TrimTrac Locator

Technical Manual

Including Enhanced Features and
Vehicle Adapter Module

(Applies to Firmware 1.08 and later)

Part Number 54200-XX-UG
Version 2.8
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REVISION HISTORY

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encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and the receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Changes and modifications not expressly approved by the manufacturer or registrant of this equipment can void your authority to operate this equipment under Federal Communications Commission rules.

Regulatory Approvals

CE
The TrimTrac Locator product complies with the essential requirements of the R&TTE Directive 199/5/EC as stated by the EC Declaration of Conformity (CE0681) and the EC R&TTE Type Examination Certificate. The TrimTrac Locator product complies with the European Telecommunications Standards Institute Specifications ETS300-342-1 (EMC for GSM 900MHZ and DCS 1800MHZ Radio Equipment and Systems).

EEC
The TrimTrac Locator product complies with Directive 72/245/EEC as amended by Directive 95/54/EC (el*72/245*95/54).

FCC The TrimTrac product complies with the FCC Part 15, FCC Part 24, and Industry Canada requirements. The TrimTrac product complies with Part 15 of the FCC rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) This device must accept any interference received, including interference that may cause undesired operation. FCC ID: JUPTRIMTRAC1

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About this Manual

Welcome to the *TrimTrac^TM Locator Technical Manual*. This manual is intended for use by system integrators, service providers and application developers (collectively, "Resellers"). It is not intended for end-users of the TrimTrac locator. Any end-user documentation is to be prepared and furnished by the Resellers.

This manual covers the TrimTrac locator with 1.08 and later firmware and operating on 900 MHz, 1800 MHz and 1900 MHz Global System for Mobile communication (GSM) networks. Data and Event Reporting support is by Short Message Service (SMS). This manual describes how to set up, configure, install, operate, and troubleshoot the product. Even if you have used other GSM or Global Positioning System (GPS) products before, Trimble recommends that you spend some time reading this manual to learn about the special features of this product. If you are not familiar with GSM or GPS, visit Trimble Component Technologies' Web site dedicated to the TrimTrac product (www.trimtrac.com) for a look at the device, GSM and GPS. Trimble assumes that you are familiar with Microsoft Windows (2000, XP), including HyperTerminal, and know how to use a mouse, select options from menus and dialogs, make selections from lists, and refer to online help.

This manual is available in portable document format (PDF) from the following Web site: http://www.trimtrac.com/support

Related Information

Other sources of related information are:

TrimTrac Web site at www.trimtrac.com . This site is dedicated to TrimTrac locator. Application notes, technical notes, and other useful product information are available from this site. These documents contain important information about software and hardware changes.

Release notes – the release notes describe new features of the product, information not included in the manuals, and any changes to the manuals. The release notes are available for download from the above Web address.

ftp://trimtrac.com – use the TrimTrac FTP site to send files or to receive files such as software patches, utilities, service bulletins, and FAQs. To obtain a User Name and Password to access this FTP site, please send an email to trimtrac@trimble.com .

Technical Assistance

If you have a problem and cannot find the information you need in the product documentation, please contact your local Trimble Component Technologies sales office or sales engineer. The technical support organization can be reached by telephone at 1-800-767-4822 when dialing from within the United States, or at +1-408-481-7921 when dialing from outside the United States.

Safety First

Simple Guidelines

Please follow these guidelines when configuring or using the TrimTrac locator. Violating these guidelines may be dangerous, illegal or otherwise detrimental. Further detailed information is provided in this manual.

Do Not Operate Where Prohibited

Do not allow the TrimTrac locator to operate wherever wireless phone use is prohibited or when doing so may cause interference or danger. Examples include but are not limited to operation in hospitals, aircraft, near blasting sites or wherever operation can cause interference.

Interference

Like all wireless devices, the TrimTrac locator may encounter electrical interference that may affect its performance.

Avoid Body Contact with Device During Operation

Do not operate the TrimTrac locator in direct contact with your body. Maintain minimum separation distance of 0.6 inch (15 mm) between the device and any parts of your body.

Qualified Service

Except for batteries and Subscriber Identification Module (SIM) card, the TrimTrac contains no user serviceable or replaceable parts. Non-functioning units must be returned to an authorized service center for repair or replacement.

Accessories and Batteries

Use only approved accessories or batteries. Do not connect incompatible products. There is risk of explosion if batteries are replaced by an incorrect type. Dispose of used batteries according to the instructions provided with the batteries.

Water-Resistance

The TrimTrac locator is not waterproof. Even though it is water-resistant, it is recommended that it be used where it is relatively dry and not subjected to either water streams or submersion.

TrimTrac

Detailed Safety Information

Exposure to Radio Frequency Signals

The TrimTrac locator is a low power radio transmitter and receiver. When it is ON, it receives and also sends out radio frequency (RF) signals.

In August 1996, the Federal Communications Commissions (FCC) adopted RF exposure guidelines with safety levels for hand-held wireless phones. Those guidelines are consistent with safety standards previously set by both U.S. and international standards bodies:

> ANSI C95.1 (1992)
>
> NCRP Report 86 (1986)
>
> ICNIRP (1996)

Those standards were based on comprehensive and periodic evaluations of the relevant scientific literature. For example, over 120 scientists, engineers, and physicians from universities, government health agencies, and industry reviewed the available body of research to develop the ANSI Standard (C95.1)

While the TrimTrac locator is not intended for hand-held use, its design nonetheless complies with the FCC guidelines (and those standards).

Electronic Devices

Most modern electronic equipment is shielded from RF signals. However, certain electronic equipment may not be shielded against the RF signals generated by the TrimTrac locator.

