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CATERPILLAR®

TC900 Radio Operation Manual

Computer Aided Earthmoving System (CAES)

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Produced for Caterpillar Inc. by Trimble Navigation Limited

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Preface

Welcome to the TC900 Operation Manual. This manual describes the installation, configuration, and operation of the TC900 radio modem.

The TC900 radio modem is a rugged unit designed for real-time differential and real-time kinematic GPS applications. It provides a high-speed wireless data link between base and rover GPS receivers, and optional repeaters.

The TC900 has been certified for license free operation in the U.S. under Part 15 of the FCC Rules, and in Canada under RSS-210 of Industrie Canada.

Scope and Audience

We recommend you spend some time reading this manual. The following section provides you with a guide to this manual, as well as to other documentation you have received with this product.

Organization

This manual contains the following chapters and appendices:

- Chapter 1, Overview - provides a brief overview and physical description of the TC900.
- Chapter 2, Using the TC900 - contains complete installation and configuration instructions for the TC900.
- Appendix A, Characteristics and Specifications - summarizes performance characteristics and specifications that can be expected from a TC900 rover.
- Appendix B, Regulations and Safety - contains regulation and safety information.

Document Conventions

Italics identify software menus, menu commands, dialog boxes, and the dialog box fields.

SMALL CAPITALS identify DOS commands, directories, filenames, and filename extensions.

`Courier` is used to represent what you see printed on the screen by the DOS system or program.

`Courier Bold` represents information that you must type in a software screen or window.

[Return] or [Ctrl] + [C] identifies a hardware function key or key combination that you must press on a PC.

Helvetica Bold represents a software command button.

Notes, Tips, Cautions, and Warnings

Notes, tips, cautions, and warnings are used to emphasize important information.

Note – Notes give additional significant information about the subject to increase your knowledge, or guide your actions. A note can precede or follow the text it references.

Tip – Indicates a shortcut or other time or labor-saving hint that can help you make better use of the TC900 radio modem.

Caution – Cautions alert you to situations that could cause hardware damage or software error. A caution precedes the text it references.

Warning – Warnings alert you to situations that could cause personal injury or unrecoverable data loss. A warning precedes the text it references.

1 Overview

A TC900 radio modem is part of a digital-data radio network. It is designed primarily for broadcasting low-latency differential GPS (DGPS) corrections or raw GPS data from a roving receiver (machine) to a repeater or reference station receiver, for use during real-time differential and real-time kinematic (RTK) surveying.

1.1 TC900 Rovers as part of a TRIMCOMM 900 Network

To achieve line-of-sight (LOS) coverage to all points in a work area, a TRIMCOMM 900 network including up to four repeaters must be used. The repeaters retransmit data packets according to a simple time-sharing scheme to avoid mutual interference. The operation of the repeaters is transparent to the TC900 rovers. This means that a TC900 rover can move around and pick up data packets from the reference station or any repeater, whichever it hears first.

The reference, rovers, and repeater radios in a TRIMCOMM 900/ TC900 network are similar units. The function of a particular unit (reference, rover, or repeater) is determined by its configuration.

Reference radios can be connected to 7400, 4400, or 4000 Series Trimble receivers through a single cable for both power and serial I/O.TC900 rover radios, as used in the CAES system (Computer Aided Earthmoving System), are usually installed on a machine, and are used with a 740 rugged receiver. They are also connected to the receiver through a single cable for both power and serial I/O.

TRIMCOMM 900 repeaters operate autonomously, requiring only external power connected to their power ports. They have up to two separate serial ports. For typical GPS applications only one serial port is used. Machine control applications may use one serial port for GPS corrections, while the other serial port is connecting computers in a wireless network.

TC900 rovers operate as part of the CAES system, and they are powered by the machine on which they are installed. Both serial ports are used, one for GPS corrections and the other for data.

1.1.1 Frequency Band

The TC900 radio modem operates in the 902 to 928 MHz frequency band. It is certified for unlicensed use in this band as a transmitter pursuant to 47 C.F.R. §§ 15.247, 15.249 (1993) (unlicensed, low-power devices) Subpart C of Part 15 of FCC Rules regarding Spread Spectrum Systems for the United States. License-free operation in Canada is covered by RSS-210 of Industrie Canada.

Note – Since other types of radio transmitters can also operate in this frequency band, there is no guarantee that the network can function in any particular area or at any particular time. Most survey sites should not have much interference in this band.

This frequency band is allocated to other uses, including cellular telephone, in other parts of the world. Regulations regarding its use vary greatly from country to country. Use of the TC900 radio modem outside the United States must be approved by the local radio authority. Contact your Trimble dealer for regulations and restrictions on operation in the country or area where you want to use the TC900.

A TRIMCOMM 900/TC900 network can hop to any one of 50 frequency channels within its frequency band. This gives TRIMCOMM 900's/TC900's some ability to avoid RF interference.

The local interface to a TC900 is through an asynchronous serial port. In the normal mode of operation, a TC900 receives data from a repeater and sends this data through a serial port to the rugged 740 receiver. The on-machine system processes the data and re-broadcasts its GPS and CAES information through the TC900, out to the network of repeaters, and ultimately to the reference station where the office is located.

1.1.2 Standard Features

The following are features of the TC900 radio modem:

- Bi-directional communication
- Wireless data connection
- No FCC license required in the U.S. or Canada
- Ruggedized, weatherproof casing
- Typical 3-5 km range
- Up to 35 kbps data transmission speed
- Interfaces with TRIMCOMM 900 radio network and with Trimble machine-mounted GPS receivers
- Low power consumption
- Two RS-232 interfaces; 9,600 bps or 38,400 bps (default)

1.2 TC900 Description

The TC900 radio modem is encased in a rugged, weatherproof, yellow metal housing. It has an antenna mount on the top end-cap, and a connector and LED on the bottom end-cap. These are described in the following paragraphs.

1.2.1 Controls and Indicators

The TC900 bottom end-cap, Figure 1-1, is fitted with an 8-pin male Bendix-Amphenol connector and an LED indicator. The light turns orange when adequate power is supplied to TC900, and green when the rover is synchronized with the reference station and can communicate with the network.

