



ITCR^{NG-BR} 1.1 Base Radio Installation and Field Service Guide

DCN 00006165-B

Tier 2: Proprietary and Confidential – Do Not Distribute

[This page left blank for print pagination purposes.]

Legal Notices

© Copyright 2024 Meteorcomm LLC. All rights reserved.

By downloading, using, or referring to this document or any of the information contained herein you acknowledge and agree:

Ownership

This document and the information contained herein are the sole and exclusive property of Meteorcomm LLC ("MCC"). Except for a limited review right, you obtain no rights in or to the document, its contents, or any related intellectual property. MCC may, upon written notice, terminate your internal review of this document and, upon such notice, you will return the original of this document to MCC together with the originals and all copies of all documents in your possession or under your control that refer or relate to it.

Limited Use and Non Disclosure

This document contains information that is considered confidential and/or proprietary to MCC. It is protected by copyright, trade secret, and other applicable laws. This document is provided to you for your internal review only and you may not disclose, transmit, distribute, duplicate or use it or any of the information contained herein, in whole or in part, except as agreed under separate written agreement with MCC. All information contained herein shall be kept strictly confidential.

Disclaimer of Warranty

THIS DOCUMENT AND ALL INFORMATION CONTAINED HEREIN OR OTHERWISE PROVIDED BY MCC, AND ALL INTELLECTUAL PROPERTY RIGHTS THEREIN ARE PROVIDED ON AN "AS IS" BASIS. MCC MAKES NO WARRANTIES OF ANY KIND WITH RESPECT THERETO AND EXPRESSLY DISCLAIMS ALL WARRANTIES OF ANY KIND, WHETHER EXPRESS, IMPLIED OR STATUTORY, INCLUDING BUT NOT LIMITED TO, WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, TITLE, NON-INFRINGEMENT, ACCURACY, COMPLETENESS, INTERFERENCE WITH QUIET ENJOYMENT, SYSTEM INTEGRATION OR WARRANTIES ARISING FROM COURSE OF DEALING, USAGE OR TRADE PRACTICE.

Assumption of Risk

You are responsible for conducting your own independent assessment of the information contained in this document (including without limitation schematic symbols, footprints and layer definitions) and for confirming its accuracy. You may not rely on the information contained herein and agree to validate all such information using your own technical experts. Accordingly, you agree to assume sole responsibility for your review, use of, or reliance on the information contained in this document. MCC assumes no responsibility for, and you unconditionally and irrevocably release and discharge MCC and its affiliates and their respective officers, directors, and employees ("MCC Parties") from any and all loss, claim, damage or other liability associated with or arising from your use of any of the information contained in this document.

Limitation of Liability

IN NO EVENT SHALL MCC OR THE MCC PARTIES BE LIABLE FOR ANY INDIRECT, INCIDENTAL, EXEMPLARY, SPECIAL, PUNITIVE OR TREBLE OR CONSEQUENTIAL DAMAGES OR LOSSES, WHETHER SUCH LIABILITY IS BASED ON CONTRACT, WARRANTY, TORT (INCLUDING NEGLIGENCE), PRODUCT LIABILITY OR OTHERWISE, REGARDLESS AS TO WHETHER THEY HAVE NOTICE AS TO ANY SUCH CLAIMS.

Hazardous Uses

None of the information contained in this document may be used in connection with the design, manufacture or use of any equipment or software intended for use in any fail safe applications or any other application where a failure may result in loss of human life or personal injury, property damage, or have a financial impact or in connection with any nuclear facility or activity or shipment or handling of any hazardous, ultra hazardous or similar materials ("Hazardous Uses"). MCC disclaims all liability of every kind for any Hazardous Uses, and you release MCC and the MCC Parties from and shall indemnify MCC and the MCC Parties against any such liability, including, but not limited to, any such liability arising from MCC's negligence.

Copyright and Trademark

Meteorcomm®; AR^{cpu}®; AR^{edge}®; AR^{eio}®; ARM®; Discovery Network®; ITCM®; ITCnet®; ITCR®; ITCR^{NG}®; ITCSM®; ITCview®; Powering the Digital Railroad Network®; stylized METEORCOMM®; and Test Executive® are registered trademarks of Meteorcomm LLC; these trademarks may not be used without express written permission of Meteorcomm LLC.

Revision History

Revision	Date	Notes / Summary of changes
A	12/6/2024	First draft.
B	12/19/2024	Initial release.

Third-Party Trademarks

The use of the following third-party marks herein is made for reference purposes only and does not indicate an association with or endorsement from the brand owners: Linux, Windows (Microsoft Corporation), and ZynQ (Xilinx, Inc.).

Contents

1	Introduction	1
1.1	Audience	1
1.2	Some Terms Used in this Documentation	1
1.3	Specifications for ITC Model Base Radio 65030	2
1.4	Release Documentation	5
1.5	How to Get Help	5
2	Safety	7
2.1	Electrical Safety Guidelines	7
2.2	RF Safety Information	7
2.2.1	Limiting RF Exposure	7
2.2.2	Fixed Antenna Guidelines	8
2.2.3	RF Interference Considerations	8
2.2.4	Equipment Modifications	9
3	Transmitter Operation	10
3.1	Radio Channelization and Frequency Range	10
3.2	Channel Restrictions	10
3.2.1	Restricting Base Transmission	10
3.3	Radiated Power Limits	11
3.3.1	Mobile Installation	11
3.3.2	Fixed Installation	11
4	Installation	13
4.1	Equipment Required for Verification of Specification Compliance	13
4.2	Unpacking and Inspecting the Radio	14
4.3	Mounting the Radio	15
4.4	Power Supply Requirements for Base Radios	15
4.5	Grounding the Radio	16
4.6	Installing Current Limiting Circuit Protection	16
4.7	Connecting the Antenna	16

4.7.1	Antenna planning	16
4.7.2	Connecting the cable	16
4.8	Connecting the Ethernet Cable	17
4.9	Connecting the GNSS Antenna	17
4.9.1	GNSS satellite constellation overview	17
4.9.2	GNSS antenna planning considerations	18
4.9.3	Minimize potential of GNSS antenna issues	20
4.9.3.1	Antenna separation at collocated sites	20
4.9.4	Connecting the GNSS antenna	20
4.10	Connecting the Power Cable	21
4.11	Connecting the GPIO connectors	22
4.12	Powering On the Radio	22
4.13	Checking the Front Panel LEDs	23
4.13.1	LEDs at Power-On	23
4.13.2	Normal LED States	25
4.14	Displaying POST Results	28
4.15	Initializing UTC Time Correction Data	29
5	Command Security	30
5.1	Logging On to a Radio	30
5.2	Logging Off from a Radio	31
5.3	Managing SSH Authentication Keys	31
6	Troubleshooting	32
6.1	Guidelines for Troubleshooting Common Problems	32
6.1.1	Commonly used diagnostic commands	33
6.1.2	Front panel LEDs	33
6.1.3	Check the state of the radio with the radiostate command	33
6.1.4	View the results of the most recent POST	34
6.1.5	System log contents	35
6.1.6	Boot a radio	35
6.2	Radio Power Problems	35

6.3	Antenna Problems	36
6.3.1	GNSS Antenna	37
6.4	Transmission Problems	37
6.5	Receiver Problems	38
6.6	Ethernet Connectivity Problems	38
6.7	RF Link Problems	39
6.8	Time and Location Problems	39
6.9	Replacing a Radio	41
7	Real-Time Log (a.k.a "Trace") Monitoring	42
8	Managing Software Application Images	43
8.1	Determining Software Images Status	43
8.2	Updating Software Application Images	44
8.3	Rolling Back an Image	45
8.3.1	How automatic rollback occurs	45
9	Routine Maintenance	46
Appendix A: Configure Computer Ethernet Interfaces		47
Appendix B: Parts List		48
Appendix C: Block Diagram		52
Appendix D: Sample Post Results		53
Appendix E: Acronyms		54

Figures

Figure 4-1:	Base radio	13
Figure 4-2:	Vertical mount	15

Figure 4-3: 19-inch rack mount	15
Figure 4-4: Antenna connector	16
Figure 4-5: Ethernet connections	17
Figure 4-6: GNSS satellite constellation	18
Figure 4-7: GNSS antenna considerations	19
Figure 4-8: GNSS connector	21
Figure 4-9: Example of a typical power cable externally fused with 10A ATO	21
Figure 4-10: Power connector	21
Figure 4-11: GPIO connectors	22
Figure 6-1: Partial cgps output	40

Tables

Table 1-1: ITC Model Base Radio 65030 General Specifications	2
Table 1-2: ITC Model Base Radio 65030 Transmitter Specifications	4
Table 1-3: ITC Model Base Radio 65030 Receiver Specifications	4
Table 4-1: Equipment required for installation and field service	14
Table 4-2: Base radio input power parameters	15
Table 4-3: Front panel LED sequence on radio start-up	23
Table 4-4: Normal states of front panel LEDs	25
Table 6-1: radiostate command response	33
Table B-1: Base radio parts and part numbers	48
Table E-1: Initialisms and acronyms	54

1 Introduction

The *ITCR^{NG-BR} Base Radio Installation and Field Service Guide* provides important radio-frequency safety information, installation procedures, and servicing instructions for the Meteorcomm Interoperable Train Control (ITC) Base radio model 65030.

The model name of this radio is ITCR-NG-BR, expressed in this document variously as ITCR-NG-BR and ITCR^{NG-BR}. Informally, throughout this and other documents, the radio is referred to as the "ITCR^{NG} Base radio" or the "Base radio".

1.1 Audience

This guide is intended for users who perform any of the following tasks on Base radios:

- Install or replace them.
- Diagnose common problems.
- Adjust radio characteristics.
- Make simple repairs.
- Perform routine maintenance.

Prerequisites for users of this guide include:

- The ability to work with standard radio-frequency (RF) test equipment, including knowledge of how to prevent equipment damage or personal injury.
- The ability to measure basic transceiver performance, including RF power, frequency and receiver sensitivity, and the knowledge to analyze RF performance.
- Basic knowledge of the Linux shell.
- Knowledge of how to use an SSH client.
- Familiarity with means to limit RF exposure from antennas and familiarity with the Meteorcomm *RF Energy Exposure Guide*.

1.2 Some Terms Used in this Documentation

Certain terms and conventions are used throughout many ITCR documents.

The term "Base radio" refers to the radio hardware unit and its immediately associated equipment, such as antenna, GNSS, and power source.

The term "base" refers to a network role that provides a connection to the Back Office. At present, only a Base radio can occupy the base role.

The term "remote" refers to a network role that does not provide a direct connection to the Back Office but that maintains its connection to a radio in the base role. Locomotive or Wayside radios usually fill the remote role, but you can also configure a Base radio to operate in the remote role.

The terms “class C address” and “class D address” refer to the IPv4 address ranges.

The term “Class C messaging” refers to the UDP-based message protocol used to broadcast short messages. Interoperable applications in the ITC interoperable messaging architecture join multicast groups to receive messages of interest.

The term “Class D messaging” refers to the TCP-based message protocol used for reliable point to point message delivery. Class D messaging is used between interoperable applications and the ITC Application Gateways. Class D messaging is also used between radios in remote areas and one or more ITC Messaging (ITCM) Connection Managers as well as bases and one or more ITCM External Link Managers.

The *ITCR^{NG-BR} Base Radio Installation and Field Service Guide* uses Linux-style notation.