Pacemakers

The Health Industry Manufacturers Association recommends that a minimum separation of six (6") inches be maintained between a handheld wireless phone and a pacemaker to avoid potential interference with the pacemaker. These recommendations are consistent with the independent research by and recommendations of Wireless Technology Research.

Persons with pacemakers:

Should ALWAYS keep the TrimTrac locator more than eight inches from their pacemaker with the device is operational.

Should not carry the TrimTrac locator on their person

If there is any reason to suspect that interference is taking place, the TrimTrac locator battery pack should be removed immediately.

Other Medical Devices

If any other personal medical devices are used in the vicinity of a TrimTrac locator, consult the manufacturers of the medical devices to determine if they are adequately shielded from external RF energy. Physicians may be able to assist in obtaining this information.

Disable operation of the TrimTrac locator by removing the battery pack in health care facilities when any regulations posted in these areas prohibit the use of wireless phones or two-way radios. Hospitals and health care facilities may be using equipment that could be sensitive to external RF energy.

Vehicles

RF signals may affect improperly installed or inadequately shielded electronic systems in motor vehicles. Check with the manufacturer or its representative regarding the vehicle. Also consult the manufacturer of any equipment that has been added to the vehicle.

Posted Facilities

Disable operation of the TrimTrac locator by removing the battery pack in any facility where posted notices prohibit the use of wireless phones or two-way radios.

Aircraft

FCC and FAA regulations prohibit using wireless phones while in the air. Disable operation of the TrimTrac locator by removing the battery pack prior to boarding or loading in an aircraft

Blasting Areas

To avoid interfering with blasting operations, disable operation of the TrimTrac locator by removing the battery pack when in a "blasting area" or in areas posted: "Turn off two-way radio". Obey all signs and instructions.

Potentially Explosive Atmospheres

Disable operation of the TrimTrac locator by removing the battery pack prior to entering any area with a potentially explosive atmosphere and obey all signs and instructions. Sparks in such areas could cause an explosion or fire resulting in bodily injury or even death.

Areas with a potentially explosive atmosphere are often, but not always marked clearly. Potential areas may include: fueling areas (such as gasoline stations); below deck on boats; fuel or chemical transfer or storage facilities; vehicles using liquefied petroleum gas (such as propane or butane); areas where the air contains chemicals or particles (such as grain, dust, or metal powders); and any other area where it would normally be advisable to turn off motor vehicle engines.

For Vehicles Equipped with an Air Bag

An air bag inflates with great force. DO NOT place objects, including the TrimTrac locator, in the area over the air bag or in the air bag deployment area. If in-vehicle wireless equipment is improperly installed and the air bag inflates, serious injury could result.

Specific Absorption Rates (SAR)

THE TRIMTRAC LOCATOR MEETS CERTAIN GOVERNMENT REQUIREMENTS FOR EXPOSURE TO RADIO WAVES.

The TrimTrac locator is a radio transmitter and receiver. It is designed and manufactured not to exceed the emissions limits from exposure to radio frequency (RF) energy set by the Federal Communications Commission of the U.S. government when used in accordance with the instructions set forth in this manual. These limits are part of comprehensive guidelines and establish permitted levels of RF energy for the general population. The guidelines are based on standards that were developed by independent scientific organization through periodic and thorough evaluation of scientific studies. The standards include a substantial safety margin designed to assure the safety of all persons, regardless of age and health.

The exposure standard for wireless mobile phones employs a unit of measurement known as the Specific Absorption Rate, or SAR. The SAR limit set by the FCC is 1.6W/kg.[1] Tests of SAR are conducted using standard operation positions specified by the FCC with the phone transmitting at its highest certified power level in all tested frequency bands. Although the SAR is determined at the highest certified power level, the actual SAR level of the phone while operating can be well below the maximum value. This is because the phone is designed to operate at multiple power levels so as to use only the power required to reach the network. In general, the closer the device is to a wireless base station antenna, the lower the power output.

Before a phone is available for sale to the public, it must be tested and certified to the FCC that it does not exceed the limit established by the government-adopted requirement for safe exposure when used in accordance with manufacturer instructions. The tests are performed in positions and locations (e.g. near or on the body) as required by the FCC for each model. The SAR value for the TrimTrac locator is less than 1.6 W/kg measured at a minimum separation distance of 0.6 inch (15 mm). The TrimTrac locator is not designed to be worn on a person's body.

The FCC has granted an Equipment Authorization for the TrimTrac locator with all reported SAR levels evaluated as in compliance with the FCC RF guidelines for devices not worn on the body. SAR information on the TrimTrac locator is on

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[1] In the United States and Canada, the SAR limit for mobile phones used by the public is 1.6 watts/kg (W/kg) averaged over one gram of tissue. The standard incorporates a substantial margin of safety to give additional protection for the public and to account for any variations in measurement.

file with the FCC and can be found under the Display Grant section of http://www.fcc.gov/oet/fccid after searching on FCC ID: JUPTRIMTRAC1.

Additional information on Specific Absorption Rates (SAR) can be found on the Cellular Telecommunications & Internet Association (CTIA) Web site at http://www.phonefacts.net

Overview

Introduction

This manual covers the TrimTrac locator operating on 900 MHz, 1800 MHz and 1900 MHz GSM networks. As used in this manual, the term GSM shall include any and all of these frequencies.

Regulatory Approvals

CE
The TrimTrac product complies with the essential requirements of the R&TTE Directive 199/5/EC as stated by the EC Declaration of Conformity (CE0681) and the EC R&TTE Type Examination Certificate.

The TrimTrac product complies with the European Telecommunications Standards Institute Specifications ETS300-342-1 (EMC for GSM 900MHZ and DCS 1800MHZ Radio Equipment and Systems).