The bottom end-cap has:

1. POWER I/O connector (8-pin male Bendix-Amphenol)
2. DATA/POWER indicator LED

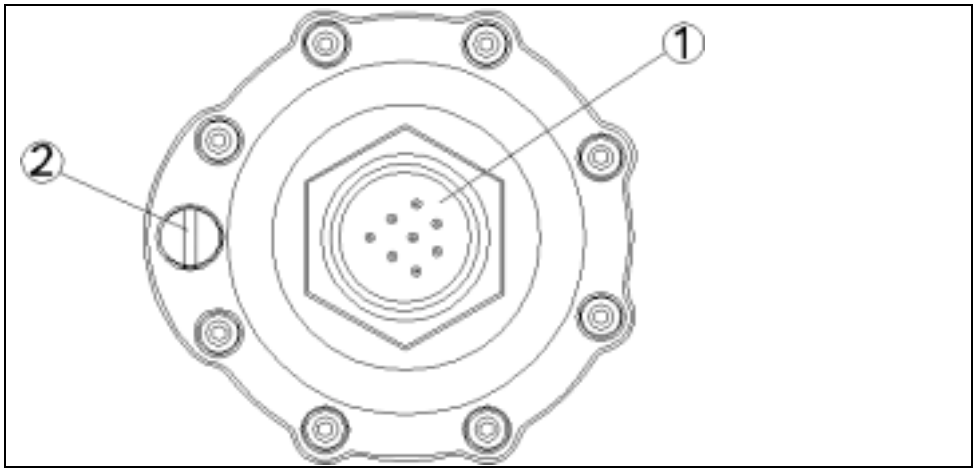

Figure 1-1. TC900 Bottom End-Cap

Note – Typically, the TC900 requires a few seconds to re-synchronize with the communications network, after the system has been rebooted.

The TC900 top end-cap, Figure 1-2, has:

1. Contact Tip
2. ANTENNA mount

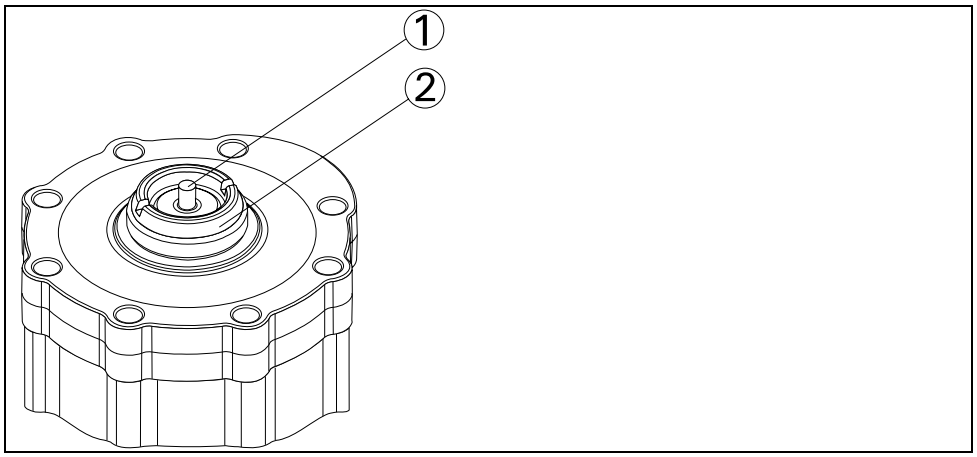

Figure 1-2. TC900 Top End-Cap

A flexible antenna base, see Figure 2-2, is bonded to the TC900 top end-cap at the factory. This antenna base should not be forcibly removed.

Note – The TC900 antenna contact tip has been designed for maximum efficiency and very low loss. In order to maintain its integrity the antenna base has been bonded to the assembly. Forcibly removing the antenna base will damage this contact tip.

Caution – Do not attempt to remove the flexible antenna base from the TC900 top end-cap under any circumstances.

1.3 TC900 Cabling Configurations

The TC900 is configured as a rover, but appropriate cables and adapters are available for both radio configuration and for standard rover operations with a variety of input power options. Table 1-1 summarizes the cabling items available or provided with the TC900 unit. Shaded areas in the table denote optional items available for use with the TC900.

Table 1- 1 TC900 Cabling and Power Accessories

Item and Description	Part Number
Gender Changer	33405-00
Software Configuration Cable	33471
Power & I/O Cable, 17 ft or	32942-17
Power & I/O Cable, 99 ft	32942-99
16 VDC, 1.5 A power supply with 5-pin LEMO connector	29148-10
12 V, 6 Ah battery with case and 5 ft. cable/5-pin LEMO connector	13543-00
12 V, 10 Ah battery with bag and 5 ft. cable/5-pin LEMO connector	13542-00
Camcorder battery clip cable to 5-pin LEMO connector	14555
Solar panel (not available from Trimble)	N/A
Service kit, with P/N 33405-00, P/N 33471, and COMMSET software	33276-20

1.3.1 Gender Changer (P/N 33405-00)

The Gender Changer, Figure 1-3, is a small box with one 8-pin Bendix-Amphenol connector on each side. It is used when configuration of the TC900 is necessary, and it serves the purpose of adapting an 8-pin male connector to an 8-pin female connector and vice versa.