Throughout this document the names of commands and their arguments in running text, as well as examples of commands and their outputs in shaded example boxes, are printed in `fixed-width font`, as in the following example:

```
config --profile --list
```

1.3 Specifications for ITC Model Base Radio 65030

The following tables describe the general, transmitter and receiver specifications for the Base Radio 65030.

Note: Specifications are subject to change without notice.

Table 1-1: ITC Model Base Radio 65030 General Specifications

Specification	Description
Frequency range	217.6 to 222 MHz
Channel spacing	25 kHz
Temperature range	Operating: -30°C to +70°C Storage: -55°C to +85°C
Humidity, operating	95% non-condensing; test per S-9401
Frequency stability	±0.1 ppm over operating temperature range (+25°C reference)
DC input voltage range	21 to 61 V Damage limit 65 VDC

Specification	Description
DC current drain (13.6VDC input)	Transmit: 11A max into 50 Ohm load, 4A to 7.5A typical Receive: 1.2A max while receiving
DC power connector	5/16"-18 threaded posts for ring lug connection
Height	5.25 in.
Width	17.17 in.
Depth	18.66 in.
Weight	30.4 lbs. (13.8 kg)
Antenna connector	Type N female
GNSS receiver	Antenna power: 3.3V or 5V at 50mA max Antenna connector: TNC female
GNSS antenna	Active or passive
External interface: Ethernet (3) 10/100/1000 Mbps	Data Network ports (2) – Type RJ-45 Maintenance port - (1) Type RJ-45
External interface: USB	USB 2.0/3.0 compatible
General purpose I/O	2x - Phoenix pluggable terminal block – 8 pos pn: 1873113
Display	Activity/Diagnostic LEDs on front panel

Table 1-2: ITC Model Base Radio 65030 Transmitter Specifications

Specification	Description
RF power output	75W PEP Adjustable 0.75 W to 75 W PEP
Output impedance	50 ohms Operating VSWR \leq 4:1
Modulation waveforms	16kbps $\pi/4$ DQPSK (linear) 32kbps $\pi/4$ DQPSK 48kbps $\pi/8$ D8PSK 64kbps $\pi/8$ 16 DAPSK
Occupied bandwidth	Meets: Part 80 Occupied BW: 2.1049 Part 90 Occupied BW: 90.209, 90.733(d)
Conducted spurious emissions	-25dBm max
Max duty cycle rating	50%
Emission designator	17K6DXW (32kbps $\pi/4$ DQPSK, 48kbps $\pi/8$ D8PSK, 64kbps $\pi/8$ 16 DAPSK) 8K90DXW (16kbps $\pi/4$ DQPSK)
Regulatory approval IDs	FCC (US) BIB65030 IC (Canada) 1300A-65030

Table 1-3: ITC Model Base Radio 65030 Receiver Specifications

Specification	Description
Maximum usable sensitivity, static, BER < 10 ⁻⁴	16kbps PI/4DQPSK -111dBm 32kbps PI/4DQPSK -108dBm

Specification	Description
Adjacent channel selectivity	70dB @ 25kHz offset
Spurious response rejection	65dB
Intermodulation response rejection	65dB
High input level (-7dBm)	BER < 10 ⁻⁴
Blocking, 1MHz offset	Half rate: 80dB
	Full rate: 77dB
Number of channels simultaneously received	40 (20 diversity receivers)
Diversity support	Equipped with two RF antenna connectors to support diversity reception

1.4 Release Documentation

Along with this document, the following documents are included in the release package.

- *ITC Radio System Architecture*, DCN 00004692-A
- *ITCR^{NG} 1.0 Release Notes*, DCN 00004475-A
- *ITCR^{NG} API Reference*, DCN 00004474-A
- *ITCR^{NG} Command Line Reference for Administration and Service (also called "CLI Reference")*, DCN 00004461-C
- *ITCR^{NG} Data Dictionary User Guide and Reference*, DCN 00004470-C
- *ITCR^{NG} Getting Started Guide*, DCN 00005090-A
- *ITCR^{NG} Logging User Guide and Reference*, DCN 00004469-C
- *ITCR^{NG} Radio Configuration Guide*, DCN 00004468-C
- *ITCR^{NG} Radio Management Guide*, DCN 00004463-C
- *ITCR^{NG} Security User Guide and Reference*, DCN 00004471-A
- *Meteorcomm Product Compatibility Matrix*, DCN 00003775-L
- *RF Energy Exposure Guide*, DCN 00001235-G

1.5 How to Get Help

Please contact our Service Desk (<https://support.meteorcomm.com/home>) if you have any questions regarding this release.

We encourage you to provide feedback, comments, and suggestions so that we can improve the documentation to better meet your needs. Send your comments to the Service Desk and provide the following information:

- Document name
- Section or page number
- Software release number

2 Safety

Your employer has created safety guidelines that apply to your work environment and tasks. Please follow them. If you have questions about general on-the-job safety concerns, please consult your employer's established safety guidelines.

2.1 Electrical Safety Guidelines

To reduce the risk of electric shock:

- Follow your employer's established electrical-safety guidelines.
- Disconnect power from radio before removing the cover.
- Be aware that removing the radio cover may expose you to dangerous voltages or other risks. Avoid making internal adjustments to the radio when you are alone.
- Avoid contact with a radio's electrical components. Electric shock from voltages present within the radio is potentially fatal.
- Reassemble radios correctly. Incorrect reassembly of a radio can cause a harmful electric shock to radio handlers.

2.2 RF Safety Information

You must be aware of the following information to prevent your physical harm or death or damage to the equipment.

2.2.1 Limiting RF Exposure



CAUTION! Please see the *RF Energy Exposure Guide* that is packaged with each radio for specific information regarding safe distances that must be maintained between personnel and energized transmitting antennas.

The information in the *RF Energy Exposure Guide* is determined from FCC and Industry Canada (IC) rules that, when followed, limit human exposure to radio frequency energy to acceptable levels. Note that although the Base radio should be sited, installed, and maintained only by professionals in a controlled-exposure environment, the *RF Energy Exposure Guide* lists the larger lateral safe distances for an uncontrolled environment. Obeying these limits will protect both railroad employees and the public.

The transmitter should be operated with a fixed antenna in an Occupational/Controlled Exposure environment per Federal Communications Commission (FCC) Office of Engineering and Technology (OET) 65 or Controlled Use Environment per IC RSS-102. The Maximum Permitted Exposure (MPE) limit

for devices in the presence of the general public in the 100-300 MHz range is $0.2 \text{ mW/cm}^2 = 2 \text{ W/m}^2$ vs. 10 W/m^2 in a controlled-exposure environment.

This radio is intended for use by railroad employees who have full knowledge of their exposure and can exercise control over their exposure to meet FCC and IC limits. This radio device is not intended for use by consumers or the general population.

The table in the *RF Energy Exposure Guide* lists the calculated lateral distances to be maintained between the general public and an operational Base radio transmitter antenna for two antenna types suitable for fixed applications.



CAUTION! RF exposure compliance while servicing multiple transmitter sites must be addressed on a site-by-site basis. It is the responsibility of the licensee to ensure compliance with maximum exposure limits.

2.2.2 Fixed Antenna Guidelines

This section contains antenna information and additional notes regarding methods to limit RF exposure.

You must:

- Comply with limits on antenna location, power and effective antenna height per 47CFR Subpart T §90.701 et. seq., or Industry Canada SRSP-512 §6.3 as applicable. See section 4.3 for additional information about how to comply with ERP limits. See the *RF Energy Exposure Guide* for specific guidelines regarding the siting and installation of fixed antennas.
- Follow the acceptable fixed-antenna types that are listed in the lateral separation distance tables in the *RF Energy Exposure Guide*.
- Install antennas in accordance with the manufacturer's instructions.
- Disable the transmitter when installing or servicing its antenna or transmission line.
- Maintain a safe distance from energized transmitting antennas. See the table of safe distances for Base radios in the *RF Energy Exposure Guide*, which is packaged with each radio.
- Remove any unauthorized antennas, equipment modifications, or attachments that could invalidate any equipment warranty or authority to transmit. Modification could damage the radio and may violate FCC or IC regulations. Contact Meteorcomm before using other antennas.

2.2.3 RF Interference Considerations

Notice to user: This equipment complies with Part 15 of the FCC Rules. Operation is subject to the condition that this device does not cause harmful interference.

Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

2.2.4 Equipment Modifications



CAUTION! Any changes or modifications to this equipment not expressly approved by the party responsible for compliance (in the respective country of use) could void the user's authority to operate the equipment.

3 Transmitter Operation

It is your responsibility, as the licensee, to operate this radio transmitter in compliance with FCC and Industry Canada service rules for 220-222 MHz, namely FCC Rules Part 90 Subpart T and Industry Canada SRSP-512. It is also your responsibility to coordinate specific frequency use within a specified area with PTC-220 LLC.

3.1 Radio Channelization and Frequency Range

You can configure the Base radio to transmit on any one of 80 selectable 25 kHz-spaced channels ranging from 220.0125 to 221.9875 MHz inclusive. The spectrum included corresponds to all 5-kHz-wide FCC channels numbered from 1 at 220.0025 MHz to 400 at 221.9975 MHz. Each Base radio transmission occupies five of the FCC-defined 5 kHz channels. The lowest channel center frequency for the Base radio is in the center of FCC channel 3 and the next is FCC channel 8, then 13, 18, and so on, up to the highest in the center of channel 398.

3.2 Channel Restrictions

Section 90.715 of the FCC Rules lists the authorized frequencies of the 400 total 5-kHz-wide channels. According to §90.733(d), these can be aggregated into larger channel widths with the exception of FCC channels 161 through 170 and 181 through 185. Therefore, the Base radio may not transmit on those channels or their 221 MHz counterparts, 361 through 370 and 381 through 385. This corresponds to Base radio frequencies 220.8125, 220.8375, 220.9125, 221.8125, 221.8375, and 221.9125 MHz.

Please see Part 90 Subpart T and SRSP-512 for additional frequency use restrictions in Canadian and Mexican border areas.

3.2.1 Restricting Base Transmission

If a Base radio connects to a Base radio advertising a local channel with a restricted frequency, the Base radio will transmit on that frequency. To prevent this situation, the `localInhibit` configuration parameter specifies a list of channels that the Base radio will not use.

```
{
  "itcnetd" : {
    "channels" : {
      "localInhibit" : [140, 141, 142]
    }
  }
}
```

There is no need to inhibit a channel if there is no risk of connecting to a Base radio using that channel.

3.3 Radiated Power Limits



WARNING! It is your responsibility, as the licensee, to comply with the effective radiated power limits based on operating frequency, geographic location, and effective antenna height set out in 47CFR Subpart T §90.701 et. seq., or Industry Canada SRSP-512 §6.3, as applicable.

Important: The following supplementary antenna system information discusses methods for you, as the licensee, to determine effective radiated power (ERP) and comply with regulatory power limits.

You must comply with the specific power and antenna height limitations for fixed-antenna stations per §90.729 or SRSP-512 §6.3. Note that U.S. and Canadian power limits vs. HAAT are not identical.

You should note that all mobiles and also fixed installations transmitting between 221 and 222 MHz must limit ERP to 50W or $10 \cdot \log(50) + 30 = 47$ dBm peak envelope power (PEP) referenced to the 2.15 dBi gain of a dipole, unless operating under a waiver of FCC rule §90.729(b) or SRSP-512 §6.3 as applicable. The EIRP for this case is 49.15 dBm. Also note that the maximum ERP on FCC/IC channels 196 through 200 at 220.975 to 221.000 MHz is 2W.