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The TrimTrac product complies with Part 15 of the FCC rules. Operation is subject to the following two conditions:

   (1) This device may not cause harmful interference, and
   (2) This device must accept any interference received, including interference that may cause undesired operation.

TrimTrac Locator

The TrimTrac locator is housed in a single, compact enclosure that simplifies installation and leads to greater reliability. The standard TrimTrac locator has four end-user replaceable alkaline AA batteries and there are no external antennas or

other external connections. This package is a mobile communications and positioning system module ideally suited for high volume automotive and asset management applications requiring a low-cost, battery or externally powered tracking device. It operates over the GSM cellular networks and allows simple, fast, and efficient transfer of information between a mobile asset and an application hosted either on a server or on an end-user PC.

Standard Features

The TrimTrac locator integrates the following into a single package:

GSM 900/1800/1900 MHz modem

High-sensitivity, 12-channel GPS receiver

Internal GSM and GPS antennas

TrimTrac application firmware and other integrated functions

Password-protected data communications

Support for limited data logging of up to 128 position or status records for subsequent download

Subscriber Identity Module (SIM)

You must install a SMS-enabled Subscriber Identity Module (SIM) that has been initialized by your GSM service provider.

Optional Plug-In Modules

The following options are available as plug-in modules that replace the standard TrimTrac locator batteries:

Provisioning Module. Allows configuration of the TrimTrac locator via a USB 2.0 connection to a PC

Vehicle Adapter Module. Allows connection to an external 9-32 VDC power supply and provides three types of open/closed switch and wiring monitoring connections.

Global System for Mobile Communications

Cellular mobile telephone systems are widely available throughout the world. However, because cellular mobile telephone systems are regulated at the national level, these systems are not generally compatible with each other. To resolve the dilemma of being able to communicate from almost anywhere, but only within your own system, the European telecommunications operators—the Conference of European Postal and Telecommunications Administration (CEPT)—designed a new mobile telephone network.

This network has evolved into GSM, and CEPT has turned over management of GSM to the European Technical Standards Institute (ETSI). GSM is the predominant mobile communications system throughout the world. Outside the United States, most GSM systems operate at 900 MHz, 1800 MHz or both and services provided by these networks are generally referred to as Digital Communication Services (DCS). The United States GSM system operates at 1900 MHz and is generally referred to as Personal Communication Service (PCS).

GSM Cellular Phone System

The Global System for Mobile (GSM) protocol offers a variety of data services that allow users to send and receive data at rates of up to 9600 bps. Data can be delivered over ISDN, Packet Switched or Circuit Switched Data Networks (PSDN or CSDN) and via the Short Message Service (SMS). The TrimTrac locator uses SMS, which is a store-and-forward service for the bi-directional exchange of alphanumeric messages of up to 160 characters.

Architecture of the GSM network

Any asset tracking or management system on GSM consists of several distinct components. The TrimTrac locator is the mobile unit that is installed in the vehicle, equipment or other mobile asset and contains the Subscriber Identity Module (SIM). The SIM card contains a unique International Mobile Subscriber Identity (IMSI) number. This enables the network to identify the user and therefore allow the terminal to have access to specific, subscriber services.

The GSM system is made up of two sections:

The Base Station Subsystem that controls the radio link with the mobiles through local cells

The Network Subsystem that controls the switching of calls between the network users, mobile to mobile, and between mobile and fixed lines

The Network Subsystem stores all administrative information including the current cell being used by the mobile unit that allows call routing and the roaming ability of GSM. An important feature of GSM is this ability to move across international and network borders, a feature that is described as "roaming." If arrangements have been made with the service provider, the SIM card will be enabled for roaming.

Mobile Station (MS)

- o The TrimTrac locator includes a radio transmitter and receiver.
- o Subscriber Identity Module (SIM) – an electronic card containing a computer chip. The chip contains the subscriber information and operating system parameters. SIMs provide authentication, encryption, information storage, and subscriber account protection services (including Personal Identity Number or PIN, and Pin Unblocking Key or PUK). GSM users can move the SIM from one TrimTrac locator to another.

Other network components (part of the GSM network)

- o Short Message Service Center (SMSC)
- o Delivers text messages (up to 160 characters) to GSM users.

GSM Operational Overview

The TrimTrac locator operates in accordance with the state diagram more fully described in the Theory of Operation chapter beginning on page 32 of this manual.

Whenever the TrimTrac locator has a new position or status to report, it updates its Status Message. The TrimTrac locator then enters the GSM Transmit State and automatically searches for a GSM network using a set of tables on the SIM card to determine which GSM network the phone should try to reach.

These tables are the Public Land Mobile Network (PLMN) tables and each GSM network has its own unique PLMN number. This number is the Mobile Country Code (MCC) and the Mobile Network Code (MNC), which are also the first numbers of the subscriber's IMSI. (The IMSI is the MCC, plus the MNC, plus the Mobile Station Identification Number.) The PLMN table finds either the subscriber's home network or a network that will allow service, and registers to the network consistent with the handset.

The responding network's Mobile Switching Center (MSC) passes this request for service to the Visitor Location Register (VLR). If the VLR has information about this IMSI, then it passes the request to the authentication center. If the VLR cannot find any information on this IMSI, it must pass the request to the Home Location Register and get approval before passing on the request.

Once the VLR has approval to grant the request for service, it knows the user identity, what features are authorized, and the authentication codes. The VLR then passes the request back to the MSC for routing to destination address specified by the TrimTrac locator. If the destination address is a land-based number, the MSC passes the call to the Public Switched Telephone Network (PSTN) for connection. If the destination address is another mobile number, the MSC repeats the process described above to locate the number being dialed.

