Handbook for the Digital Radio System

Smithsonian Institution Frederick Lawrence Whipple Observatory

Amado, AZ

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Executive Summary

The radio system installed at the Frederick Lawrence Whipple Observatory supports all essential two-way voice radio communications and provides GPS location information for all radios while supporting emergency/duress notification. This new radio system complies with the NTIA regulations for narrowband 12.5 kHz channels.

A Motorola digital mobile radio system based on the TRBO protocol provides a robust communications platform. The TRBO technology uses time division data transmission to provide two simultaneous operations separated by time slots. The first is a time slot for voice transmission; the second is a time slot for data transmission to support GPS. The wide area coverage is served with a single 100 watt digital TRBO repeater installed at Mt. Hopkins.

All mobile and portable radios will have access to the existing analog radio channels and the new digital radio channels. This is done to allow graceful transition from the old system to the new. When the mobile and portable radio units are operating on the new TRBO channels they will be tracked using GPS location and their position will be displayed on a PC using Google maps. In addition, the radios can send short text messages between radios as needed.

Each radio can also declare an emergency at the push of a button. When the Emergency button is pressed the radio will automatically switch to the Safety talkgroup and gain priority access to the repeater. In addition, all other radios on the Safety channel will sound an audible alarm and display the ID of the radio unit declaring the emergency.

Additional functions are provided for Gate control, Individual call, Radio Check, Radio Page and text messaging.

The system is initially constructed with one repeater, 60 portable radios, 48 mobile radios, 12 base stations and one GPS monitoring PC.

Frequencies and Channel Plan

The radios are programmed with the channels divided into 3 Zones (A thru C) of up to 16 Channels as follows:

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ZONE A CHANNELS will support TRBO digital radio

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Ch# 1. "NORMAL" (FLWO Routine) Repeater * Routine use - road safety
--> The P2 button will select talk-around for off road traffic
Ch# 2. "ADMIN" (FLWO Alternate) Repeater * Administrative talkgroup
Ch# 3. "U of A" (Steward Obs.) Repeater * Univ of AZ
Ch# 4. "SAFETY" (Emergency) Repeater * Safety talkgroup
Ch# 5. "VERITAS" Repeater * VERITAS talkgroup
CH# 6. "MMT" Repeater * MMT talkgroup
CH# 7. "Support" Repeater * Support talkgroup
Ch# 8. "WEATHR" (Weather Info.) 162.400 Receive Only Weather broadcasts
CH 9-14 Blank unprogrammed
CH# 15 GATES – Channel must be selected to signal gates to open or close
CH# 16 LOCAL Simplex digital channel for radio to radio communications

Data services programmed will be as follows:
1. Call Alert - direct radio to radio pager function
2. Individual Call - direct radio to radio private voice call
3. Emergency Call – Alerts on Safety talkgroup with Alarm then manual PTT for voice call
4. Text messaging – short text messaging between radios and base stations.

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ZONE B CHANNELS will support lesser used interoperability frequencies

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1. "FS" (Forest Service) 169.600/169.600/114.8
2. "FS-Rep" (USFS Repeater) 170.525/169.600/114.8
3. "FS-Air (FS- Air to ground) 170.000/170.000/none
4. "FIRE" (Tubac Fire/Amb.) 154.995/154.160/123.0
5. "POLICE" (Santa Cruz) None/155.595/None
6. "COUNTY" (24-hr Emergency) 154.100/155.715/123.0
7. "STATE" (Ariz Emergency) 154.280/154.280/None
8. "USA" (U.S. Emergency) 155.475/155.475/None

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ZONE C CHANNELS Old radio system to be phased out in a few months

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1. "NORMAL" (FLWO Routine) 169.050/169.925/114.8 Routine use - road safety
2. "LOCAL" (FLWO Local) 169.375/169.375/None Simplex to offload traffic from channel 1.
3. "TELEPHONE" 169.050/169.925/None Old phone patch
4. "ADMIN" (FLWO Alternate) 169.050/169.925/127.3 Tone isolated channel. Unused
5. "UofA" (Steward Obs.) 169.050/169.925/203.5 Tone isolated channel. Used
6. "SAFETY" (Emergency) 169.050//169.925/103.5 Tone isolated channel. Unused
16. "BYPASS" (Repeater Simplex) 169.050/169.050/114.8 Uses one frequency in simplex.

Equipment

REPEATER

The repeater installed at Mt. Hopkins is a Motorola XPR8300 repeater coupled to a TPL 100 watt power amp then filtered with a duplexer and then connected to an outside antenna. The equipment is housed in a single 30" cabinet and operates from a single 120 VAC 15 amp outlet.

BASE STATIONS

Each base station is a Motorola XPR4550 mobile radio mounted in a desktop housing with self contained power supply. The base stations are each connected to an antenna. The antenna may be located inside the building or external depending on the distance from the repeater location. The front of the radio has a display that shows the name of the channel selected and the ID of the radio currently being received.