The allowable transmitter peak envelope power output in dBm is determined by subtracting the antenna gain in dBi from 47, then adding the loss from the antenna feedline and connectors. If the result is greater than or equal to 44.85 dBm = 14.85 dBW then the maximum power output of the Base radio transmitter can be used. If the value is less than 44.85 dBm, then the transmitter output power must be reduced to the calculated value.

3.3.1 Mobile Installation

The Base radio is not intended for mobile service.

3.3.2 Fixed Installation

In a fixed installation, a common single-element exposed folded dipole antenna without reflector has 0 up to 2.9 dBd (2.1 – 5.0 dBi) azimuthal gain depending on the design.

After the allowable ERP is determined by applying all the previously listed power-restrictive rules and the antenna gain is known, the transmitter peak envelope power output feeding the transmission line is determined by subtracting the antenna gain in dBd from the ERP and adding the loss from the antenna feedline and connectors plus the loss from any external inline power sensors, combiners, filters or lightning arresters. If the net value is greater than or equal to 44.85 dBm, then the maximum power of the Base radio transmitter can be used. If the value is less than 44.85 dBm, then the transmitter output power must be reduced to the net value.

Example for the 50W ERP fixed case: Antenna gain = 2.9 dBd and feedline loss is at least 0.5 dB for 25 feet of Times Microwave LMR-400 coax plus 0.4 dB for inline lightning arrester and three connectors. Assuming no other losses, the transmitter power output limit = $47 - 2.9 + 0.9 = 45$ dBm PEP. In this case, the actual Base ERP is $44.85 + 2.9 - 0.9$ dBm = 46.85 dBm = 48.4W PEP and therefore the system is compliant with the 50W ERP limit. This installation is not allowed to transmit on FCC channels 196 through 200 because the maximum ERP is greater than 2W.

4 Installation

The Base radio satisfies the industry standard ITC requirements as part of an integrated 220 MHz radio network supporting the implementation of Positive Train Control (PTC) systems. The ITC Base, Locomotive, and Wayside radios form the transportation backbone on which a messaging application provides communication capabilities between railroad assets and their Back Offices. The ITC radio provides communication in an interoperable fashion enabling messaging to occur across railroad boundaries.

Base radios are typically installed at co-located facilities and configured as bases to make connections with remote radios. The radios are housed in metal enclosures. The radio's dimensions are approximately 17.17" wide x 5.25" tall x 18.66" deep and it weighs 30.4 pounds.

All input/output ports are grounded and/or shielded. Internal shielding, unit assembly and printed circuit board (PCB) design are used to minimize unwanted radiated emissions.

Figure 4-1: Base radio

[Illustration to be provided]

Radio installation consists of these steps:

1. Unpack and inspect the radio.
2. Mount the radio.
3. Ground the radio.
4. Install current-limiting circuit protection.
5. Connect the antenna.
6. Connect the Ethernet cable.
7. Connect the GNSS antenna.
8. Connect the power cable.
9. Power on the radio.
10. Check front-panel LEDs.
11. View the power-on self-test (POST) results.
12. Initialize coordinated universal time (UTC) time correction data.

The following sections describe each of these steps in detail.

4.1 Equipment Required for Verification of Specification Compliance

Following is a list of equipment required to perform all of the tests described in this document. You should be familiar with the pieces of test equipment listed in the following table. Instructions about how to use the following equipment are beyond the scope of this document.

Table 4-1: Equipment required for installation and field service

Type	Model	Notes
Vector signal generator	Agilent E4438C or equivalent	Recommend option for 50VDC, 50W input protection of RF signal output port. Preprogrammed with DQPSK data packet.
Vector signal analyzer	Agilent E9010A or equivalent	
10 MHz frequency standard	Standard Research Systems model FS725 or equivalent	Base radio frequency adjustments require frequency standard accuracy to 0.01 ppm or better.
60 dB power attenuator/load		Consists of two pieces with 100W and 2W min. power rating.
Constant voltage DC power supply		Verify unit supports voltage and current draw required by unit under test.
Host computer with at least one Ethernet port and MobaXterm, PuTTY, or equivalent terminal program installed		If the host computer's Ethernet port has not been configured, follow the instructions in "Appendix A: Configure Computer Ethernet Interfaces" on page 47.
Clip-on ammeter		
Antenna/VSWR test kit		
Cable ties as required		
Digital volt meter		
Network analyzer		
Portable power meter		
Site tester		

4.2 Unpacking and Inspecting the Radio

When you unpack and inspect the radio, note any damage that may have resulted from shipping including dents or loose parts. Also note any damage or discrepancies between the contents in the shipping container and the packing list.

Note: The radio is shipped with a power connector (Meteorcomm [MCC] part number 010-031-0306). Please ensure it is connected to the radio and not left in the packing box.

If you detect damage or the contents do not match the invoice, make note of the defect and contact the radio manufacturer, with particular attention to the following:

- Observable damage to chassis and connectors
- Missing parts such as screws and included connectors
- Evidence of contamination including stains and odors
- Evidence of electrical stress such as plasma flashover, pitting, and arc damage

If you do not detect any damage and the shipping invoice matches the contents, continue with the installation.

4.3 Mounting the Radio

The radio cover is equipped with top and bottom mounting features. The Base radio should be mounted on a vertical surface with the cooling fins oriented vertically for maximum heat dissipation.

In mounting the radio, ensure that:

- Equipment that produces substantial heat is not installed below the radio.
- There is adequate room to install and remove a USB memory stick. **Note:** Leaving mass storage USB devices installed while the radio is unattended is not recommended.
- There is adequate room for cable connections.
- Cables are restrained to prevent kinking, and stressing connectors.

Figure 4-2: Vertical mount

Figure 4-3: 19-inch rack mount

[Illustration to be provided]

4.4 Power Supply Requirements for Base Radios



CAUTION! Applying an incorrect voltage outside the rated voltage range of a Base radio can damage it. Confirm the voltage ratings of the radio and the power supply before applying power.

Table 4-2: Base radio input power parameters

Parameter	Value
Nominal DC Power Input Voltage	24VDC or 48VDC
Operational Range	21VDC – 61VDC
Damage Limit	65VDC
Current Drain (while transmitting rated power)	4A to 7.5A typical typical while transmitting into 50 Ohm load, 11A maximum

4.5 Grounding the Radio



WARNING! Ensure the radio is grounded. Not grounding the radio could result in possible bodily injury.

The Base radio is equipped with a 1/4-inch grounding stud located between the antenna connection and the external power connection.

To ground the radio:

1. Remove the nut and washer from the grounding stud.
2. Connect the ground wire ring lug to ground.

Note: Meteorcomm recommends that the gauge of the ground wire connected to the grounding stud of the radio be the same as or lower than the gauge of wire supplying power to the radio.

3. Replace the washer and nut and tighten to 65-75 in-lb for the 1/4-20 nut.

4.6 Installing Current Limiting Circuit Protection

External circuit protection must be supplied to each radio. If necessary, always replace the fuse with a 11A/32V-rated ATO fuse.

4.7 Connecting the Antenna

You must plan the location before you can connect the antenna.

4.7.1 Antenna planning

The radio is designed to be properly terminated to 50-Ohm resistance load. Base radios have three antenna ports.

4.7.2 Connecting the cable

The Base radio is rated for 75W peak envelope power (PEP). Sufficient termination is required to protect test equipment. The Base radio uses N-type connectors for narrowband RF antennas. For transmitter and receiver testing, connect the test equipment to the port labeled ANT.

Figure 4-4: Antenna connector

[Illustration to be provided]

To connect the cable:

1. Perform or confirm a 220 MHz antenna voltage standing wave ratio (VSWR) test prior to connecting the antenna to the radio using an antenna/VSWR test set.
2. Slip the connector over the radio port and tighten.
3. Restrain all cables while observing the cable manufacturer's minimum bend radius requirements.

4.8 Connecting the Ethernet Cable

The Base radio uses a shielded CAT5 or CAT6 Ethernet cable and three RJ-45 Ethernet I/O ports, each on its own network.

Figure 4-5: Ethernet connections

[Illustration to be provided]

Insert the cable into one of the ports on the radio marked LAN for 'local area network'.

Note: It is recommended that only shielded cable be used.

4.9 Connecting the GNSS Antenna

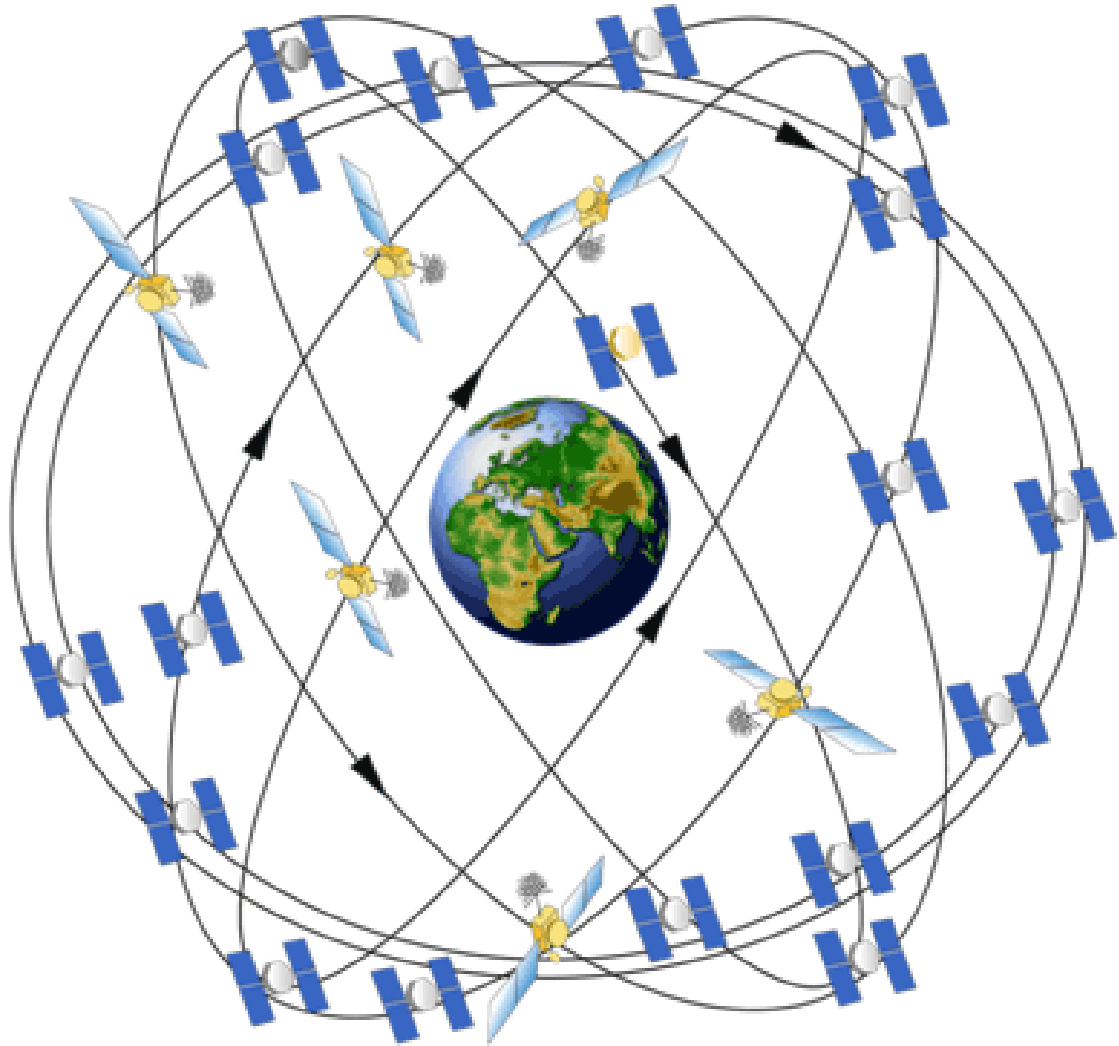
Position the GNSS antenna to avoid strong interferers that could saturate the antenna low noise amplifier or the radio GNSS receiver internal low noise amplifier. Combinations of strong interferers could mix and interfere directly with the GNSS signal quality. Test the radio GNSS with any interference source active to qualify the antenna-antenna isolation of the GNSS antenna position.