Global Positioning System

The Global Positioning System (GPS) is a satellite-based navigation system operated and maintained by the U.S. Department of Defense. GPS consists of a constellation of 24 satellites providing worldwide, 24-hour, three-dimensional (3D) coverage. Although originally conceived for military needs, GPS has a broad array of civilian applications including timing, surveying, fleet management, marine, land, aviation, and vehicle navigation. GPS is the most accurate technology available for navigation. As a satellite-based system, GPS is immune from the limitations of land-based systems, which have limited coverage and whose accuracy varies with geographic location and, even under ideal conditions, cannot compare with GPS. By computing the distance to GPS satellites orbiting the earth, a GPS receiver can calculate an accurate position. This process is called satellite ranging. GPS receivers can also provide precise time, speed, and course measurements that are important for vehicle mobile positioning and communications applications.

GPS Receiver

The TrimTrac locator includes an advanced GPS receiver, which provides the position, course, speed and time information required for mobile asset management applications. The TrimTrac locator's GPS receiver features a twelve-channel digital signal processor (DSP) which operates at the GPS L1 frequency (1575.42 MHz) and processes the Coarse/Acquisition (C/A) code portion of the GPS signal. The RF and digital signal processing components of the GPS module are custom ASICs designed by Trimble.

TrimTrac Locator Defaults

Introduction

Factory default settings of the TrimTrac locator are listed in Table 40 through Table 42, beginning on page 87. All such default settings can be changed to suit the particular application requirements. While most of the settings can be configured or changed by sending the appropriate SMS text messages over the GSM network, non-default entries for certain fields such as the Unit Identification number (Unit ID), Security Password and SIM PIN can only be entered or changed while the device is connected to a PC using the Provisioning Module. Please refer to the TrimTrac Application chapter beginning on page 50 for detailed descriptions of each TrimTrac state.

The TrimTrac locator comes from the factory without time being set and with no GPS almanac or location stored in memory. As a consequence, it is important that when the TrimTrac locator is first activated that it be given a clear view of the sky with sufficient time to calculate its first position fix and to collect a full almanac. Please see additional instructions in Use Guidelines chapter beginning on page 29.

Security Considerations

Communication Security

The security of the TrimTrac locator supports Short Message Peer to Peer (SMPP) protocol, which allows the application server or wireless carrier to insert any originating address into the messages it sends to the TrimTrac locator. To maintain the security of the TrimTrac locator it will only accept an incoming TrimTrac Application message if its Unit ID field matches its own Unit ID, the Security Password matches and the appropriate Checksum value is included. This will ensure that only the server application is able to send commands to direct it to report to a different location or to start reporting at a different rate.

Configuration Security

The configurable parameters are divided into two groups, the provisioning group and the read/write group.

The provisioning group includes parameters that are only read from once the TrimTrac locator enters normal usage. They are set at either time of manufacturing or possibly time of provisioning. Some are never written only read from. The values such as the Unit ID and Firmware Version are written at time of manufacturing. The Destination Address is written at time of provisioning or can be changed over the air using the SET_PROV_CONFIG message.

The read/write group depicted in Table 43, Read-only Parameters on page 92 includes operational parameters that are changed as a part of the normal operation of the TrimTrac locator. Sending a TrimTrac Application message to the TrimTrac locator over the air could change all these values. Using these messages the server application can change the functionality of the TrimTrac locator. The communication security methods will protect these values from being changed by an unauthorized user.

The SIM PIN is a feature of GSM SIMs that allows the owner of the SIM to put a lock on the SIM. In order to use the account associated with the SIM, the user of the GSM device must provide the SIM PIN after SIM insertion or device power up. The SIM PIN setting is stored in the firmware and is used if the SIM requests it. If requested, the SIM PIN is used to attempt to unlock the SIM. If the unlock fails, the SIM PIN is marked as having caused a failure and not retried until the user physically connects the TrimTrac locator to a Provisioning Module and uses the AT+CKTP command to change the SIM PIN. This is to prevent the SIM from becoming unusable after 10 SIM PIN failures. The SIM PIN cannot be read back once set. It can only be overwritten.

Diagnostics

When the Diagnostics Mode is enabled and set to 1 (LED) the LED on the TrimTrac locator will blink at different rates depending on the TrimTrac locator's operational state. If the TrimTrac locator is powered off the LED is off. If the estimated battery life is below the threshold of 10% the LED is turned on continuously while the TrimTrac locator is operational and not blinked. Only if the batteries are good will the blinking rates in Table 1 apply.

TrimTrac State	Blink Rate	In Plain Words…
IDLE	250ms ON / 250 ms OFF	Rapid blinking or while in OnDemand Polling Mode
FIX	2000ms ON / 2000 ms OFF	Long On, Long Off
TRANSMIT	200ms ON / 1800ms OFF	Short Blinks
QUERY	1800ms ON / 200ms OFF	Long On, very short off time
DELAY	Always OFF	Unit powers Off in Delay state.
DELAY to IDLE	One 2000ms ON	One blink as unit transitions from DELAY to IDLE state
	Always ON	Low Battery

Table 1, Diagnostic LED Blink Rates

TrimTrac Locator Configuration

Introduction

Configuration is the process of setting the operational and communication parameters of the TrimTrac locator. Most, but not all, of these parameters can be set or changed over the air; however, certain non-default entries, such as the Unit ID, Security Password and SIM PIN, can only be entered or changed when the TrimTrac locator is connected to a PC via a Provisioning Module.

