from Tait. After the bus ignition is turned on, the radio starts up and begins searching for a control channel. The radio signal contains data about the radio, including whether it is installed in a ParaTransit or Fixed route bus. The network registers the bus radio with the appropriate radio control center.

[Visio graphic depicting radio system interconnectivity has been removed.]

4.2.1 Configuration

The MDC, radio and RIB are contained in a locked ‘radio box’ on the bus. Depending on the size and shape of the bus model, this ‘radio box’ may be situated:

- Behind the bus operator
- In a bin above the passenger seats
- On top of an inside wheel well

4.2.2 Fleet Numbering

Each radio has a unique ID number, as each bus has a unique vehicle number. The bus number becomes the number of the bus radio through the MPT protocol. The MPT number is matched to the bus radio, and the bus radio uses its MPT compliant number to identify itself to the system. During the day, the bus radio continually monitors the control channel. If the bus changes sites, it re-registers with the new site and monitors that control channel.

4.2.2.1 Five-Digit Format

Bus numbers are altered to comply with the MPT protocol. For instance, if a bus is numbered 9357, a zero is added to the middle of the number, which changes the number to 93057. This fits the 5-digit format, which is termed ‘short dial’. An extra ‘0’ is added to the four-digit bus numbers so that they comply with the 5-digit format.

4.2.2.2 Eight-Digit Format

Use the 8-digit numbering system to make Group calls. The 8-digit number system follows this format:

FPPPIIII where F = “Fleet number,” P = “Prefix” and I = “Ident”

Group Number Example: Salt Lake Maintenance Group is 1-000-6340

Note: The Fleet number (F) is always “1” for MTA.

4.2.3 MTA Radio Group Assignments

Group calls engage two or more users at the same time. In a group call, a number of users can be dialed by entering a single ID number on a mobile or handheld radio. Trunking group calling allows the trunking system to appear like a conventional radio call. Mobile and handheld radios can belong to more than one group. See ‘MTA Radio Group Assignments’ in **Appendix C**.

Handheld and mobile radios handle group calls as conference (or broadcast) calls. All mobile / handheld radio users have an individual ID plus membership in none, some or all group IDs. In addition, a user can become a temporary member of a specific group.

With all radio types (mobile, bus or handheld), if you are a permanent member of a particular group, you will always receive voice traffic when a group call is made to that group, as long as your radio is powered up. Remember that only the person who initiated the group call can actually end the call.

4.2.3.1 Selectable Groups

Mobile and handheld users may have one or several selectable group memberships. In addition, these radio users can join a group call in progress. By using the Mobile Data System, bus operators can select the ski group or one of four incident groups. This is explained in Section 6.4.9, MDC Control.

4.3 Mobile and Handheld Radios

Handheld and mobile radios are both convenient; however, mobile radios outperform handheld radios.

4.3.1 Mobile Radios

Trunked mobile radios are mounted in about 44 MTA cars, vans and trucks. These radios feature hand microphones, or 'handmikes'. The PPT (press to talk) button is depressed to talk and released to listen.

These mobile radios offer 'one-click' call setup. Mobile radio users key in the number preset and momentarily press the PPT button to set up a call. The user waits until the radio rings, which indicates the requested call has been setup.

4.3.1.1 Vehicles with Mobile Radios

To view a list of MTA radio-equipped vehicles for Operations and Maintenance, along with the business unit to which they are assigned, visit the Communication Department website at: _____

4.3.1.2 Making a Call

Using the keypad, enter the Prefix and Ident number of the other party and then press the PTT button or press the Send key to make the call.

Following the MPT protocol:

To Call	Enter
Bus 9323	93023
Bus 0118	01018
Bus 06002	06002
Group 6912	10006912
Vehicle A0212	70212
Handheld Supervisor 38	60038

For additional information about Tait handheld radios, refer to the information in **Appendix C** and to Section 4.2.2, Fleet Numbering.

4.3.1.3 Re-establishing a Call

When a mobile radio call has been ended, and no other function is active, the Tait radio displays the identity of the last party called. This enables the user to easily re-establish a call. To redial this party, press the PTT key.

4.3.2 Handheld Radios

MTA handheld numbers range from 60000 to 61000, with 61000 reserved for ski bus communication. By default, handheld radios have 3-digit numbers. The 3-digit number comprises the radio's Ident number. Radio Shop technicians add a 2-digit Prefix number (60 or 61) to create the 5-digit calling number for the radio.

For 7-digit dialing, two zeroes are added between the Prefix and the Ident. The 5-digit and the 7-digit dialing systems both work on the Tait handheld radios.

The trunked portable radios carried by MTA supervisors are Tait Orca models. These compact radios have LCD screens, keypads and menu functionalities.

See **Appendix C** for additional radio operation information, including:

- Tait Orca Trunked Portable Radio User Guide
- MPT 1327 Call Types, Call Features and Data Messaging
- MTA Radio Groups Assignments

4.3.2.1 Protocol

Handheld radio users can call other handheld radios, mobile radios, RCC and landlines through the 'rules' of the MPT 1327 protocol. This communication protocol is explained in Section 2.1.4.1, MPT 1327 Protocol.

4.3.2.2 Individual Calls

In the unit-to-unit mode, handheld radio users can place individual calls to other handheld radio users.

- Within the same site: A handheld user can call another handheld user within vicinity of the same repeater.
- In separate sites: When a handheld user near one repeater calls a handheld user near another repeater, the signal travels via backhaul from radio site to the network Node and out to the second radio site for rebroadcast.