4.9.1 GNSS satellite constellation overview

The current GNSS satellite constellation is comprised of 30 active satellites in six inclined orbits, with several on-orbit spares. The GNSS satellites operate in circular, ~11-hour, 58-minute orbits at an inclination of 55 degrees, at an altitude of 20,200 km.

This type of satellite is referred to as a medium Earth orbit (MEO). It is not in geostationary orbit. This is important because unlike geostationary orbit (GEO) satellites, which are located at an altitude of 35,790 km over the equator, MEO satellites move throughout most of the sky so there is no significant preferential sky visibility sector when installing the GNSS antennas at the site. You must optimize the GNSS antenna location selection for as much sky visibility as possible, in all directions, not just south.

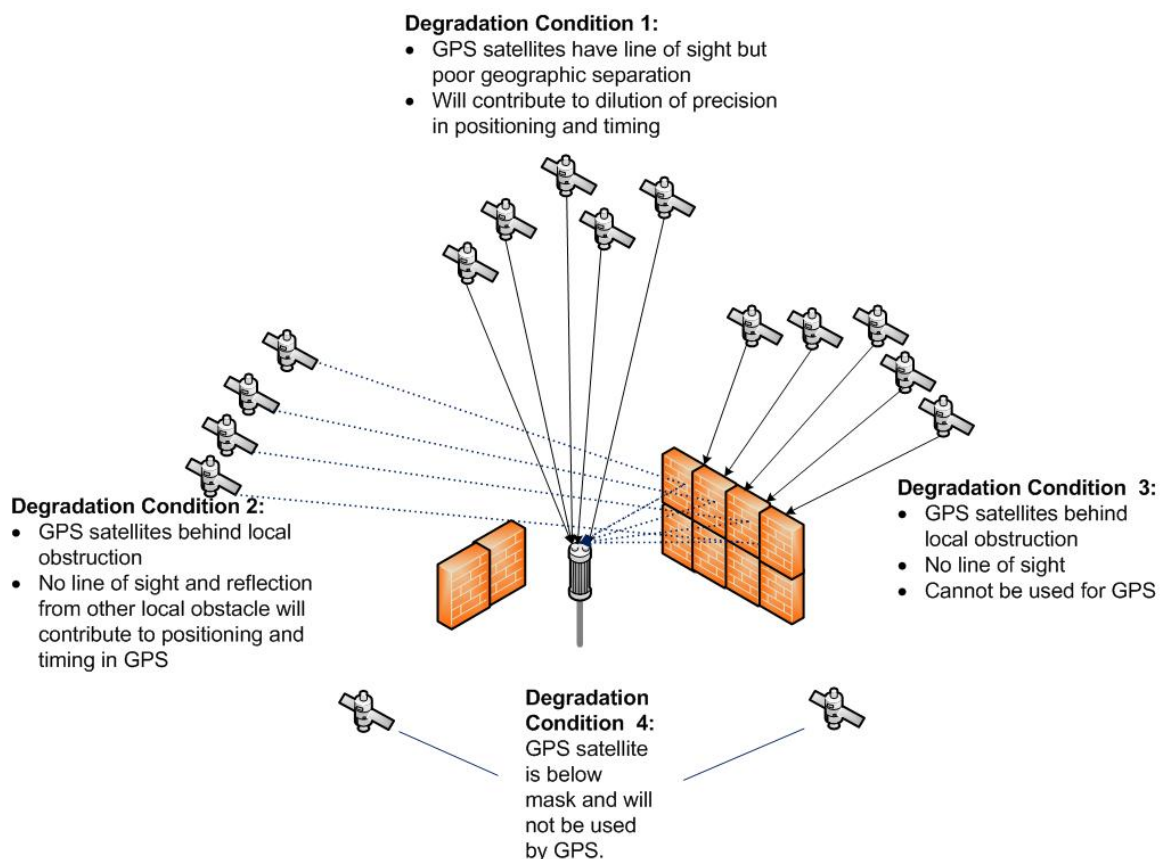
Figure 4-6: GNSS satellite constellation



4.9.2 GNSS antenna planning considerations

When determining antenna locations, you should consider several factors. The figure below illustrates four typical degradation conditions that a GNSS antenna may face.

Figure 4-7: GNSS antenna considerations



- Degradation Condition 1: Some of the satellites have a direct view to the GNSS antenna and as they move they fall behind various obstructions. There may be instances where the satellite constellation can provide replacement satellites that have unobstructed visibility. However, in the example shown, even the visible GNSS satellites have a poor geographic separation and this contributes to a poor dilution of precision (DOP).
- Degradation Condition 2: Some satellites may only have an indirect view of the GNSS antenna so that a reflected path that is longer than the direct path is all that is available. This results in an artificially long path, and timing errors are introduced, likely causing position errors during the self-survey and timing anomalies, depending on the distance of the reflecting object.
- Degradation Condition 3: Satellites that are completely obstructed have no view of the antenna and are invisible to the antenna, even though they are in the GNSS Almanac in the radio.
- Degradation Condition 4: Satellites that are below the mask angle (~10 degrees) that is set in the radio are ignored by the radio, even if they have perfect visibility of the antenna.

4.9.3 Minimize potential of GNSS antenna issues

You should optimize the GNSS antenna installation to avoid intermittent timing anomalies. In many cases, simply roof-mounting the GNSS antenna to a bungalow may not be sufficient.

The best ways to minimize impact from timing problems are to do the following:

- Install the antenna as high as is practical and as allowed by local, state, and federal laws.
- Reduce the obstruction angles by installing the antenna further from obstructions to reduce their apparent size from the perspective of the GNSS antenna:
 - Static obstructions to sky aperture include terrain, buildings, highway overpasses, flyovers, and coniferous vegetation.
 - Transient obstructions to sky aperture include vehicles, rolling stock (either moving or parked in a siding, especially at AAR Plate H), stored Conexes, and deciduous vegetation.
- Always note the format of the GNSS coordinates (for example, decimal-degrees or decimal-minutes).

4.9.3.1 Antenna separation at collocated sites

If multiple GNSS antennas are to be collocated, you should consider separation options.

This consideration stems from the use of high-gain low-noise amplifiers (LNAs) in the GNSS antenna itself. Close proximity can result in the input of one LNA detecting the output of an adjacent LNA, creating a feedback loop that may result in jitter and desensing.

Generally, active GNSS antennas should be separated by at least 6 feet, without compromising sky aperture. This is especially important at collocated sites where maintenance responsibilities of the various GNSS antennas and their transmission systems may span different departments, or even different companies. This is less of an issue with GNSS antennas installed on locomotives, where one department in a single company is responsible for the maintenance of GNSS antennas and their transmission systems.

Sometimes, due to environmental and economic constraints, optimizing the GNSS antenna location any further is not possible. In those cases, it may be more effective to reconsider which of the three available timing modes will best serve an impaired GNSS installation.

4.9.4 Connecting the GNSS antenna

The GNSS antenna connection is a threaded Neill–Concelman (TNC) female connector and always provides an active antenna voltage. If the active antenna installed exceeds either the voltage or current ability of the radio then external power must be supplied to that antenna. A DC block must be used at the radio when the additional power is supplied to avoid damage to the radio.

Figure 4-8: GNSS connector

Insert image showing connector on a Base radio

To connect the GNSS antenna:

1. Confirm that the GNSS antenna has been verified with a network analyzer.
2. Verify the power requirement of the GNSS antenna and connect a DC block and tee in the case that external power is necessary.
3. Connect the GNSS antenna cable to the GNSS antenna input connector on the radio and tighten securely but do not overtighten. Avoid cross-threading the connector.

4.10

Connecting the Power Cable



CAUTION! Applying an incorrect voltage to a radio can cause damage. Confirm the voltage of the power supply and the polarity before applying power to the radio.

The Base radio operates from a 24VDC or 48VDC nominal supply (21VDC – 61VDC range) isolated from other electronic equipment using a DC-DC isolated converter. The Base radio uses terminal studs; it is recommended to use the compatible ring lugs.

Note: The radio only operates on DC voltage. Any application of AC voltage could damage the radio.

Figure 4-9: Example of a typical power cable externally fused with 10A ATO

[Illustration to be provided]

Figure 4-10: Power connector

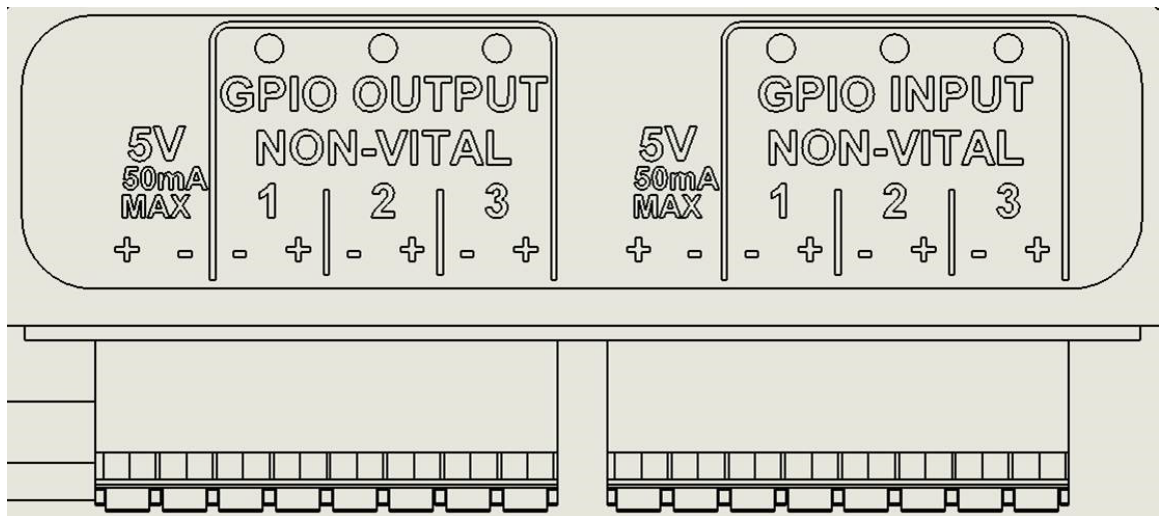
[Illustration to be provided]

To connect the power cable:

1. The radio does not have a power switch. Verify that the power is off before connecting the radio to a power source.
2. Confirm proper grounding.
3. Verify the ground bond from the ground lug on the radio through external surge protection.
4. Confirm that the ground lug connection has not bypassed the isolator converter.
5. Insert the connector into the slot. The connector can only fit one way. Make sure the red wire is connected to the slot marked +.

4.11 Connecting the GPIO connectors

Figure 4-11: GPIO connectors



4.12 Powering On the Radio



WARNING! You should never apply power to any radio unless you are acutely aware of your intentions and the environment in which the radio is operating. Applying power to an improperly terminated radio may result in damage to the radio, cause operator injury, or violate regulatory laws regarding radio transmissions because radios will begin transmitting full-rated power without any user intervention under certain conditions.