Personnel without prior configuration or provisioning experience should familiarize themselves with the TrimTrac operation and application characteristics as more fully described in the Theory of Operation chapter beginning on page 32.

Provisioning Mode and Equipment

Before a new TrimTrac locator can communicate for the first time, it must be properly configured. This entails substituting the Battery Pack Module or other optional modules with a Provisioning Module and then connecting it to the USB 2.0 port on a Microsoft Windows (2000, XP)-based PC. Use of USB 1.0 ports or hubs is not recommended. Some laptop computers may not have enough power available on the USB port to power Provisioning Module, especially when the laptop is operating on batteries. If laptop is used to provision the TrimTrac locator, it is best to have the laptop connected to AC power.

Microsoft's HyperTerminal is then used as the primary programming interface to send the proper AT Commands. The AT Commands are described in this section and must be used the first time the TrimTrac locator is provisioned. Text fields need to be enclosed in quotation marks "_".

Provisioning Set-up

Before a TrimTrac Provisioning Module can be connected and used with an USB 2.0-equipped Microsoft Windows (2000, XP)-based PC, the appropriate USB 2.0 drivers and HyperTerminal program must be installed on the PC.

FTDI Driver Loading

The Provisioning Module uses an USB 2.0 interface chip from Future Technology Devices International Ltd. (FTDI). The easiest way for HyperTerminal to communicate with the Provisioning Module is to download and install the appropriate FTDI driver on the PC on which HyperTerminal will run.

These Windows (2000, XP) drivers are available from FTDI for download and use at:

www.ftdichip.com/FTWinDriver.htm

Select, download and install the VCP Driver for either Win'98 / ME / 2000 / XP (with enhanced BM series support) driver following the instructions provided on the Web site and with the driver.

HyperTerminal

HyperTerminal is a standard program included in all current versions of Microsoft Windows (2000, XP) and can be typically found in the Communications directory under Accessories. If HyperTerminal is not already installed on the Windows (2000, XP) PC that will be used to configure the TrimTrac locator, you will need to install it from your original Windows (2000, XP) CDs.

Connecting the Devices

Once the FTDI USB 2.0 device driver and HyperTerminal program are installed on the PC, connect the TrimTrac locator and Provisioning Module to the PC USB 2.0 port as follows:

1. Remove the TrimTrac battery pack from the base TrimTrac locator

2. Install an active SMS-enabled SIM card in the base unit SIM card holder

3. Insert Provisioning Module into base TrimTrac locator and secure it using screw provided.

4. Connect the USB 2.0 Type-A Male end of the data cable to the Provisioning Module

5. Connect the other USB 2.0 Type-A Male end of the cable to the PC USB 2.0 port. (Note: if the PC sound is enabled, there may be an audible sound when the cable and Provisioning Module are connected to the PC. This indicates that the USB port on the PC may not have sufficient power.)

Beginning a Provisioning Session

To commence a provisioning session, you must start HyperTerminal in the following steps

1. Start HyperTerminal from the Windows (2000, XP), Start, All Programs, Accessories, Communications menu.

2. A "New Connection" panel will appear and enter "TrimTrac" for the New Connection Name and click "OK" button

3. A "Connect Using" panel will appear and from the pull down menu select the Com port you designated as the USB 2.0 port when you installed the FTDI driver (commonly, COM4)

4. On the next panel and under "Port Settings", select the following from the pull down menus:

Bits Per Second:	115200
Data Bit	8
Parity	None
Stop Bits	1
Flow Control	None

Click "OK" when done.

5. If you wish to view what you type on the HyperTerminal Screen, click on File, Properties, Settings, ASCII Settings and checkmark the "Echo Typed Characters Locally" box. Click "OK" to close each panel.

6. To check whether you have successfully connected the TrimTrac and Provisioning Module to HyperTerminal, type:

at+ctkc?

7. Assuming the factory default configuration has not been previously changed, the following response should appear:

+ctkc: 43200,300,120,900,60,168,15,0,0,1,0

OK

8. You are now ready to begin provisioning the TrimTrac locator(s) by typing the AT+commands described in the following sections.

9. When complete, reinstall the battery pack with four "AA" batteries.

Configuring Multiple Units

If multiple TrimTrac locators need to be configured, then you can send the units text files with the desired settings rather then typing individual AT+commands. For instance, sending the following from a text file sets the TrimTrac locator to its default settings and confirms the final settings and firmware version number:

```
at+ctkp="00000000","","","00000000"
at+ctkc=43200,300,120,900,60,168,15,0,0,1,0
at+ctkg=5,120,60,10,5
at+ctkx=0,0,0,0,3600,60,0,1,1,1,1,20,10,0
at+ctky=10,10,10,10,0,120,60,0,0,0,0,0,0
ati
```

To configure HyperTerminal to send text files to the TrimTrac locator, select Echo and set the line delay to 500 milliseconds from the HyperTerminal ASCII Setup panel under File, Properties, Settings.

To send a text file, select and open the desired text file from Transfer, Send Text File panel.

Provisioning Commands

Provisioning AT Command Summary

The following AT commands are used to provision and configure the TrimTrac locator via HyperTerminal when connected to the Provisioning Module.