Base station radios have special functions that allow the operator to interrogate any radio to determine if it is turned on. In addition, a radio can be remotely disabled if it is suspected of being lost or the in the event the user is disrupting communications.

VEHICLE RADIOS

The radios are the Motorola XPR4550 dash mounted 25 watt mobile units. The front of the radio has a display that shows the name of the channel selected and the ID of the radio currently being received.

The units have a rear connector to support external ignition sense and an external Emergency Button input.

PORTABLE RADIOS

The handheld portable radios are the Motorola XPR6550 handheld 5 watt units. The front of the radio has a display that shows the name of the channel selected and the ID of the radio currently being received. The portable radios also have a full keypad to allow direct entry of text messages.

A top mounted Red button when pressed declares an emergency alarm. The button must be pressed a 2nd time and held to clear the emergency.

GPS TRACKING SYSTEM

A Windows 7 Pro computer with 20" LCD monitor is provided to display the position of each mobile and portable radio in operation. The PC is connected to two gateway TRBO base radios to act as wireless modem and communication with the units. The GPS location will be updated every 7 minutes and displayed on a map provided by Google maps subscription. *The subscription must be renewed annually.*

Remote access to the computer is provided for remote viewing and maintenance.

System Operation

BASIC OPERATION

The Motorola TRBO radio system assigns a unique ID to all radios in the system. This Radio ID is how the system keeps track of you. When you make a call on the radio your ID number is displayed on the screen of all radios hearing you. The GPS computer displays your location using an icon with your ID number. The radios all have a "Contact List" that allows the user to select a specific radio to send a text message or a private call.

All portable and mobile ID's are displayed as a number on the screen of a receiving radio. All base stations are displayed as its location such as "Office" or "Motor Pool".

The Motorola XPR6550 handheld and XPR4550 mobile/base radios are capable of operating in multiple zones. A "zone" is a bank of radio channels that are grouped by function. All of the radios use the following Zone definitions:

Zone A = New radio system TRBO channels w GPS and Emergency
Zone B = Rarely used Interoperability channels
Zone C = Old analog radio system channels for use during migration
Zone D = GPS data functions –not for voice or user access.

Changing between Zones is done using the Menu key, scroll using arrow key to Zone the press OK. Select the desired Zone with the arrow key and press OK. You can then select the desired channel using the channel select knob (on a handheld radio) or using the up/dn button on the mobile radio.

Let's assume you have selected Zone A Channel 1 "NORMAL" talkgroup. This is a channel that operates through the Motorola TRBO repeater. To make a call press the large round PTT switch on the side of the handheld radio or press the PTT switch on the microphone of the mobile radio. The radio will send a channel request to the repeater, the repeater will respond with a go ahead beep to indicate that the repeater has accepted your call request and you are clear to speak your message. You will also see the green LED is on solid.

At this time all radios that have the "NORMAL" talkgroup selected will hear your message.

The new TRBO system operates like the old radio system in that multiple groups share the same repeater channel but do not hear each others conversation unless that talk group is selected. Only one talk group can use the repeater at a time.

If a talkgroup other than the one you have selected is currently talking on the repeater your radio will flash the green LED to indicate a "Busy" condition. You should wait until the busy condition is over before making your call.

TALK-AROUND

The radios are also equipped with a repeater "Talk-around" function. Talk-around lets two or more radio users that are in close proximity, talk directly to each other without busying the repeater but will still listen to the repeater for a call on their talkgroup.

An example of Talk-around use could be as follows:
Bob and Sue are working on a repair to a telescope and need to exchange rapid communication during critical adjustments. They will be physically in the same building. Their radios are usually operated on Zone A Ch 5 “VERITAS” talkgroup. They are using the handheld radios. Both Bob and Sue must enter the Talk-around mode by pressing the P2 button; now they can talk directly to each other without others on the VERITAS group hearing them and without putting traffic on the repeater. Now let’s say that at base camp Steve needs to talk to Sue. Steve can select the “Veritas” talkgroup on Zone A Ch 5 and simply press the PTT switch and make the call to Sue. Even though Steve is miles away from Sue the repeater will process Steve’s call and since Sue is in the Talkaround mode she will hear the call. To talkback, Sue will need to press the P2 button to allow her radio to talkback through the repeater.

Talk-around is a great way to allow two or more people to communicate locally without becoming isolated from to rest of the group.

EMERGENCY CALL

All mobile and handheld radios can declare an emergency and get priority access to the “Safety” channel. The operation of the emergency call is very simple. When the RED button on a handheld radio is pressed the radio will automatically switch to Zone 1 Ch 4 “SAFETY” and send a distress alarm. This causes all radios that are currently on the Safety channel to begin beeping and to display the ID of the declaring radio. The user that declared the emergency can begin speaking into the radio as normal but with the knowledge that the call is processed by the repeater with the highest priority.