To power on the radio:

1. Confirm that all connections are tight and secure.
2. Power on the radio.

4.13 Checking the Front Panel LEDs

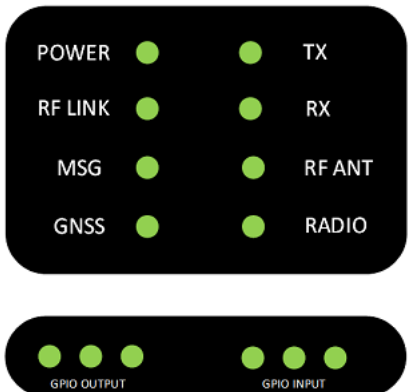
The layout of the LEDs is as follows:

First row: POWER | TX
 Second row: RF LINK | RX
 Third row: MSG | RF ANT
 Fourth row: GNSS | RADIO
 Bottom row: GPIO LEDs

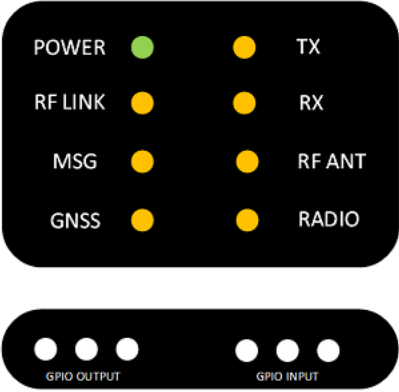
4.13.1 LEDs at Power-On

On power-on, the front panel LEDs, including the general purpose input output (GPIO) LEDs, progress through a sequence indicating that the operating system has booted and the radio application software is starting. The Power LED is not under software control. The progress is described in [Table 4-3](#).

Table 4-3: Front panel LED sequence on radio start-up

Trigger	Pattern	Notes
Start of boot sequence		All settable LEDs Green for a brief period, approximately 0.5 seconds.

Trigger	Pattern	Notes
		All settable LEDs Off for a brief period, approximately 2.5 seconds.
		All settable LEDs Red for a brief period, approximately 2.5 seconds. GPIO LEDs are Off.
		All settable LEDs Green for a brief period, approximately 2.5 seconds.

Trigger	Pattern	Notes
		All settable LEDs Amber for a brief period, approximately 2.5 seconds. GPIO LEDs are Off.

The LEDs take on their normal states upon completion of the boot sequence. These are described in [Table 4-4](#).

The LEDs (except POWER) remain amber if the radio is booted to the failsafe partition upon factory reset.

4.13.2 Normal LED States

The normal states of the front panel LEDs are described in the following table.

Important: Read the description of each LED below carefully. Some LEDs, such as the POWER LED, indicate a problem when they are off. Other LEDs, such as MSG (Message) and RADIO, indicate a problem when they are steady red.

Table 4-4: Normal states of front panel LEDs

Label	Description	Color
POWER	<ul style="list-style-type: none"> GREEN when the power is good. 	Red/Green/Amber
RF LINK	<ul style="list-style-type: none"> OFF before itcnetd is running. AMBER after first DTDMA cycle and before first remote has connected. GREEN after one or more remotes have connected to the base. RED if there are no remotes connected to the base. 	Red/Green/Amber

Label	Description	Color
	<p>Note: The RF LINK LED only transitions to RED from GREEN.</p>	
MSG	<ul style="list-style-type: none"> • OFF until configured HRX servers are started. • AMBER after HRX servers are started and waiting for ELM connection on startup. • GREEN when primary and backup ELMs are connected. • RED if primary connection is lost (indicates message fault). • RED for 5 seconds if backup connection attempt fails. <p>Note: The MSG LED will remain OFF if, for any reason, the radio is not configured for an HRX connection to a messaging host.</p>	Red/Green/Amber
GNSS	<ul style="list-style-type: none"> • OFF after timesyncd service starts. • AMBER after GNSS initialization is complete and before radio enters Precise timesync state (or a valid GNSS UTC time is received). • GREEN when a valid GNSS fix is achieved. • RED when initial configuration is not complete within 60 seconds. • RED when the valid GNSS UTC time has not been received within 60 seconds after timesyncd service starts or 3 seconds after previous GNSS UTC time update, which occurs every second. • RED when an SBF ReceiverStatus is not received within 60 seconds. • RED when GNSS antenna circuit is open or short (an overcurrent is detected); remains RED until condition is cleared (the fault condition of not receiving GNSS UTC time within 3 seconds will likely be triggered before an antenna fault condition but the LED remains RED until the next ReceiverStatus report, which occurs every 30 seconds, to confirm the antenna condition is cleared or not). • RED when radio discovers any health related issues causing reconfiguration or recovery; remains RED until fully recovered (i.e. Precise timesync state is entered). 	Red/Green/Amber

Label	Description	Color
TX	<ul style="list-style-type: none"> • OFF initially • OFF when transmit is completed successfully • GREEN when the transmitter is active 	Red/Green
RX	<ul style="list-style-type: none"> • OFF initially • OFF when no receiver is in RECEIVING state • GREEN when any receiver is in RECEIVING state 	Red/Green
RF ANT	<ul style="list-style-type: none"> • OFF before itcnetd or testmoded is running. • AMBER when no transmit measurements have been made. • GREEN if VSWR is less than the threshold AND forward power is between 75% to 133% of PA power. The threshold is 4.0 (if transitioning from AMBER) or 3.0 (if transitioning from RED or GREEN). • RED when VSWR is greater than 4.0. • RED when forward power is less than 75% or more than 133% of PA power. • AMBER when no VSWR measurements have been made within 30 minutes of a good transmission. 	Red/Green/Amber
RADIO	<ul style="list-style-type: none"> • OFF Initially upon radio boot until software is sufficiently running to maintain proper states. • OFF when a restart is requested. • AMBER when one or more of the following conditions exists: <ul style="list-style-type: none"> • Configuration and calibration have not yet completed. • The duration of the period when duty cycle limiting is being enforced. • Radio is configured to be in test mode. • Transmitter is disabled (as for example with the <code>txdisable</code> command). • GREEN when all of the following conditions are met: 	Red/Green/Amber

Label	Description	Color
	<ul style="list-style-type: none"> Radio is in normal mode (itcnetd is operational). A valid configuration is loaded and calibration is locked. Transmitter is not disabled. RED when any of the following conditions are met, regardless of above conditions: <ul style="list-style-type: none"> The selected configuration is invalid. Radio is not calibrated (calibration is unlocked). A required service is not running. 	
GPIO OUTPUT 1	Illuminated on GPIO Output 1 activity.	Green
GPIO OUTPUT 2	Illuminated on GPIO Output 2 activity.	Green
GPIO OUTPUT 3	Illuminated on GPIO Output 3 activity.	Green
GPIO INPUT 1	Illuminated on GPIO Input 1 activity.	Green
GPIO INPUT 2	Illuminated on GPIO Input 2 activity.	Green
GPIO INPUT 3	Illuminated on GPIO Input 3 activity.	Green

4.14 Displaying POST Results

A power-on self-test (POST) is a series of several dozen tests that the radio quickly runs on itself each time it boots up to determine whether it has any problems or is missing any critical information. Entering the `post` command multiple times does not rerun the tests. The `post` command only reports the results of the most recent POST.

Possible POST results are: PASS, FAIL, or NOT RUN.

To display the POST results:

1. Connect to the radio.
2. On the command line, enter: `post`

3. View the POST results list. (For information about using the `post` command see the *ITCR^{NG} CLI Reference for Administration and Service*.)

4.15 Initializing UTC Time Correction Data

Following initial connection of the GNSS antenna, it may take up to 12.5 minutes (assuming nominal conditions) for the radio to obtain UTC time correction data from the GNSS satellite constellation. Prior to receiving the UTC time correction data, the GNSS receiver outputs a time value that is an integral number of seconds ahead of the correct time. The radio detects this condition and inhibits time-synchronized ITCnet transmissions in order to avoid causing network interference. Upon receipt of the UTC time correction data, the GNSS receiver reports the correct time and the radio stores the UTC time correction data in nonvolatile memory for future use in aiding the GNSS receiver.

Note: A radio that is put in storage after this initialization may hold stale UTC time correction data, and may require reinitialization when placed into service.

5 Command Security

User authentication identifies you as someone who is allowed to change the radio's configuration settings.

User authentication tasks consist of:

- Logging on to a radio
- Logging off from a radio
- Managing your SSH authentication keys

The following sections describe each task in detail.

5.1 Logging On to a Radio

To log on to a radio, you must configure a computer to communicate with the radio. Your computer and terminal emulator application must satisfy the following prerequisites:

- The computer is connected to the radio's maintenance (MAINT) port.
- The Ethernet interface is configured to communicate with Transmission Control Protocol (TCP) port 22 on the radio.
- The firewall rules are configured to allow Secure Shell Protocol (SSH) access.
- The computer has native support for an SSH client or has an SSH client installed.
- The radio's SSH private key for the user account or the admin account is available to the computer's SSH client. The predefined identity files containing the private keys are in Privacy Enhancement Mail (PEM) format and may need to be converted to a different format if your SSH client does not support PEM files.

Additional prerequisites for logging on to a radio are:

- The radio has been powered.
- You have permission to enter commands that can change configuration settings.

You may log on to a radio using SSH through an account named "user" or "admin"; these account names are case sensitive. The admin account has permission to run more commands than the user account. These accounts do not have passwords, but they are authenticated through SSH using private keys provided to your SSH client.

Notes:

- You can make an unlimited number of log-on attempts without being locked out of the radio.
- More than one SSH authentication key can be associated with an account.

To log on to the radio:

1. On your computer, use your SSH client to log on to the account that you wish to use with the account's identity file. The radio uses the default SSH port, TCP port 22.
2. When you have successfully logged on to the radio, you will see the command prompt of a Linux interactive login shell.

5.2 Logging Off from a Radio

After you log on to a radio, you can log off at any time by ending the SSH session. If you have opened more than one session with the radio, ending one session will not affect the other sessions.

To log off from a radio:

1. On your computer, access your SSH client that is handling the session that you wish to end.
2. At the command prompt type:

```
exit
```

Alternatively, enter Ctrl+D.

Note: You may have to do this more than once if you have opened sub-shells.

The final command logs off the login shell and closes the SSH session.

5.3 Managing SSH Authentication Keys

Changing your SSH authentication key from the predefined key or a key you have been using for a while to a new authentication key improves radio security. If you are not sure when to change your authentication key, ask an administrator to check with your company's established procedures for guidance.

The `userkey` command can be used by the admin account to list keys. See the section "Creating New SSH Keys" in the *ITCR^{NG} Getting Started Guide* for information about how to create a new key and create a kit containing the new key. Then, if you are using MobaXterm, see the section "Kit Management" in that document for information about how to add and remove kits containing keys for the admin and user accounts. To manage kits using the command line see "Managing User Access" in the *ITCR^{NG} Radio Management Guide* and the `kit` command in the *ITCR^{NG} Command Line Reference for Administration and Service*.

The predefined keys for each user account can only be replaced by installing a kit with new SSH auth keys for the same user account.

6 Troubleshooting

This section describes common radio problems, their probable causes, and likely solutions. Problems covered in this section are those related to:

- Power
- Antenna
- Transmitter
- Receiver
- Ethernet connectivity
- RF link
- Time and location

In the following sections, solutions to a given problem are listed in the order you should try them.