Command	Description	See Page
AT+CTKP	Assigns Communication parameters	17
AT+CTKP?	Queries Communication parameters	17
AT+CTKC	Assigns Application parameters	19
AT+CTKC?	Queries Application parameters	19
AT+CTKX	Assigns Extended Application parameters	21
AT+CTKX?	Queries Extended Application parameters	21
AT+CTKG	Assigns GPS parameters	25
AT+CTKG?	Queries GPS parameters	25
AT+CTKY	Assign Vehicle Adapter Module parameters	26
AT+CTKY?	Queries Vehicle Adapter Module parameters	26
AT+CTKO?	Retrieves Logged Messages	28
ATI	Queries Firmware Version	28

Table 2, Summary of Provisioning Commands

Commands to Return Unit to Default Configuration	See Page
AT+CTKP="00000000","","","00000000"	18
AT+CTKC=43200,300,120,900,60,168,15,0,0,1,0	19
AT+CTKX=0,0,0,0,3600,60,0,1,1,1,1,20,10,0	21
AT+CTKG=5,120,60,10,5	25
AT+CTKY=10,10,10,10,0,120,60,0,0,0,0,0,0,0	26

Table 3, Provisioning Commands for Default Configuration Settings

AT+CTKP Provisioning

Prior to the TrimTrac locator being used for the first time, the application must be provisioned using this command. The AT+CTKP command configures the Communication parameters. This command is the only method to change the Unit ID, SIM PIN and Security Password. It can query the current settings or change them to new values.

AT+CTKP=<Unit ID>,<Destination Address>,<SIM PIN>,<Security Password> OK	
<Unit ID>	Always 8 alphanumeric characters, UPPER CASE ONLY. Must use quotation marks " ". Default "00000000"
<Destination Address>	Maximum 24 characters including international dialing "+" sign and country code. Must be in quotation marks. Default <Empty>
<SIM PIN>	If used, must be between 4 and 8 digits. Must use quotation marks " " Default <Empty>
<Security Password>	Always 8 alphanumeric characters, UPPER CASE ONLY. . Must use quotation marks " " Default "00000000"

Table 4, AT+CTKP Assignment

Default Setting: AT+CTKP="00000000","","","00000000"

AT+CTKP? +CTKP: <Unit ID>,<Destination Address >,<SIM PIN>,<Security Password> OK	
<Unit ID>	Always 8 alphanumeric characters, UPPER CASE ONLY
<Destination Address>	24 characters including international dialing "+" sign and country code.
<SIM PIN>	If used, must be between 4 and 8 digits.
<Security Password>	"********"

Table 5, AT+CTKP Query

Note that when the SIM PIN field and the Security Password fields are queried using either AT+commands or TrimTrac Application Protocol messages, they are shown masked out with the '*' character to prevent theft of the information.

AT+CTKC Application Configuration

The AT+CTKC command is used to configure the Basic Read/Write parameters of the TrimTrac locator. It can query the current settings or change them to new values.

AT+CTKC=<IDLE Timeout, T1>,<FIX Timeout, T2>,<TRANSMIT Timeout, T3>,<DELAY Timeout, T4>,<QUERY Timeout, T5>,<Almanac Timeout, T6>,<IDLE Wakeup Motion Timeout, T7>,<Motion Report Flag>,<Report Delay Flag>,<Diagnostics Mode>,<Communication Mode> OK	
<IDLE Timeout, T1>	In seconds (10 – 999990). Default 43200
<FIX Timeout, T2>	In seconds (10 – 3600). Default 300
<TRANSMIT Timeout, T3>	In seconds (10 – 3600). Default 120
<DELAY Timeout, T4>	In seconds (10 – 86400). Default 900
<QUERY Timeout, T5>	In seconds (10 – 3600). Default 60
<Almanac Timeout, T6>	In hours (10 – 990). Default 168
<IDLE Wakeup Motion Timeout, T7>	In seconds (0 – 90). Note: T7 is used exclusively while in the IDLE state; however, it is superseded by the Rolling Motion Window, T21, whenever IDLE State Polling Mode is set "2=OnDemand" OR while IDLE State Polling Cycle Duration, T20, is running due to IDLE State Polling Mode being set "1=Cycled". WARNING: IDLE Wakeup Motion Timeout, T7, must always be set greater than or equal to IDLE Wakeup Motion Second Count; else unit may not exit IDLE state due to motion. Default 15
<Motion Report Flag>	0=None; 1=Report Motion in IDLE (before attempting new GPS fix. Default 0
<Report Delay Flag>	0=Transmit All Messages; 1=Transmit NO Messages; 2=Transmit Motion-related Messages-only; 3= Transmit IDLE Timeout, T1 Status Messages-only. Default 0
<Diagnostics Mode>	0= None; 1= LED. Default 1
<Communication Mode>	0= SMS; 1= Future. Default 0

Table 6, AT+CTKC Assignment

Default Setting: AT+CTKC=43200,300,120,900,60,168,15,0,0,1,0

AT+CTKC?	
+CTKC: <IDLE Timeout, T1>,<FIX Timeout, T2>,<TRANSMIT Timeout, T3>,<DELAY Timeout, T4>,<QUERY Timeout, T5>,<Almanac Timeout, T6>,<IDLE Wakeup Motion Timeout, T7>,<Motion Report Flag>,<Report Delay Flag>,<Diagnostics Mode>,<Communication Mode> OK	
<IDLE Timeout, T1>	In seconds (10 – 999990). Default 43200
<FIX Timeout, T2>	In seconds (10 – 3600). Default 300
<TRANSMIT Timeout, T3>	In seconds (10 – 3600). Default 120
<DELAY Timeout, T4>	In seconds (10 – 86400). Default 900
<QUERY Timeout, T5>	In seconds (10 – 3600). Default 60
<Almanac Timeout, T6>	In hours (10 – 990). Default 168
<IDLE Wakeup Motion Timeout, T7>	In seconds (0 – 90). Note: T7 is used exclusively while in the IDLE state; however, it is superseded by the Rolling Motion Window, T21, whenever IDLE State Polling Mode is set "2=OnDemand" OR while IDLE State Polling Cycle Duration, T20, is running due to IDLE State Polling Mode being set "1=Cycled". WARNING: IDLE Wakeup Motion Timeout, T7, must always be set greater than or equal to IDLE Wakeup Motion Second Count; else unit may not exit IDLE state due to motion. Default 15
<Motion Report Flag>	0=None; 1=Report Motion in IDLE (before attempting new GPS fix. Default 0
<Report Delay Flag>	0=Transmit All Messages; 1=Transmit NO Messages; 2=Transmit Motion-related Messages-only; 3= Transmit IDLE Timeout, T1 Status Messages-only. Default 0
<Diagnostics Mode>	0= None; 1= LED. Default 1
<Communication Mode>	0= SMS; 1= Future. Default 0