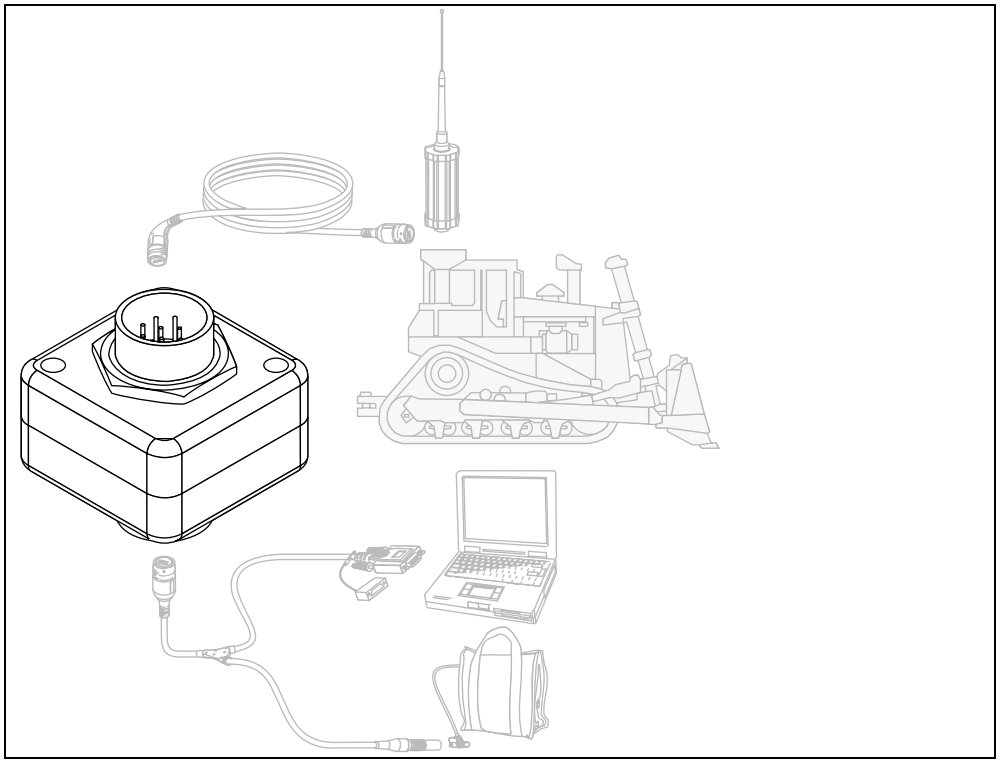

Figure 1-3. Gender Changer (P/N 33405-00)

1.3.2 Software Configuration Cable (P/N 33471)

The Software Configuration cable, Figure 1-4, is 1-foot long. This cable has one LEMO connector, one Bendix-Amphenol connector, and one DB9 connector.

The 5-pin LEMO female receptacle can be connected to a variety of power sources, outlined in Table 1-1, as follows:

- a 16V AC/DC low cost power supply
- a 6Ah or 10Ah 12 V battery or
- a battery clip cable that can be used with a Camcorder power pack or a solar panel.

The Bendix-Amphenol 8-pin female connector attaches to the TC900 bottom end-cap, either directly or by way of a gender changer and longer cable as shown in Figure 1-3.

The DB9 connector attaches to a PC that has been loaded with the desired configuration software.

This cable is used to power the unit during configuration of the software parameters into the memory of the TC900.

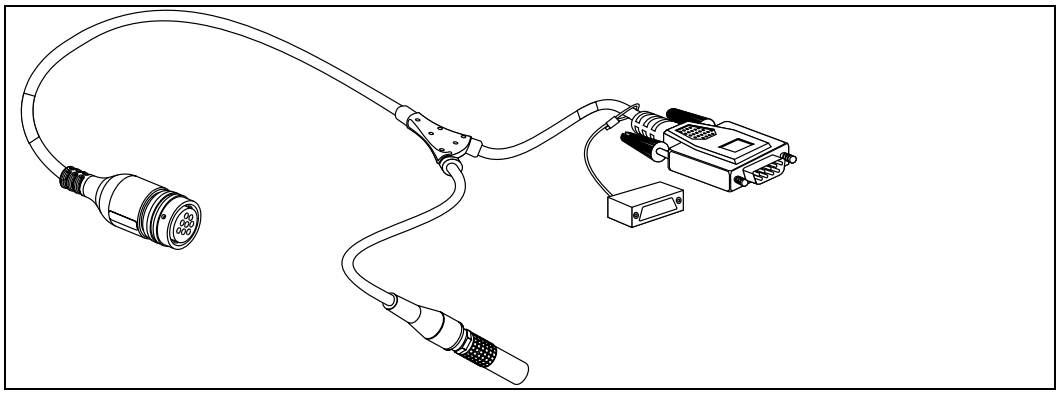

Figure 1-4. Software Configuration Cable (P/N 33471)

1.3.3 Power & I/O Cable (P/N 32942-17)

The machine TC900 Power & I/O cable, Figure 1-5, is 17 feet long (99-foot lengths are also available). It has two 8-pin female Bendix-Amphenol connectors, one at each end. The straight connector attaches to the bottom end-cap of the TC900 radio, and the angled connector attaches to the 8-pin Bendix-Amphenol connector on the rugged 740 receiver.

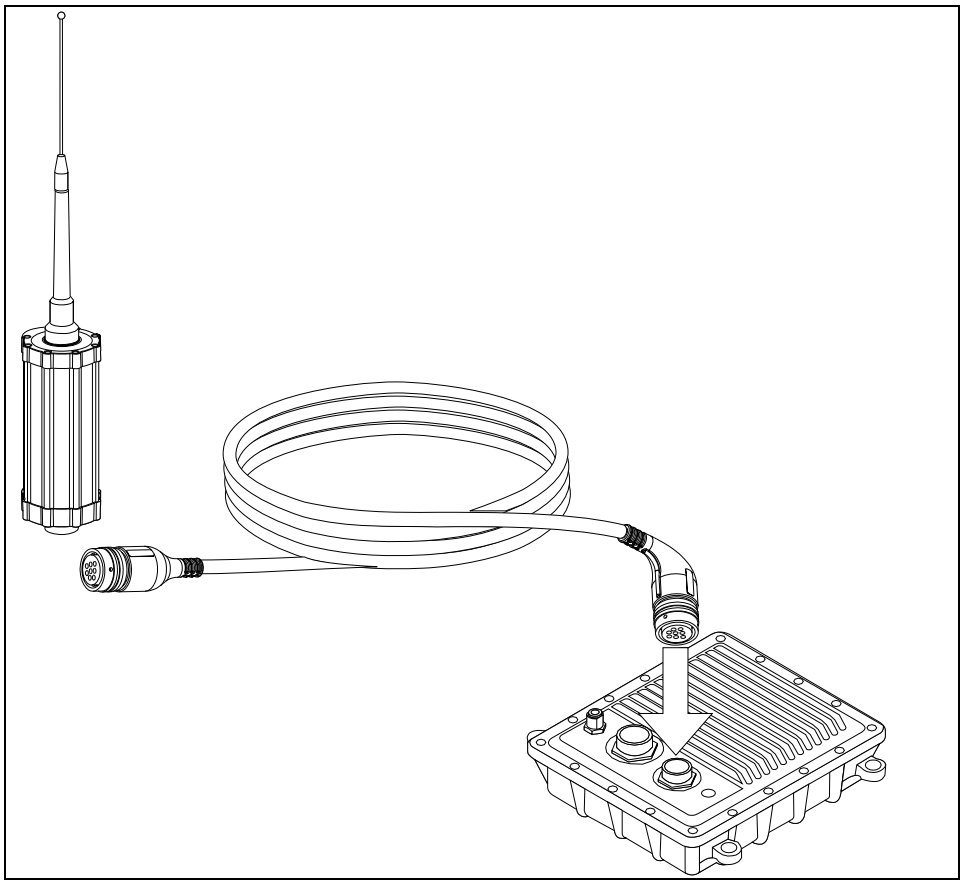

Figure 1-5. Power and I/O Cable (P/N 32942-17)