6.1 Guidelines for Troubleshooting Common Problems

Always check these items first when a radio problem occurs:

1. **Check physical radio connections**

Make sure that all physical connections to the radio are secure. This includes: power, Ethernet, antenna(s), and GNSS.

2. **Check the LEDs**

Use the LEDs to determine the state of the system and whether there is a fault condition. See ["Front panel LEDs" on the facing page](#) for more information.

3. **Determine the software version each radio is running**

Check the result of the `apps` command to determine what revision of radio software is running.

4. **Check the state of the radio**

Use the `radiostate` command to view the state of the radio.

5. **Check the POST results**

Check the output of the `post` command on the radio to ensure that no tests failed during the most recent `post`. See ["View the results of the most recent POST" on page 34](#) for more information.

6. **Check that the radio configuration is up-to-date**

Use the `config` command to query the configuration components of interest (see the *ITCR^{NG} CLI Reference*). For more information on radio configuration, see the *ITCR^{NG} Radio Configuration Guide*.

6.1.1 Commonly used diagnostic commands

A number of CLI commands are available to provide information about the state of the radio, including current RF connections and software version information. You can use them to collect information that may be useful in determining why a radio connection is not performing as expected. The `radiostate` command is described below. For the full list of CLI commands, see "Commands Grouped by Function" in the *ITCR^{NG} Command Line Reference*, paying particular attention to the Status and Diagnostic groups.

6.1.2 Front panel LEDs

On power-on, the front panel LEDs indicate the progress through the boot sequence.

The front panel LEDs show the general operational status of the radio after the radio conducts a POST, which it does each time the radio boots up. [Table 1-2](#) includes a description of the function of each LED as well as the color of each LED when the radio is functioning properly.

6.1.3 Check the state of the radio with the radiostate command

The `radiostate` command queries the radio's operational states, composed of the asset state and the POST state. It displays the LED status and the detailed reason why the LED is in its current state.

As shown in [Table 6-1](#), the `radiostate` command returns an asset state value indicating the radio's current state, including the Radio LED color, and a table listing the status of each of the radio's subcomponents.

Table 6-1: radiostate command response

Asset state: Fully Operational (Radio LED: Green)		
Subcomponent	Status	Reason
-----	-----	-----
Configuration	Good	Valid
HRX connection	Good	Connected to host
Calibration	Good	Calibration locked
Mode	Good	itcnet operational
Tx state	Good	Enabled
VSWR	Good	In range
Timesync	Good	Precise
Temperature	Good	In range

Voltage	Good	In range
Software	Good	All services active
Hardware	Good	No failures
POST	Pass	All post tests pass

The asset state portion of the response is a summary based on a set of criteria. Each criterion is included in the table and reported as "Good" or "Bad", depending on the criterion's value compared to a fully operational radio. Only when all criteria are designated as "Good" is the asset state shown as "Fully Operational".

The POST item in the response is a summary of the results of the power-on self-test, which is actually many discrete tests. See the `post` command for additional information regarding the results of individual tests.

The value returned for Radio LED is one of the following: Off, Red, Green, or Amber.

To view the radiostate command output:

1. Connect the computer to the radio MAINT port.
2. On the command line, enter the `radiostate` command with no arguments:

```
radiostate
```

6.1.4 View the results of the most recent POST

A POST (power-on self-test) is a series of several dozen tests that the radio quickly runs on itself each time it boots up to determine whether it has any problems or is missing any critical information. Entering the `post` command multiple times does not rerun the tests. The `post` command only reports the condition of the radio at the time it was last powered up.

Possible POST results are PASS, FAIL, and NOT RUN.

To display the POST results:

1. Connect to the radio.
2. On the command line, enter the `post` command with no arguments:

```
post
```

3. View the POST results list. For details about each test, see the `post` command in the *ITCR^{NG} Command Line Reference*.)

6.1.5 System log contents

The system log adds more debug information that you can use for POST analysis so that you can troubleshoot issues with your radios by analyzing the system log.

6.1.6 Boot a radio

A radio boots up when it is powered on, when the `sysreboot` command is sent to it, or the software stops responding.

To boot a radio:

1. Power on the radio by connecting it to a power supply that meets the "DC input voltage range" specified (see "[Specifications for ITC Model Base Radio 65030](#)" on page 2) or send the `sysreboot` command to the radio.
2. Connect the computer to the radio MAINT port.
3. On the command line, enter the `sysreboot` command with no arguments.

```
sysreboot
```

If you solved the radio problem, the front panel LED that indicated a problem should now indicate normal operation. If it still indicates a problem, continue troubleshooting.

6.2 Radio Power Problems

Problem indicators:

- There is no power to the radio.
- The POWER LED is off.
- The radio does not transmit.
- The Fault LED is on.
- The POST results show that the internal voltages are out of range.

To troubleshoot radio power issues:

1. Make sure the power-cable connectors are securely connected to the power supply and to the radio.
2. Make sure the power-cable polarity is correct.
3. Make sure the power supply is turned on.
4. Measure the voltage at the power-cable connector to the radio. Adjust the power supply to within the rated operating voltage.
5. Verify that current limiting on the supply is not less than the maximum current draw.

6. Replace the power cable.
7. Replace the radio. See ["Replacing a Radio" on page 41](#).

6.3 Antenna Problems

Problem indicators:

- Transmissions from or to the radio are poor or absent.
- The radio's RF ANT LED is on.

To troubleshoot antenna issues:

1. Make sure the antenna-cable connector is securely connected to the antenna and to the radio.
2. Check the antenna for any defects or breaks.
3. Check the cable connector and radio connector for corrosion.
4. Check the lightning suppression device for shorts, faults, etc.
5. Use the commands `txtest`, `canmsg`, and `vswr` to verify that there are no electrically detectable defects in the above components (for information about these commands, see the *ITCR^{NG} Command Line Reference*).
6. Replace the cable or connector if necessary.
7. Replace the antenna if necessary.
8. Replace the lightning suppression device if necessary.
9. Check the radio output power with a nonreactive load connected.
10. If the RF ANT LED is lit, use the `vswr` command to determine why. On the command line enter:

```
vswr
```

Following are examples of the response to the `vswr` command that show good and bad status.

A good status looks like this:

```

      Status: good
      Age: 1 min
      VSWR: 1.2:1
Forward power: 43.90dBm
Reflected power: 23.07dBm
PA temperature: 32.0C
      PA current: 5.97A
PA driver current: 0.00A
Battery voltage: 13.70V

```

A bad status looks like this:

```
Status: bad
Age: 1 min
VSWR: 4.5:1
Forward power: 39.96dBm
Reflected power: 36.03dBm
PA temperature: 33.0C
PA current: 5.93A
PA driver current: 0.00A
Battery voltage: 13.70V
```

11. Replace the radio. See ["Replacing a Radio" on page 41](#).

6.3.1 GNSS Antenna

Check your GNSS antenna. It is recommended that your GNSS antenna supports L1, L2, and L5.

6.4 Transmission Problems

Problem indicators:

- Transmissions from the radio are weak or intermittent.
- Another radio in the network stops receiving expected communications from this radio.
- The TX LED never comes on.
- The RADIO LED is on.

To troubleshoot transmission issues:

- Make sure the radio is turned on and the green PWR LED is on.
- Use the `vswr` command to confirm the power output of the last transmission and VSWR (for information about this and other commands, see the *ITCR^{NG} Command Line Reference*).
- Check the cable connector and the radio connector for corrosion. If there is evidence of corrosion, replace the connector.
- If the STBY LED is on, use the `txstate` command to verify that the transmitter is enabled.
- Use the `radiostate` command to check subcomponents of the radio to ensure it is in proper working condition.
- Make sure the antenna-cable connectors are securely connected to the antenna, to the lightning protector, and to the radio.
- Adjust the RF power output higher and lower to verify that the transmitter output is controllable.

- Monitor the current supplied by the power supply to confirm that the typical transmit current is drawn and the radio is not current-limited.
- Check the antenna for any defects or breaks.
- Check the power supply voltage. If the power-supply voltage is too low, the radio might stop transmitting.
- Replace the cable or connector.
- Replace the radio (see ["Replacing a Radio" on page 41](#)).

6.5 Receiver Problems

Problem indicators:

- This radio stops receiving communications from another radio in the network.

To troubleshoot receiver issues:

1. Make sure the radio is turned on and the green POWER LED is on.
2. Verify that the receive frequency of this radio is within limits (see ["Specifications for ITC Model Base Radio 65030" on page 2](#)).
3. Make sure the antenna-cable connectors are securely connected to the antenna and to the radio.
4. Check the cable connector and radio connector for corrosion. If there is evidence of corrosion, replace the connector.
5. Make sure the base has a local channel configured for transmit. See the section on channel assignments for bases in the *ITCR^{NG} Radio Configuration Guide* for more information.
6. Check the antenna for any defects or breaks.
7. Replace the radio. See ["Replacing a Radio" on page 41](#).

6.6 Ethernet Connectivity Problems

Problem indicators:

- The radio is disconnected from the network.
- The MSG LED is off.
- The link and activity indicators are off.

To troubleshoot network connectivity issues:

1. Check network activity. If the network is down, then the problem probably is not in the radio.
2. Make sure the Ethernet cable is securely connected to the radio's LAN port.
 - a. Physically inspect the cable and connectors for damage and missing pins.
 - b. Inspect the Ethernet socket on the laptop and the radio for damage or "crossed fingers".

3. Verify that external equipment is functioning properly.
4. Connect your computer to one of the radio's LAN ports, send commands to the radio, and then see if the radio responds.

Note: To connect the computer to the LAN port, you must configure the computer's Ethernet interfaces to communicate with the radio, and you must know the LAN port's IP address. If you do not know the IP address, contact your system administrator.

5. Replace the cable.
6. Replace the radio. See ["Replacing a Radio" on page 41](#).

6.7 RF Link Problems

[Information to be updated for Base radio]

Problem indicators:

- The RF Link LED never comes on.

To troubleshoot RF link issues:

- Make sure the radio is turned on and the green PWR LED is on.
- Make sure the antenna-cable connectors are securely connected to the antenna and to the radio.
- Check the antenna for any defects or breaks.
- Check the antenna leading cable or coax for defects, breaks, or sharp bends (those with less than the cable's rated bend radius)
- Use the `radiostate` comand to make sure there is a valid configuration loaded.
- Verify that the base is transmitting. Use a signal source and perform a direct receiver test if necessary to isolate the problem.
- Replace the radio. See ["Replacing a Radio" on page 41](#).

6.8 Time and Location Problems

The ITCR^{NG} radio's CLI commands, configuration items, and logging provide enough information to support the radio's operation within the ITCNet protocol. In particular, the CLI command `itctime` can be used to display time of day, timesync state, and day length, while the `pntinfo` command displays location along with hardware, firmware and software version numbers and other data (see the *ITCR^{NG} Command Line Reference for Administration and Service* for more information). Enabling log TS-1312 provides human-readable printout of NMEA sentences to the monitor (see the *ITCR^{NG} Logging User Guide and Reference* for more information). These data are handled by Metercomm's time synchronization service as a client application of `gpsd`, an open source service that interfaces with the GNSS module.

Further useful information is available through cgps, a client-side utility of gpsd that also displays NMEA sentences in real time from the GNSS module. Most of the information displayed by cgps is available in the radio's timesync-related log messages, but some users may wish to use cgps rather than the radio's time synchronization service for debugging GNSS issues. Along with NMEA sentence monitoring, the cgps output also contains a table displaying data about all the satellites the GNSS module detects, as shown in [Figure 6-1](#), and would immediately give evidence of problems such as a broken antenna.