Table 7, AT+CTKC Query

AT+CTKX Extended Application Configuration

The AT+CTKX command is used to configure the enhanced Basic Read/Write parameters of the TrimTrac locator. It can query the current settings or change them to new values.

AT+CTKX=<Scheduled Reporting Mode>,<Scheduled Report Time, T18>,<DELAY State Polling Mode>,<IDLE State Polling Mode>,<IDLE State Polling Cycle Interval, T19>,<IDLE State Polling Cycle Duration, T20>,<Query Hold Flag>,<DELAY State Extended Motion Detection>,<Position Report Transmit Attempts, N1>,<Status Message Transmit Attempts, N2>,<IDLE Wakeup Motion Second Count>,<Rolling Motion Window, T21>,<Rolling Motion Second Count>,<Motion Override> OK	
<Scheduled Reporting Mode>	0=None; 1=Daily; 2=Weekly. Default 0
<Scheduled Report Time, T18>	In Seconds (0-604799). Note: This is either the seconds into the day or into the week for the device to schedule a report when this feature is enabled. If Scheduled Reporting Mode is set "0=None", then enter 0. Default 0
<DELAY State Polling Mode>	0=Disabled; 1=OnDemand. Note: If set to "1=OnDemand", the unit is able to receive and process SMS commands during the QUERY and DELAY states. Default 0
<IDLE State Polling Mode>	0=Disabled; 1=Cycled; 2=OnDemand. Default 0
<IDLE State Polling Cycle Interval, T19>	In Seconds (10-999990). Note: Determines the interval at which the IDLE State Polling Cycle Duration, T20, timer is started if and only if the IDLE State Polling Mode is set to "1=Cycled". WARNING: IDLE State Polling Cycle Interval, T19, must always be set greater than IDLE State Polling Cycle Duration, T20, or QUERY Timeout, T5, whichever applies. Default 3600
<IDLE State Polling Cycle Duration, T20>	In Seconds (0, 10-3600). Note: Determines how long the unit is able to receive and process SMS messages each time IDLE State Polling Cycle Interval, T19, expires. A value of zero causes the QUERY Timeout, T5, value to be used WARNING: IDLE State Polling Cycle Interval, T19, must always be set greater than IDLE State Polling Cycle Duration, T20, or QUERY Timeout, T5, whichever applies. Default 60
<Query Hold Flag>	0=Disabled; 1=Enabled. Note: Unit attempts to reconnect to the GSM network if the connection is lost during the QUERY state prior to the expiration of QUERY Timeout, T5. Default 0
<DELAY State Extended Motion Detection>	0=Disabled; 1=Enabled. Note: Allows the unit to filter spurious motion detections in DELAY state when set to "1=Enabled". The unit does not power off during DELAY state and power consumption will increase. Default 1

<Position Report Transmit Attempts, N1>	0=Until T3 Expires; 1-255=Number of Tx Attempts. Default 1
<Status Message Transmit Attempts, N2>	0=Until T3 Expires; 1-255=Number of Tx Attempts**.** Default 1
<IDLE Wakeup Motion Second Count>	In Seconds (1-90). Note: This parameter is used only while IDLE Wakeup Motion Timeout, T7, is running. It is superseded by Rolling Motion Second Count whenever IDLE State Polling Mode is set "2=OnDemand" OR while IDLE State Polling Cycle Duration, T20, is running due to IDLE State Polling Mode being set "1=Cycled". WARNING: IDLE Wakeup Motion Second Count must always be set equal to or less than IDLE Wakeup Motion Timeout, T7; else unit may not exit IDLE state due to motion. Default 1
<Rolling Motion Window, T21>	In Seconds (1-90). Note: T21 applies in all states except IDLE and FIX; provided, however, that is also automatically enabled for IDLE state whenever IDLE State Polling Mode is set "2=OnDemand" OR when IDLE State Polling Cycle Duration, T20, is running due to IDLE State Polling Mode being set "1=Cycled". WARNING: Rolling Motion Window, T21, must always be set equal to or greater than Rolling Motion Second Count; else the unit may not exit QUERY state. Default 20
<Rolling Motion Second Count>	In Seconds (1-90). Note: This parameter is enabled only when Rolling Motion Window, T21, is active. Default 10
<Motion Override>	0=Normal; 1=Motion Always; 2=Motion Never. Note: Overrides the motion sensor if set to a value other than "0=Normal". If set to "1=Motion" Always, then the TrimTrac locator will override the motion sensor such that the unit operates as if motion is always present. If set to "2=Motion Never", then the TrimTrac locator will ignore all motion and never generate a fix until the configuration is changed or otherwise commanded to do so (see QUERY_POSITION message). Default 0