1.4 Antenna Description

The TC900 antenna comes with interchangeable 0 or 3 dB tips.
The 0 dB antenna tip measures 4.25 in/11 cm in length (12 in/30cm including antenna base). The 3 dB antenna tip measures 13.5 in/34.5 cm in length (21.5in/55 cm including antenna base). The 7 dBi antenna measures 23"/58.4cm in length (31"/78.7 cm including antenna base).

Figure 1-6 illustrates the TC900 antenna components.

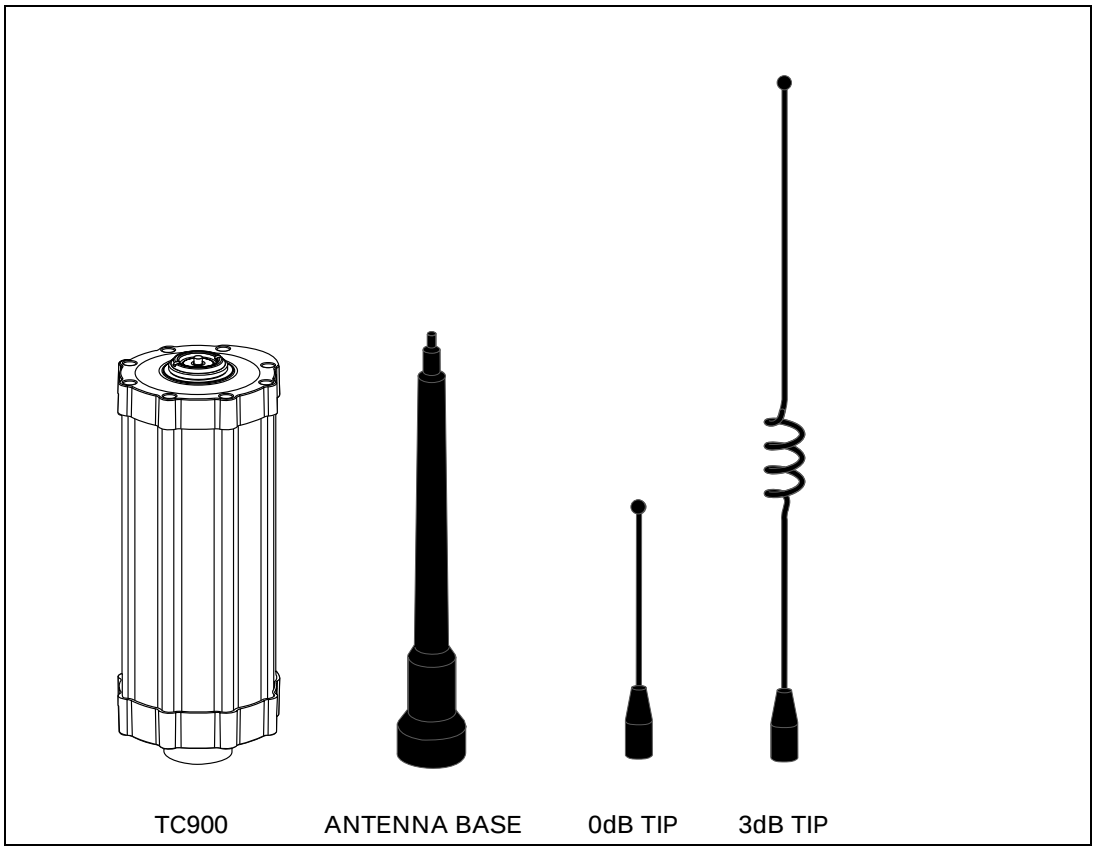

Figure 1-6. TC900 Radio Modem and Antennas

Appendix A describes the trade-offs involved in selecting antenna gain.

2 Using the TC900

A TC900 is a wireless data modem used to provide communications between machine applications and other components of a real-time mining information system.

The TC900 is configured for optimal network performance and no modifications should be necessary. Configuration software is provided should modifications, maintenance, or equipment replacement be necessary. For more information, consult the software and installation documentation provided with your system.

Pertinent settings should be documented in the installations notes, and these values should not be changed without consulting the installation specialist or qualified technical support person.

Caution – The incorrect use of the software program can load radio settings that will cause the network to fail.

2.1 TC900 Installation

The TC900 is pre-configured at the factory as a rover. No additional configuration is necessary.

To install a TC900 as a rover, follow these steps:

1. Mount the provided o-ring and antenna tip (0dB or 3dB only) on the flexible antenna base located on the top end-cap.

2. Use the recommended rover Power & I/O cable P/N 32942-17, see . Attach the straight 8-pin female Bendix-Amphenol connector to the TC900 and the angled connector to the rugged receiver.