Note: This transfer from site to site may be transparent to the user.

Handheld radios can be used to directly call the Control Centers and MTA Security. Handheld radios can be configured to either allow or disallow calls to public telephone lines.

4.3.3 Templates

Using templates simplifies fleet management. Individual call features are set up in each radio by the use of templates. Call rights templates allow radio technicians to combine a set of call rights and apply them to a radio in a single action.

When Radio Shop technicians program new radios, they use the template application to apply features and permissions templates that set preferences for group calls, telephone access, personal calls, emergency calling, data calls, etc. See examples of these Radio Programming Templates in **Appendix C**.

4.3.3.1 Call Rights

When a template is assigned to a radio, it gives or takes away that radio's right to make a particular call type, depending on whether the appropriate check box is enabled or disabled in the template application. The Call Rights designation tells the Node how to validate call requests. The templates to be installed are determined by MTA service, department, and business unit.

4.3.3.2 Updates

Templates make maintaining validation information easier because radio administrators can change the template and globally apply the changes to all radios or groups with that template. These radio programming templates are maintained by Radio Shop technicians.

5 Communication Network Infrastructure

5.1 Network Diagram

[The data in this section is proprietary and has been removed.]

6 Mobile Data System

The Mobile Data System (MDS) used by MTA includes three Data911 components: the Mobile Data Computer (MDC), the touchscreen display, and the mobile computer power supply. Along with the Tait radio and RIB, the MDC and power supply are housed in the 'radio box' (or 'shelf') on MTA buses. Only Communication Department employees can open the radio box to access these MetroTrans System components.

This section provides an overview of the MDS system, along with a detailed look at the software installed on the Mobile Data Computers, including examples and instructions for using the touchscreen displays.

6.1 MDS Components

The Data911 Mobile Data System works in tandem with MTA radio trunking and wireless systems to offer MTA transportation operators quick, real-time communication with dispatchers and supervisors.

[This section was originally 60 pages long and contained numerous screenshots along with detailed operating instructions.]

7 Radio Control Centers

The MTA Radio Control Centers are central to the MetroTrans System and are home to MTA radio dispatchers. The Radio Control Center is located at the Central facility and the ParaTransit Radio Control Center is located at the Lakeside facility.

7.1 Radio Control Center

The Radio Control Center provides communications support services for:

- Fixed route buses in the counties serviced by MTA
- Bus maintenance
- Fixed route bus Operations supervisors, engineers, security and staff

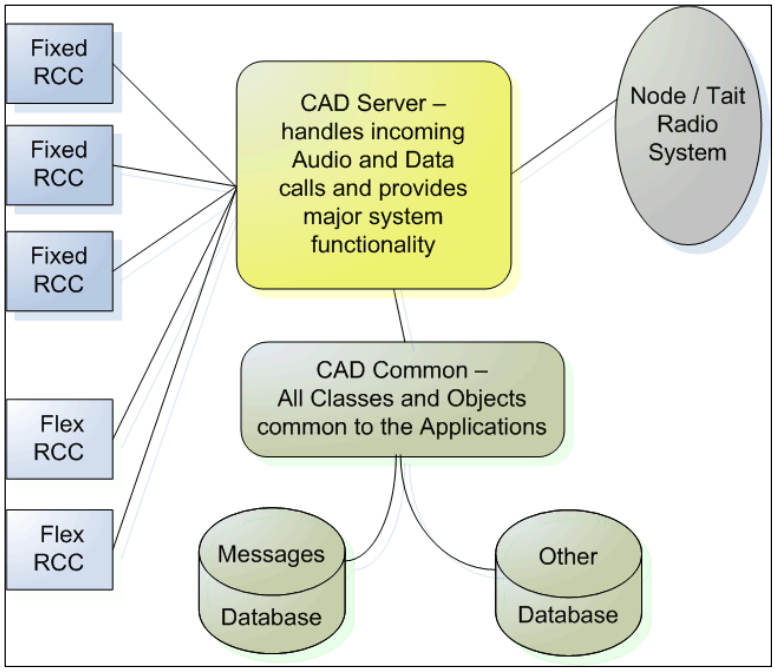
Two Dispatchers at the Control Center

[The rest of this section has been removed.]

8 Computer-Aided Dispatch

The MTA communication system is comprised of a trunked 900 MHz two-way radio system with Computer Aided Dispatch (CAD) features that utilize both control and voice channels for data. MTA's CAD system was designed in-house and is an enhancement of the original MetroTrans system that has been in service since 1991.

MTA personnel developed the Computer-Aided Dispatch system as a custom solution that utilizes Window's architecture, .NET technologies, common libraries (dll files) and the Tait Radio System. The CAD and MDS facilitate communication between operators and dispatchers.



System Structure

8.1 Network Connectivity

Each CAD station has its own connection to the Radio Node via DIP over I/P network as well as a 4-wire audio connection to a Dispatcher Audio Console. Each CAD station maintains contact with the CAD Server as well as the Node, enabling both data and voice communication. The interface also enables RadioLog entry, mapping, and basic system monitoring.

[The rest of this section has been removed.]

9 System Testing and Repair

This section covers two of the basic testing and repair functions performed by MTA field service technicians, along with training documents and information for accessing Mobile Data Computer system online support.

[The rest of this section has been removed.]