Radios that have received the call and beeped to indicate the alarm can silence the beep by pressing the back button. To clear the alarm indication from the screen, press the back button and then immediately press the alarm button.

In addition to sounding the audible beep and displaying the ID on all radios; the GPS computer icon for that radio will change color and provide location information of the radio.

When the emergency event is over the radio user that initiated the call must cancel the emergency by pressing and holding the RED emergency button.

Mobile radio users can initiate an Emergency with the “P1” button. Press and hold the “P1” button for 3 seconds to declare and emergency. To cancel the emergency, short press the “P1” button. The vehicle may also be equipped with a dash mounted or other external Emergency button which will act in a similar manner.

GPS LOCATION

A computer will track the location of each mobile and portable radio that is set to operate in Zone A. When a radio is first powered on it will register with the repeater and the GPS computer. From that point on the radio will be asked to update its location once every 7 minutes. The computer will log location, speed and other factors as determined by the operator.

When a radio location is updated the radio's position will be indicated on the map. The operator can customize the map with local names for landmarks and run reports on any unit's activities.

GATE CONTROLS

There are three road gates can be opened and closed by the radio. This is a telemetry function sent by the radio to the local gate. The radio sends the command to the closest gate on a separate low power channel.

To activate a gate you must first select the GATE channel. Zone A Ch 15 "GATES" then press the assigned telemetry button.

Handheld radio users press and hold "P1" button for 3 seconds. The radio will beep and indicate the telemetry command to open or close has been sent.

Mobile radio users press the "P2" button. The radio will beep and indicate the telemetry command to open or close has been sent.

A mobile radio mounted to the gate control unit will receive the telemetry signal and output a logic low pulse for 500mS to command the gate to open or close.

Operator Guides

The following pages provide reference for the operation of the mobile and portable radios. These pages used in conjunction with the operator videos will provide thorough understanding of the radios and system operation.

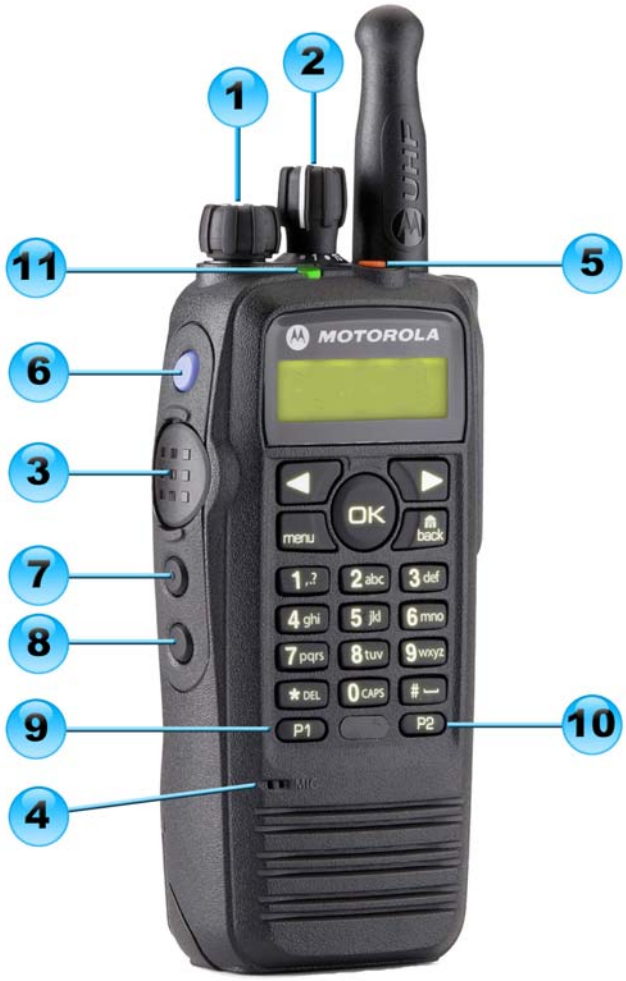
1) SI FLWO Portable
2) SI FLWO Mobile
3) SI FLWO Base Station

MOTOROLA MOTOTRBO™

Serial Number 037TLS6895 Model Number H55JDH9LA1AN

1. Power On/Off, Volume
2. Channel Selection
3. Push To Talk
4. Microphone
5. **Short Press:** Emergency On
   Long Press: Emergency Off
6. **Short Press:** Monitor
   Long Press: Permanent Monitor
7. **Short Press:** Unassigned
   Long Press: Unassigned
8. **Short Press:** Contacts
   Long Press: Unassigned
9. **Short Press:** Unassigned
   Long Press: Telemetry Button 1
10. **Short Press:** Repeater/Talkaround
    Long Press: Unassigned
11.