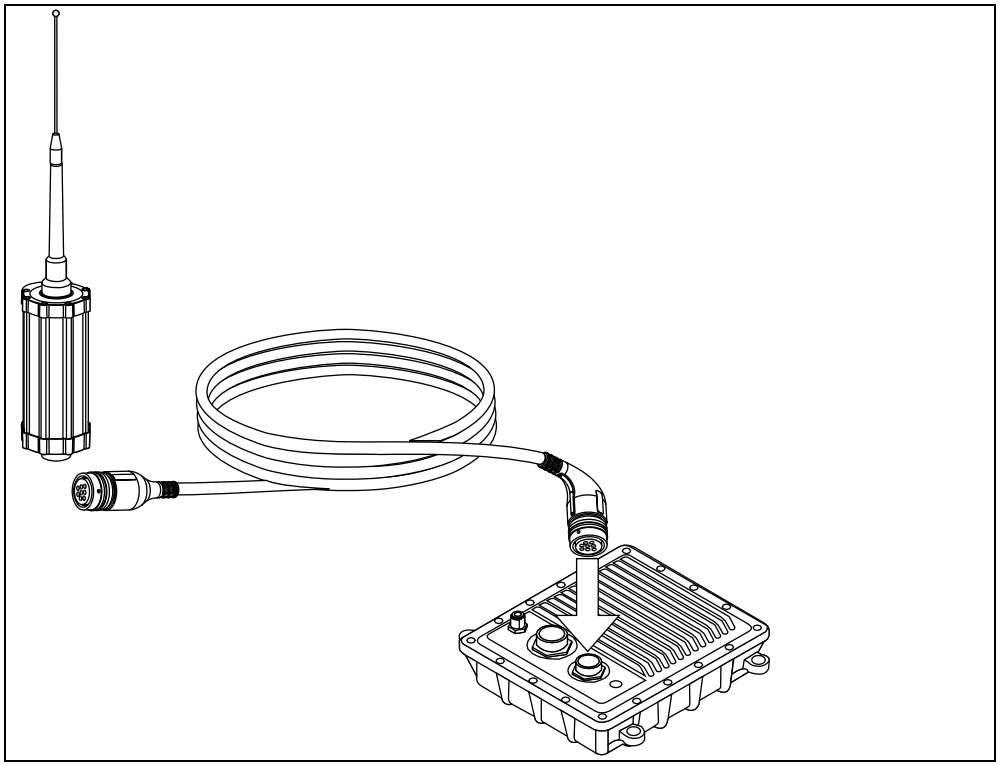

Figure 2-1 Power and I/O Cable (P/N 32942-17)

The TC900 rover works with a network of TRIMCOMM 900 repeaters. Instructions for installation of the reference station and repeaters are described in the *TRIMCOMM 900 Operation Manual*, P/N 33553-00.

2.1.1 TC900 Location on Machine

Several factors should be considered when locating the optimum site for TC900 installation. The unit should be placed as high as feasible on the machine.

Make sure the antenna is mounted so that its radiating element is completely above the top of any obstructions, including any mast used as a means to elevate the modem to a more favorable location on the machine.

2.1.2 Antenna Considerations

The efficiency of the TC900 wireless modem can be severely impaired if the mounting location permits obstruction of the antenna radiation path by metal objects. When the TC900 is installed on a machine, ensure that the antenna base and tip are above the machine, such that if the antenna were bent to its full extent, it would not hit anything.

Note – The TC900 antenna contact tip, see Figure 1-2, has been designed for maximum efficiency and very low loss. In order to maintain its integrity the flexible antenna base has been bonded to the top end-cap assembly.

Caution – Do not attempt to remove the flexible antenna base from the TC900 top end-cap under any circumstances. Forcibly removing the antenna base will damage this contact tip.

Figure 2-2 shows the standard antenna mounting for the TC900.

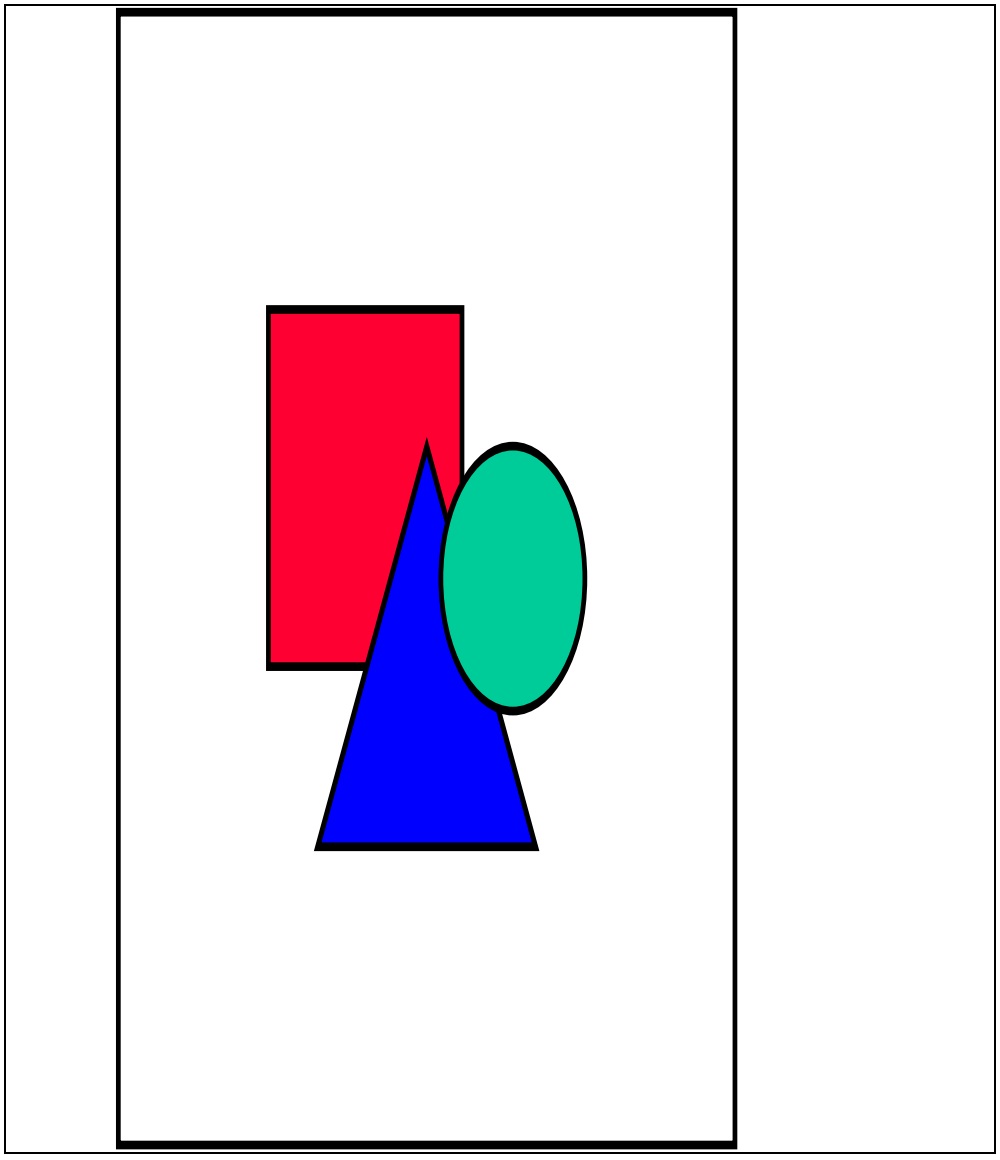

Figure 2-2. Standard Antenna Mounting

2.2 Configuration

The TC900 is configured at the factory for 38,400 baud, 8 data bits, none parity, and one stop bit. The parameters are stored in non-volatile memory. The TC900 retrieves these parameters at power up.