Figure 6-1: Partial cgps output

				Seen 15/Used 10					
Time:		2021-07-07T21:07:49.000Z			PRN	Elev	Azim	SNR	Use
Latitude:		47.47301250 N		GP	5	47.0	59.0	29.0	Y
Longitude:		122.23358633 W		GP	13	20.0	93.0	39.0	Y
Alt (HAE, MSL):		-24.606,	37.402 ft	GP	15	25.0	128.0	26.0	Y
Speed:		0.04 mph		GP	16	23.0	316.0	22.0	Y
Track (true, var):		n/a deg		GP	18	62.0	278.0	34.0	Y
Climb:		-19.69 ft/min		GP	20	23.0	51.0	44.0	Y
Status:		3D DGPS FIX (1 secs)		GP	23	31.0	205.0	47.0	Y
Long Err (XDOP, EPX):	0.54,	+/-	6.6 ft	GP	26	36.0	284.0	35.0	Y
Lat Err (YDOP, EPY):	0.63,	+/-	7.8 ft	GP	29	67.0	128.0	43.0	Y
Alt Err (VDOP, EPV):	1.67,	+/-	31.5 ft	SB	46	35.0	189.0	36.0	Y
2D Err (HDOP, CEP):	0.83,	+/-	12.9 ft	GP	10	2.0	213.0	0.0	N
3D Err (PDOP, SEP):	1.86,	+/-	29.0 ft	GP	25	10.0	186.0	13.0	N
Time Err (TDOP):	1.02			SB	48	35.0	184.0	32.0	N
Geo Err (GDOP):	2.12			SB	51	33.0	160.0	0.0	N
ECEF X, VX:	n/a	n/a	/s	QZ	194	18.0	301.0	14.0	N
ECEF Y, VY:	n/a	n/a	/s						
ECEF Z, VZ:	n/a	n/a	/s						
Speed Err (EPS):	+/- 10.6 mph								
Track Err (EPD):	n/a								
Time offset:	0.082 sec								
Grid Square:	CN87v1								

Review the cgps output:

1. Verify that Time is correct for UTC Time
2. Verify latitude, longitude, and altitude are correct for this location.
 - a. If they match your measurements, there are no issues
 - b. If they do not match your measurements, there may be a problem with the configuration loaded into the radio, if extant.
3. Check the Status field. Acceptable statuses are 2D Fix, 3D Fix, 3D DGPS Fix, and 3D RTK Fix.

4. Verify that you are seeing multiple satellites with signal-to-noise ratios (SNRs) that are greater than 30.
 - a. Some satellites may have SNRs less than 30, but this would mean that those satellites are screened by vegetation, clutter, or terrain.
 - b. To simplify this scenario, select a satellite with an elevation above 60 degrees, and the SNR should be in the mid 30s or higher.
 - c. Consistently poor SNRs indicate a GNSS antenna location issue, or a hardware fault in the GNSS transmission system (GNSS antenna, lightning suppressor, coaxial cable segments).
 - d. Satellites with a zero SNR (or no SNR at all) indicate that some satellites are completely blocked by vegetation, clutter, or terrain.
5. Verify that most of the satellites are marked as 'Y'.
 - a. If most or all satellites are marked 'N', this indicates a probable issue with the configuration loaded into the radio.

For more information see the following:

- gpsd - <https://gpsd.gitlab.io/gpsd/>
- cgps - <https://gpsd.gitlab.io/gpsd/cgps.html>

6.9 Replacing a Radio

When replacing a radio in the field, follow the safety information in "Safety" on page 7. Inspect the installation of the radio to determine if an installation problem caused the radio to fail.

To uninstall the existing radio:

1. Power down the radio.
2. Disconnect the power cable.
3. Disconnect the antennas.
4. Disconnect the Ethernet cable(s).
5. Disconnect the GPIO connectors.
6. Disconnect the GNSS antenna.
7. Remove the ground connection from the radio.

After uninstalling the radio, follow the instructions in "Installation" on page 13 to install the replacement radio.

For radios with manually obtained GNSS coordinates, reobtain the GNSS coordinates. If you do not know how the GNSS coordinates were determined, contact your network administrator.

7 Real-Time Log (a.k.a "Trace") Monitoring

The Base radio has combined tracing and logging into one function. See the *ITCR^{NG} Logging User Guide and Reference* for log definitions and the *ITCR^{NG} Radio Configuration Guide* for configuration instructions.

To provide a live view of log messages as they occur you can use `journalctl`. The `journalctl` utility is a standard Linux tool used to interact with logs captured by `systemd`. Using `journalctl` you can read, filter, and monitor logs in real time. The following briefly describes how to use `journalctl` to monitor logs in real time, but please see the `journalctl` man pages for complete details on all the uses of the utility.

In monitoring logs with `journalctl`, the most important switch is `--follow` (or `-f`), which continually prints log messages to the screen as they are produced. The following command displays all new log messages as they arrive.

```
journalctl --follow
```

8 Managing Software Application Images

From time to time, new functionality becomes available from the radio manufacturer in the form of a new software application image (also simply called an “image”). This new functionality is provided to the radio by updating the radio software.

All image management operations may be accomplished using operator commands. However, the radios also support performing some image management operations using ITC Systems Management (ITCSM) features through network connection from an application gateway. See the *ITCR^{NG} Radio Configuration Guide* for information about how to configure a radio for ITCSM connectivity.

Using ITCSM features involves creating a radio software kit, as well as sending the appropriate messages to the radio in order to perform the management operations. Consult with your Back Office support team or engineers for more information about ITCSM support of your radios.

This section offers instructions for:

- Determining software image status.
- Updating radio software application images.
- Performing a manual software rollback.
- Determining whether automatic rollback has occurred.
- Maintaining multiple software application images in the radio.

8.1 Determining Software Images Status

The radio is partitioned into three areas: A, B, and F. Partitions A and B are the alternate active and backup (or *rollback*) partitions, and F is the Failsafe partition used to recover the radio.

The `apps` command lists the current active and rollback software images loaded into the radio, as shown in the example output below.

Slot	Status	Version	SHA	Rem	Installed
----	-----	-----	---	---	-----
linuxA	Booted	0.1.72.06-f2-36-g475fd7c	820ab1	3	2023-04-07T15:40:42Z
mccfsA	Booted	0.1.117.01-f2-0-g1e045e19b	e9be89	3	2023-04-07T15:40:13Z
linuxB				3	
mccfsB				3	
linuxF		0.1.72.06-f2-36-g475fd7c	11c8d5	3	2022-01-06T03:33:30Z
boot		0.1.72.06-f2-36-g475fd7c	8a6c68		2023-04-07T15:40:03Z

8.2 Updating Software Application Images

The Base radio does not directly ingests images, but rather kits containing images that are signed for security purposes. Kits are created off the radio.

Updating the software means installing the software application kit, selecting it to be active, and then running it. This procedure can be done using the command line as shown below, or using MobaXterm as described in the "Kit Management" section of the *ITCR^{NG} Getting Started Guide*. To roll back an image, see ["Rolling Back an Image" on the facing page](#). For information about uninstalling and removing images, see the *ITCR^{NG} Radio Management Guide*.

To update the radio's software application image using CLI commands:

Use the following procedure to transfer and add a software kit to the radio and install the updated software image contained in the kit.

Note: You cannot schedule a software update with the command line. This can be done using ITCSM (see "Updating radio software through ITCSM" in the *ITCR^{NG} Radio Management Guide*).

- 1. Transfer the software kit to the radio using the `kit` command with the `--add` operation.

```
kit --add=/dev/sda/usb-drive/myKit.kit
```

This command also adds the kit to the kit directory.

- 2. You can use the `kit` command with `--list` operation to verify that the kit is now in the kit directory.

```
kit --list
```

This command displays all the kit files in the kit directory, as well as whether or not each is installed, active, available to be installed, and in the rollback position.

Kit name	Kit ID	Available	Installed	Active	Rollback
-----	-----	-----	-----	-----	-----
abc.kit	2	Yes	Yes	No	No
xyz.kit	4	Yes	Yes	Yes	Yes
34.kit	7	Yes	Yes	Yes	Yes
c_luffman3.kit	3	Yes	Yes	No	No
mykit.kit	Not installed	Yes	No	No	No

- 3. Install the kit using the `kit` command with the `--install` operation. The following command dispatches elements from the specified kit file to the installers.

```
kit --install=myKit.kit
```

4. Verify the contents of the installed kit. The following command queries the contents of an available kit file.

```
kit --query=myKit.kit
```

The above command receives a response indicating that the kit contains a manifest file and two RAUC bundles.

```
KitFileID      :myKit
Description     :Manifest file used for manual testing
Size of kit file :59888040 bytes
Elements:
boot.raucb
rootfs.raucb
```

5. Restart the radio.
6. Confirm the software update using the `apps` command.

8.3 Rolling Back an Image

You can manually rollback software when there are multiple images installed in the radio.

To manually roll back an image:

1. Run the `apps` command and view the list of images in the output table, noting whether the Status column for each image reports "Booted" or "Bad" or is blank.
2. Select the image listed as blank to roll back to using the `apps` CLI command with the `--select` option.

```
apps --select=b
```

3. Reboot the radio using the `sysreboot` CLI command.

8.3.1 How automatic rollback occurs

If for some reason the active image cannot boot, the backup image becomes active and is booted. If there is no backup image or it also fails, the failsafe image is run. The radio will not be fully operational running in failsafe partition.

9 Routine Maintenance

The following are maintenance items that you should perform routinely:

- Remove dust and obstructions from heatsink fins.
- Ensure that the radio is free of excessive condensation and moisture.
- Ensure that the radio is not subjected to excessive heat from adjacent equipment.
- Make sure that the radio is securely mounted and supported.
- Make sure that the cables do not bend with less than the minimum bend radius.
- Restrain cables to prevent stress on connectors.
- Keep the LED panel dust-free and viewable.
- Remove cables during a powered-off maintenance cycle and make sure the pins do not have corrosion nor signs of thermal stress:
 - Discoloration and flaky or granular material
 - Darkened color, signs of oxidation, pitting, or plasma flashover
- Verify that cable insulation is not sliced, worn, or cracked.
- Verify that all unused connectors are covered with the appropriate dust cover.

Appendix A: Configure Computer Ethernet Interfaces

It is recommended that you use a computer with two Ethernet interfaces, Ethernet 1 and Ethernet 2, so that your computer can communicate with a radio's maintenance (MAINT) and LAN Ethernet ports at the same time. You must have a terminal emulator such as MobaXTERM or PuTTY installed on the computer and have administrative rights to configure the Ethernet interfaces.

Notes:

- The following configuration example is for directly connecting to the radio and bypassing any network infrastructure. If you cannot get direct access to the radio, contact your network administrator for instructions.
- If you are using the factory defaults, use the following example. If you are not using the factory defaults, contact your network administrator for the appropriate IP settings.
- The following procedures are intended for use with Windows 10. Consult with your network administrator if you are using a different version of Windows.

To configure the computer Ethernet interface for connecting to the radio's MAINT port:

1. On the computer, click **Start**, then click **Control Panel**.
2. Click **Network and Internet**, then click **Network and Sharing Center**.
3. Click **Change adapter settings**.
4. Click **Local Area Connection**, then click **Properties**.
5. On the Networking tab, select the **Internet Protocol (TCP/IPv4)** check box, and then click **Properties**.
6. Click **Obtain an IP address automatically**.
7. Click **OK**.