Display	Description
Flashing Red	Low Battery or Receiving Emergency Alarm
Solid Yellow	Enter Permanent Monitor or Private Call Request or Monitor Activity or Mid Battery
Flashing Yellow	Scanning or Call Alert Ack Wait
Solid Green	Transmitting or High Battery
Flashing Green	Receiving or Powering Up



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MOTOROLA MOTOTRBO™

Menu Digital Channel

Contacts	Call Alert • View Number • View Position • New Contact • Edit Name • Edit Number • Edit Position • Manual Dial • Ring Style • Delete
Scan	Turn On/Off • View/Edit List
Zone	
Messages	Inbox • Write • Quick Text
Call Log	Missed • Answered • Outgoing
Utilities	Radio Settings • Radio Info • Talkaround • Tones/Alerts • Keypad Lock

Menu Analog Channel

Contacts	Call Alert • View Number
Scan	Turn On/Off • View/Edit List
Zone	
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Accessory Buttons

	Name	Short Press	Long Press
	Orange Button	Emergency On	Emergency Off
	No Dot Button	Monitor	Unassigned
	1-Dot Button	Unassigned	Unassigned
	2-Dot Button	Unassigned	Unassigned

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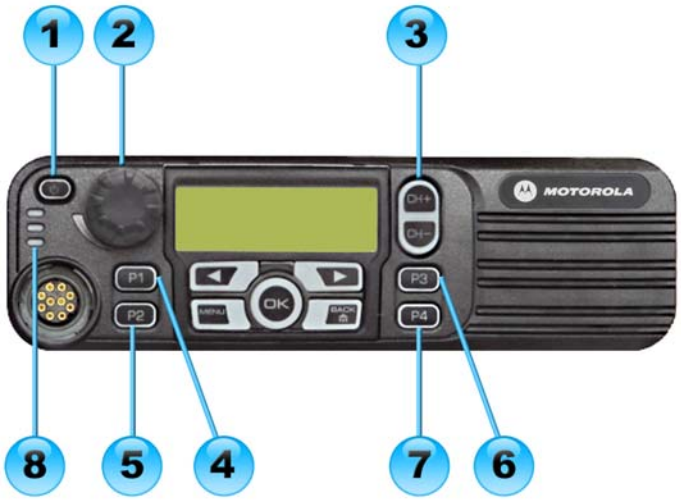
MOTOROLA MOTOTRBO™

Serial Number 038TLU0540 Model Number M27JNH9LA1AN

1. Power On/Off
2. Volume
3. Channel Selection
4. **Short Press:** Emergency Off
   Long Press: Emergency On
5. **Short Press:** Telemetry Button 1
   Long Press: Unassigned
6. **Short Press:** One Touch Access 1 - Home
   Revert: NORMAL
   Long Press: Unassigned
7. **Short Press:** Repeater/Talkaround
   Long Press: Unassigned
8.

Display	Description
Flashing Red	Receiving Emergency Alarm
Solid Yellow	Enter Permanent Monitor or Private Call Request or Monitor Activity
Flashing Yellow	Scanning or Call Alert Ack Wait
Solid Green	Transmitting
Flashing Green	Receiving or Powering Up



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	2-Dot Button	Unassigned	Unassigned

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MOTOROLA MOTOTRBO

Serial Number 038TLU0488 Model Number M27JNH9LA1AN

1. Power On/Off
2. Volume
3. Channel Selection
4. **Short Press:** Emergency Off
   Long Press: Emergency On
5. **Short Press:** Unassigned
   Long Press: Unassigned
6. **Short Press:** Unassigned
   Long Press: Unassigned
7. **Short Press:** Repeater/Talkaround
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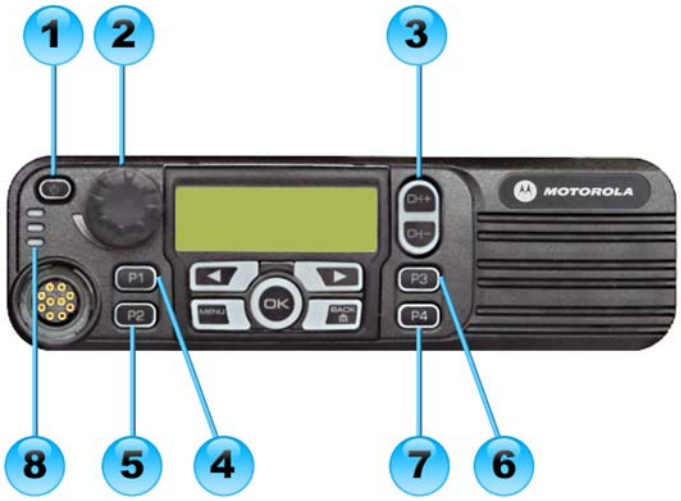

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Zone	
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