2.2.1 Configuration Software

COMMSET is a Windows-based program for configuring operational parameters of the TC900. COMMSET can be used in the office to configure all wireless modems for a project prior to deployment, or in the field at any time.

To install COMMSET, copy all files on the distribution diskette to a new directory on your computer's hard disk. To start the application, run the utility COMMSET.EXE.

If you need help performing these tasks, consult your Windows documentation or the Windows on-line help. COMMSET Setup can be used with Windows 95/98 or Windows NT.

When COMMSET starts, an initial connection window, Figure 2-3, is displayed. This window helps the user through the process of connecting a radio to the computer. If more help is required, click on the **HELP** button for additional instructions.

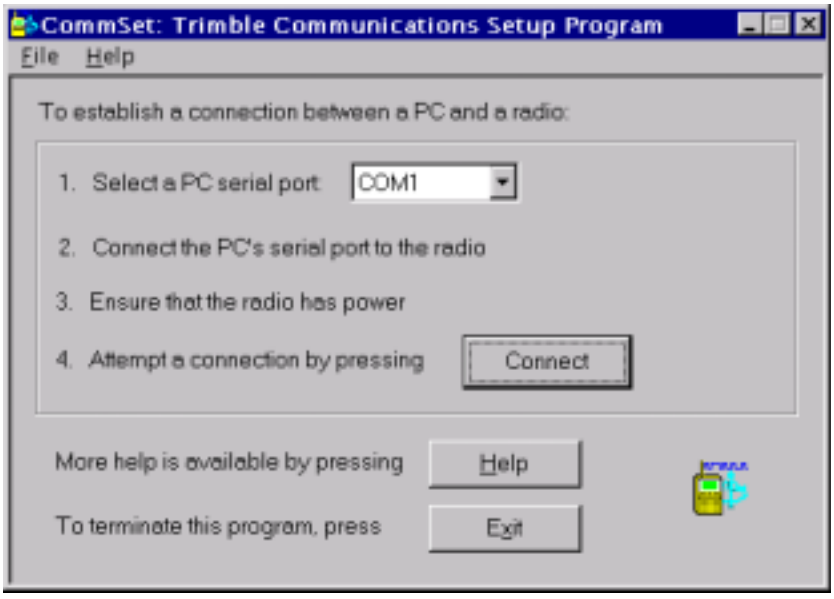

Figure 2-3 Main Window

After a connection is established between COMMSET and the radio, a set-up window opens, Figure 2-4. The user can check and set the radio's configuration parameters with this window.

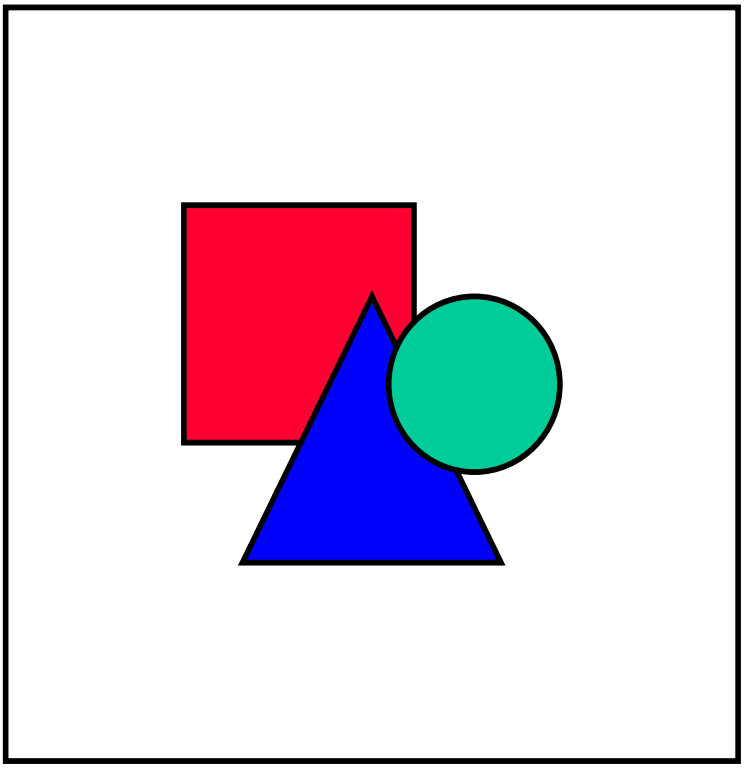

Figure 2-4 Set-up Window

If more help is required, click on the **HELP** button for additional instructions.

Note – If you want to check the configuration, upgrade firmware, or troubleshoot the radio, use Service Kit P/N 33276-20. The Service Kit contains a software configuration cable, COMMSET software, and a Bendix-Amphenol gender changer, (see Figure 1-3).

A Characteristics and Specifications

This appendix briefly summarizes performance characteristics and specifications that can be expected from a TC900 radio modem.

A.1 Antenna Gain

TC900 antennas do not increase the energy radiated by the radio. They can, however, concentrate the energy from the radio in a particular direction. The degree to which they concentrate radio frequency energy in any particular direction is measured in dB, or decibels. The greater the antenna gain in dB, the more the radiated energy from the antenna is concentrated in some direction. As a standard for reference, a half-wavelength dipole antenna is referred to as having 0 dB gain.

An antenna that radiates energy equally in all directions is called omnidirectional. All of the standard TC900 antennas are omnidirectional in the horizontal plane. They radiate an equal amount of energy at every azimuth. However, they are not omnidirectional in the vertical.

Figure A-1 compares the radiated energy patterns of the TC900 antennas. All antennas must be oriented vertically when used.