To configure the computer Ethernet interface for connecting to the radio's LAN1 port:

1. On the computer, click **Start**, then click **Control Panel**.
2. Click **Network and Internet**, then click **Network and Sharing Center**.
3. Click **Change adapter settings**.
4. Click **Local Area Connection**, then click **Properties**.
5. On the Networking tab, select the **Internet Protocol (TCP/IPv4)** check box, and then click **Properties**.
6. Click **Use the following IP address**.
7. In the IP address field, type 10.255.255.200.
8. In the Subnet mask field, type 255.255.255.0.
9. Click **OK**.

Appendix B: Parts List

The following part numbers are for reference only and are subject to change without notice.

Table B-1: Base radio parts and part numbers

Part Number	Part Name	Qty	Unit of Measurement
65030001-01	Final Assembly, Base Radio, NGR		EA
000-046-0024	Adhesive, Loctite Permanent, Thread	0	AS_REQ
000-046-0026	Adhesive, Loctite 242 Threadlocker	0	AS_REQ
000-160-0018	Cable, USB 3.0, Type A Male/Type A Male, 1.6FT	1	EA
000-160-0020	Cable, Ethernet, CAT6, RJ45, Shielded, 2.5FT, Gray	1	EA
000-160-0021	Cable, Ethernet, CAT6, RJ45, Shielded, 2.5FT, Beige	1	EA
000-160-0023	Cable, Ethernet, CAT6, RJ45, Shielded, 1.5FT, Black	1	EA
005-002-0104	SCREW, MACH, 4-40X1/4, FL HD, PHIL, SST	12	EA
005-002-4008	SCREW,MACH,4-40X1/2,PN HD,PHIL,SST, BLK OX	2	EA
005-004-0106	SCREW, MACH, 8-32X3/8, FL HD, 100 DEG, PHIL, SST	36	EA
005-005-0106	Screw, 10-32 X 0.375" LG, Undercut, 82deg, FH PHIL, SST	4	EA
005-005-4008	SCREW,MACH,10-32X1/2,PH PHIL,SST,BLK OX	6	EA
005-005-4106	SCREW,MACH,10-32X3/8,FH PHIL,100 DEG,SST,BLK OX	7	EA
005-007-0008	SCREW, 1/4-20 X 0.50" LG, PH PHIL, SST	2	EA
005-007-0903	NUT, HEX, 1/4-20, SST	1	EA
005-008-0902	Washer, External Lock, 1/4", SST	1	EA
005-009-0902	WASHER, FLAT, 5/16" ID, 0.750" OD, 0.05" Thk, SST	4	EA
005-009-0903	NUT, HEX, 5/16-18, SST	4	EA
005-009-0919	WASHER, EXT LOCK, 5/16" ID, SST	4	EA
005-015-4004	SCREW,MACH,M3X10MM,PH,PHIL,SST,BLK OX	4	EA
005-040-0068	HANDLE, 0.38" DIA, 10-32 THREAD, ALUM, BLACK	2	EA
005-051-0001	Coding Key for Terminal Block Headers	2	EA
005-051-0002	Coding Key for Pluggable Terminal Block	2	EA
005-051-0802	Pluggable Terminal Block, 5.08 mm, 8 Pos., 24AWG to 12AWG, 2.5 mm ² , Push In, 12 A	2	EA

Part Number	Part Name	Qty	Unit of Measurement
005-091-0055	Clamp, TO270WB, for RF amplifier	1	EA
005-103-0001	Spacer, #4, 3/16" Dia, 3/16" Lg, Aluminum	1	EA
005-130-0060	TIE, CABLE, 4.52" X 0.1", 1" MAX DIA BUNDLE	10	EA
005-130-0068	Holder, Cable Tie, #4, Natural	1	EA
005-130-0069	Holder, Cable Tie, #8, Black	9	EA
005-201-0065	Label, Tamper Proof	4	EA
010-020-0904	Term Block, Feedthru, 2x 5/16-18 Studs, DC Input	1	EA
010-220-0002	Dust Cover, USB A, Black	1	EA
010-220-0004	Adapter, USB Feedthrough, Type A, Panel Mnt	1	EA
020-031-0011	Resistor, RF Termination, 50 ohm, 100W, Alum Nit	1	EA
030-071-0068	Amplifier, RF, MRFE6VP5300NR1, 2-600MHz, 300W, Gain 27dB, TO-270AB	1	EA
030-122-1002	CIRCULATOR, RF, ENIG, 217-222 MHz, LCL357-C03	1	EA
040-010-0008	Light Pipe, Panel Mt, 0.100", Wht	14	EA
055-022-2007	DC/DC Converter, 18-75Vin, 28Vout, 14A, 400W, -40 to +100degC	1	EA
14001674-01	Cable, MCX_MCX, RG-316, 12.6", PRI	1	EA
14001674-03	Cable, MCX_MCX, RG-316, 7.3", LO	1	EA
14001674-04	Cable, MCX_MCX, RG-316, 12.6", DIV	1	EA
14001674-05	Cable, MCX_MCX, RG-316, 7.1", FB	1	EA
14001678-01	Cable, Sense, 8p	1	EA
14001679-01	Cable, RF DC Power, 4-PIN	1	EA
14001680-01	Cable, Panel LED Interface, 24-Pin, Ribbon	1	EA
14001681-01	Cable, FE Interface, 16P	1	EA
14001684-01	Cable, Main Power Input, Red	1	EA
14001684-02	Cable, Main Power Input, Black	1	EA
14001686-01	Cable, RF Antenna, MCX/N	3	EA
14001687-01	Cable, GPIO LED, 10-Pin, Ribbon	1	EA
14001690-01	Cable, Ethernet, LED, MAINT, 4p/4p	1	EA
14001690-02	Cable, Ethernet, LED, LAN1, 4p/4p	1	EA
14001690-03	Cable, Ethernet, LED, LAN2, 4p/4p	1	EA
14001692-01	Cable, GNSS Antenna, MCX/TNC, RG-316, 24"	1	EA

Part Number	Part Name	Qty	Unit of Measurement
14001693-01	Cable, RF I/O, 30 Pin, Ribbon, 24.75", Base	1	EA
5-50-000012	PCBA, Daughter Board, GNSS, Mosaic-X5	1	EA
5-50-000015	PCBA, Power Supply Board, Base, NGR	1	EA
5-50-000023	PCBA, Front-End, Base, NGR	1	EA
5-50-000024	PCBA, RF Board, Base, NGR	1	EA
5-50-000043	PCBA, Main Board, Base, NGR	1	EA
6-32-000001	Sleeving, 1/2" I.D., Self Wrapping, Flexible	12	IN
6-41-000007	SCREW, MACH, 8-32X1/4, PN HD, PHIL, SST	9	EA
6-41-000008	Screw, 4-40 X 0.25, Nylon Patch, PH PHIL, SST	88	EA
6-41-000009	Screw, 4-40 X 0.50, Nylon Patch, PH PHIL, SST	7	EA
6-41-000010	Threaded Stud, 1/4-20 x 1.0", SST	1	EA
6-41-000061	Screw, 4-40 x 0.75", Pan Head, Philips, Stainless	4	EA
6-42-000007	Cap, Protective, Black, For 1/2" hex nut	1	EA
6-42-000008	Cap, Protective, Red, For 1/2" hex nut	1	EA
63030509-01	BRACKET, DUST SHIELD, LAN	3	EA
65010510-01	Gap Pad, 1.00" SQ, 0.08" THK, Master Board, NGR	1	EA
65010511-01	Gap Pad, 0.64" x 2.60", 0.08" THK, Master Board, NGR	1	EA
65010512-01	Gap Pad, 0.46" SQ, 0.08" THK, Master Board, NGR	1	EA
65010514-01	Gap Pad, 0.58" SQR, 0.08" THK, Master Board, NGR	1	EA
65010515-01	Gap Pad, 0.34" x 1.15", NGR	1	EA
65010516-01	Gap Pad, 0.20 SQ, 0.08 THK, Master Board, NGR	3	EA
65030001-01_EXPLODED_VIEW	Assembly Drawing, Base Radio, NGR - Exploded View	0	EA
65030305-01	PCBA, LED Board, Base, NGR	1	EA
65030307-01	PCBA, GPIO, Base Radio, NGR	1	EA
65030308-01	PCBA, Ethernet Board, 1Gb, Base Radio, NGR	3	EA
65030513-01	Heat Spreader, RF Board, Base Radio, NGR	1	EA
65030514-01	Thermal Pad, PA, Base Radio, NGR	1	EA
65030515-01	Thermal Pad, Cincon, Base Radio, NGR	1	EA
65030516-01	Front Panel, Base Radio, NGR	1	EA
65030517-01	Rear Panel, Base Radio, NGR	1	EA

Part Number	Part Name	Qty	Unit of Measurement
65030518-01	Top Cover, Base Radio, NGR	1	EA
65030519-01	Bottom Cover, Base Radio, NGR	1	EA
65030520-01	Chassis, Base Radio, NGR	1	EA
65030521-01	Label, LED, Base Radio, NGR	1	EA
65030522-01	Label, GPIO, Base Radio, NGR	1	EA
65030523-01	Label, Part Number, Base Radio, NGR	1	EA
65030524-01	Gasket, LED Blinder, GPIO, Base, NGR	1	EA
65030525-01	Gasket, Status LED Blinder, Base, NGR	1	EA
65030526-01	Mounting Ear, Base Radio, NGR	2	EA
7-01-000013	Cable, Main Board Power, 4-Pin	1	EA
7-01-000031	Cable Assy, GPIO Input, NGR Base	1	EA
7-01-000032	Cable Assy, GPIO Output, NGR Base	1	EA
7-21-000005	Label, Operation License, NGR	1	EA
MFG_DOCS_65030001-01	[MFG DOCS] Base Radio, NGR	0	EA
TEST_DATA_65030001-01	[TEST DATA] 65030001-01	0	EA

Appendix C: Block Diagram

[Illustration to be provided.]

Appendix D: Sample Post Results

Following is an example of the output from the `post` command for a Base radio.

Appendix E: Acronyms

The following table defines initialisms and acronyms used in this document.

Table E-1: Initialisms and acronyms

Usage	Meaning or description
A	amp
AWG	American wire gauge, a unit of wire diameter
cm	centimeter
CM	Connection Manager
dB	decibel
dB _i	decibel, isotropic
dBm	decibel referenced to one milliwatt
DC	direct current
DOP	dilution of precision
DQPSK	differential quadrature phase-shift keying
DSP	digital signal processor
EIRP	effective isotropic radiated power
ERP	effective radiated power
EVM	error vector magnitude
FCC	Federal Communications Commission
GEO	geostationary orbit
GNSS	global navigation satellite system
GPIO	general purpose input output
IC	Industry Canada
ITC	Interoperable Train Control
ITCM	ITC Messaging
ITCR	ITC Radio
LAN	local area network
LNA	low noise amplifier
m	meter
MCC	Meteorcomm LLC
MEO	medium Earth orbit
MHz	megahertz, a unit of frequency measurement
MPE	maximum permitted exposure
mW	milliwatt

Usage	Meaning or description
PEP	peak envelope power
POST	power-on self-test
PPM	parts per million
PTC	Positive Train Control
RF	radio frequency
RU	rack unit, defined as a height of 44.5 mm
SAR	specific absorption rate
SMA	subminiature, version A, a type of connector
SNR	signal-to-noise ratio
SWR	standing wave ratio
TCP/IP	transmission control protocol/Internet protocol
TNC	Threaded Neill-Concelman, a type of connector
VDC	voltage, direct current
VSWR	voltage standing wave ratio
W	watt