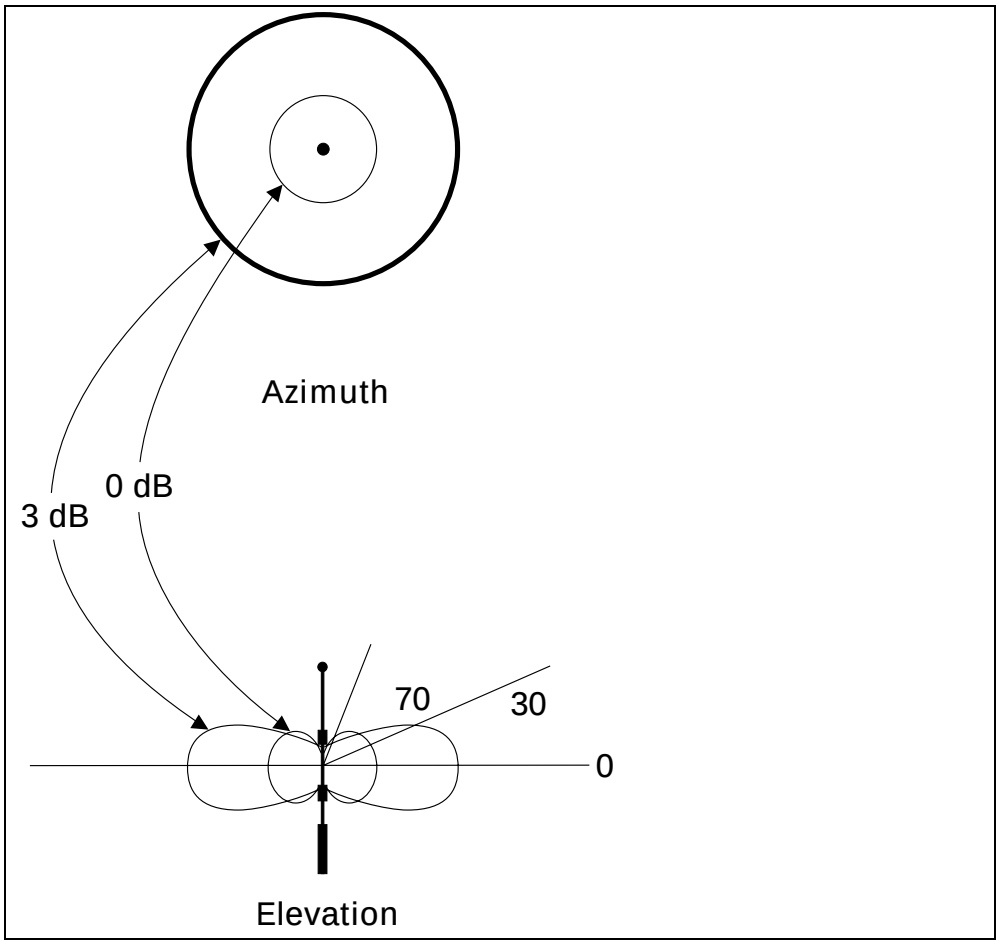

Figure A-1. Omnidirectional Antenna Gain Patterns

Because of the trade-off between gain and vertical coverage, the TC900 radio modem is shipped with a 0 dB and a 3 dB antenna.

In ,Figure A-1 the top view shows radiated energy patterns in the horizontal, or azimuth plane of the antennas. Note that the 3 dB antenna radiates more power in the horizontal plane than does the 0 dB antenna.

The ground level, or the bottom view shows that much of the energy from the 3 dB antenna is concentrated within 30° of horizontal. If a receiver antenna is within this sector, it receives significantly more power from the 3 dB antenna. However, at angles greater than 30° from horizontal, the 0 dB gain antenna actually radiates more energy.

Antenna gain has exactly the same effect when transmitting as when receiving. In general, the use of the 3 dB tip will result in more reliable radio communications for machine-mounted applications.

Note – For TC900 antennas, this means keeping the antenna element vertical and at the same elevation as the transmitting antenna. Otherwise, it may be better to use an antenna with less gain.

A.2 Point-To-Point Link

Many factors can reduce the reliability of a TC900 link: multipath fading, shadowing, and interference. Multipath fading results when multiple reflected copies of the transmitted waveform destructively interfere at the receive antenna. However, this type of fading is usually localized to areas just a few inches across, so moving an antenna just a few inches can sometimes overcome it.

Shadowing results when the link loses line-of-sight (LOS) due to an obstruction such as a building, hill or trees. Sometimes it is possible to receive a signal without LOS because radio waves may diffract around some obstructions or travel through others. The only way to know where a link will work is to try it.

Interference is generally caused by other transmitters in the same frequency band. The TC900 minimizes interference problems from other transmitters by utilizing unique state-of-the-art spread spectrum, frequency-hopping radio technology.

Tip – Antenna height is the single most important factor that you can use to increase link distance. Always place omnidirectional reference, repeater, and rover antennas as high as possible above surrounding obstructions. Use hill tops and antenna masts wherever practical.

A.3 Electrical Interface

The machine rover TC900 bottom end-cap has one POWER & I/O connector, and the top end-cap has one ANTENNA connector. For illustrations of the bottom end-cap connector and indicator light, see Figure 1-1. For illustrations of the top end-cap supporting the antenna base and tip, see Figure 2-2.

One LED indicator light is located on the bottom end-cap. This LED indicates that the TC900 is receiving power (orange) and transferring data (green). The bottom end-cap also holds the 8-pin Bendix-Amphenol male connector for the Power & I/O cable connection.

The radio Bendix-Amphenol connector pinout is shown in Figure A-2. The pinouts are described in Table A-1. TC900 has a dual-port configuration. In the dual-port configuration, the radio uses pins F and G to carry GPS correction data, while pins D and C are used for configuring software inside the radio AND for two-way communication within the network.

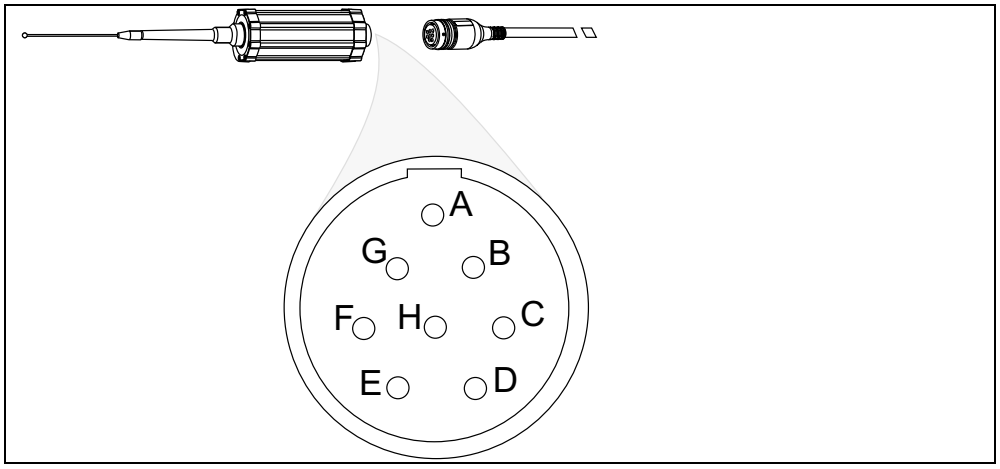

Figure A-2. Radio Power & I/O Connector Pinout

Table A-1. POWER I/O Connector Pinout

Pin Label	Name	I/O	Description
B	GROUND		Signal Ground/ RTN DC Source (-)
C	I/O (TXD)	O	RS-232 data from TC900 to display terminal
F	GPS (TXD)	O	RS-232 data from TC900 to rugged 740 GPS receiver
G	GPS (RXD)	I	RS-232 data from rugged 740 GPS receiver to TC900
A	PWR		10.5 to 20 volt DC source (+)
D	I/O (RXD)	I	RS-232 data from display terminal to TC900
E			spare, no connection
H			spare, no connection

For dual-port TC900 radio modems, one of the RS-232 ports is used for transmitting and receiving GPS data, while the other port relays two-way data between the radios in the network.

A TC900 radio requires a DC power source. The power source must be regulated to eliminate voltage spikes or voids. It must be filtered to within the 10.5V - 20V DC operating range; power from an unfiltered automobile battery charger is not acceptable. Standard installations provide power to the TC900 radio from the rugged 740 GPS receiver.

For office use, an optional Trimble OSM2 unit can convert regular AC into DC needed to run the TC900.

A.4 Specifications

The following tables contain information on the TC900 radio modem, antennas, and frequency.

Table A-2. TC900 Physical Specifications

Size	3.4" (8.64 cm) Wide	
	8.5" (21.59 cm) High (No antenna; Model dependent)	
Weight	2.0 lbs (0.90kg)	
Power	Input 10.5 V to 20 V DC	
Connectors	Power & I/O	8-pin female Bendix-Amphenol (supports two serial ports)
Indicators	Power LED	
	Data LED	
Temperature	Operating	–40° C to +70° C (–40°F to +158° F)
	Storage	–40° C to +85° C (–40° C to +185° F)
Weather Proofing	Fully sealed; rain, dust, spray, and splash proof	
Vibration	Operating	6 gRMS, 20-2000 Hz
Mechanical Shock	Operating	±75 g, 6 msec

Table A-3. TC900 Technical Specifications

Power Consumption	3.3 watt (typical in "Receive" mode) 5 watt maximum (typical in "Transmit" mode)
Radio Link	902-928 MHz band Frequency hop spread spectrum
Battery Life	8 hours on one 12V 2.3 Amp Hour camcorder battery (typical at room temperature)
Serial Port	One or two RS-232 interfaces available on one connector. Data is 8 bits with selectable parity (default odd, even, none) and 1 stop bit. Supported bit rates are 9600, and 38400 (default).

Table A-4. Antenna Physical Specifications

3 dB Length	21.5" (55 cm) Long including the base
0 dB Length	12" (30 cm) Long including the base
3 dB Weight	0.56 lbs (0.25 Kg) including the base
0 dB Weight	0.52 lbs (0.23 Kg) including the base
Range	Varies with terrain and operating conditions. Typically 3 to 5 Km.

B Regulations and Safety

The TC900 has been certified to operate pursuant to Subpart C of Part 15 of FCC Rules (CFR 47) regarding Spread Spectrum Systems and to Industrie Canada's specification RSS-210. The end user does not need to obtain any additional license or approval for use in the U.S. and Canada.

Shielded cables and I/O cords must be used for this equipment to comply with relevant FCC regulations.

Caution – Changes or modifications to this equipment not expressly approved, in writing, by Trimble Navigation Limited could void the user's authority to operate the equipment.

For use in Canada:

This device complies with RSS-210 of Industrie Canada

Operation is subject to the following two conditions:
(1) This device may not cause interference, and
(2) This device must accept any interference, including interference that may cause undesired operation of the device.

Note – This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a reception, which can be determined by turning the equipment off and on. The user is encouraged to try to correct the interference by one or more of the following measures:
1) re-orient or relocate the receiving antenna,
2) increase the separation between the equipment and receiver,
3) connect the equipment to an outlet on a circuit different from that to which the receiver is connected, and
4) consult the dealer or an experienced radio/TV technician for help.

B.1 Safety

Notice: Exposure to Radio frequency Energy

Exposure to RF energy is an important safety consideration. The Institute of Electrical and Electronic Engineers, the U.S. Department of the Navy, and the American National Standards Institute have created a standard set of guidelines entitled *Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 300 kHz to 100 GHz*. Based on a wide variety of tests, the standard excludes from concern those devices that emit less than 7 watts at frequencies between 300 kHz and 1 GHz. The TC900 emits less than 1.0 watts on average at 902-928 MHz, and is therefore considered safe. However, due to the extreme sensitivity of human tissue to heating effects, Trimble recommends maintaining a distance of at least one foot (0.3 meter) from a TC900 antenna.

In order for this device to comply with FCC rules, under the provision of Part 15.247(b)(4), it must operate in a manner that ensures that the public is not exposed to radio frequency energy levels in excess of the Maximum Permissible Limits (MPE). It is recommended that the antenna of this device be placed at 30 cm (12") or more from its user and nearby persons, during continuous and extended data transmissions. The users of this device should ensure that the operation of this device is in compliance with these provisions.

B.2 Service and Technical Support

The TC900 contains no user-serviceable parts. For service information or technical support, call 1-800-SOS-4TAC from within the United States, and +1-408-481-6940 from outside the United States.