Table 8, AT+CTKX Assignment

Default Setting: AT+CTKX=0,0,0,0,3600,60,0,1,1,1,1,20,10,0

AT+CTKX?	
+CTKX: <Scheduled Reporting Mode>,<Scheduled Report Time, T18>,<DELAY State Polling Mode>,<IDLE State Polling Mode>,<IDLE State Polling Cycle Interval, T19>,<IDLE State Polling Cycle Duration, T20>,<Query Hold Flag>,<DELAY State Extended Motion Detection>,<Position Report Transmit Attempts, N1>,<Status Message Transmit Attempts, N2>,<IDLE Wakeup Motion Second Count>,<Rolling Motion Window, T21>,<Rolling Motion Second Count>,<Motion Override> OK	
<Scheduled Reporting Mode>	0=None; 1=Daily; 2=Weekly. Default 0
<Scheduled Report Time, T18>	In Seconds (0-604799). Note: This is either the seconds into the day or into the week for the device to schedule a report when this feature is enabled. If Scheduled Reporting Mode is set "0=None", then enter 0. Default 0
<DELAY State Polling Mode>	0=Disabled; 1=OnDemand. Note: If set to "1=OnDemand", the unit is able to receive and process SMS commands during the QUERY and DELAY states. Default 0
<IDLE State Polling Mode>	0=Disabled; 1=Cycled; 2=OnDemand. Default 0
<IDLE State Polling Cycle Interval, T19>	In Seconds (10-999990). Note: Determines the interval at which the IDLE State Polling Cycle Duration, T20, timer is started if and only if the IDLE State Polling Mode is set to "1=Cycled". WARNING: IDLE State Polling Cycle Interval, T19, must always be set greater than IDLE State Polling Cycle Duration, T20, or QUERY Timeout, T5, whichever applies. Default 3600
<IDLE State Polling Cycle Duration, T20>	In Seconds (0, 10-3600). Note: Determines how long the unit is able to receive and process SMS messages each time IDLE State Polling Cycle Interval, T19, expires. A value of zero causes the QUERY Timeout, T5, value to be used WARNING: IDLE State Polling Cycle Interval, T19, must always be set greater than IDLE State Polling Cycle Duration, T20, or QUERY Timeout, T5, whichever applies. Default 60
<Query Hold Flag>	0=Disabled; 1=Enabled. Note: Unit attempts to reconnect to the GSM network if the connection is lost during the QUERY state prior to the expiration of QUERY Timeout, T5. Default 0
<DELAY State Extended Motion Detection>	0=Disabled; 1=Enabled. Note: Allows the unit to filter spurious motion detections in DELAY state when set to "1=Enabled". The unit does not power off during DELAY state and power consumption will increase. Default 1
<Position Report Transmit Attempts, N1>	0=Until T3 Expires; 1-255=Number of Tx Attempts. Default 1
<Status Message Transmit	0=Until T3 Expires; 1-255=Number of Tx Attempts. Default

Attempts, N2>	1
<IDLE Wakeup Motion Second Count>	In Seconds (1-90). Note: This parameter is used only while IDLE Wakeup Motion Timeout, T7, is running. It is superseded by Rolling Motion Second Count whenever IDLE State Polling Mode is set "2=OnDemand" OR while IDLE State Polling Cycle Duration, T20, is running due to IDLE State Polling Mode being set "1=Cycled". WARNING: IDLE Wakeup Motion Second Count must always be set equal to or less than IDLE Wakeup Motion Timeout, T7; else unit may not exit IDLE state due to motion. Default 1
<Rolling Motion Window, T21>	In Seconds (1-90). Note: T21 applies in all states except IDLE and FIX; provided, however, that is also automatically enabled for IDLE state whenever IDLE State Polling Mode is set "2=OnDemand" OR when IDLE State Polling Cycle Duration, T20, is running due to IDLE State Polling Mode being set "1=Cycled". WARNING: Rolling Motion Window, T21, must always be set equal to or greater than Rolling Motion Second Count; else the unit may not exit QUERY state. Default 20
<Rolling Motion Second Count>	In Seconds (1-90). Note: This parameter is enabled only when Rolling Motion Window, T21, is active. Default 10
<Motion Override>	0=Normal; 1=Motion Always; 2=Motion Never. Note: Overrides the motion sensor if set to a value other than "0=Normal". If set to "1=Motion" Always, then the TrimTrac locator will override the motion sensor such that the unit operates as if motion is always present. If set to "2=Motion Never", then the TrimTrac locator will ignore all motion and never generate a fix until the configuration is changed or otherwise commanded to do so (see QUERY_POSITION message). Default 0

Table 9, AT+CTKX Query

AT+CTKG GPS Configure

The AT+CTKG command configures the GPS parameters. This command mirrors the functionality of the over-the-air GPS_CONFIG message. It can query the current settings or change them to new values.

AT+CTKG=<GPS Elevation Mask>,<GPS PDOP Mask>,<GPS PDOP Switch>,<GPS Signal Level>,<GPS Dynamics Mode> OK	
<GPS Elevation Mask>	In degrees (0-30). Default 5
<GPS PDOP Mask>	In tenths of PDOP (60 – 200). Default 120
<GPS PDOP Switch>	In tenths of PDOP (40 – 120). Default 60
<GPS Signal Level>	In tenths of AMUs (10 – 80). Default 10
<GPS Dynamics Mode>	5=Automobile; Default 5

Table 10, AT+CTKG Assignment

Default Setting: AT+CTKG=5,120,60,10,5

AT+CTKG? +CTKG: <GPS Elevation Mask>,<GPS PDOP Mask>,<GPS PDOP Switch>,<GPS Signal Level>,<GPS Dynamics Mode> OK	
<GPS Elevation Mask>	In degrees (0-30). Default 5
<GPS PDOP Mask>	In tenths of PDOP (60 – 200). Default 120
<GPS PDOP Switch>	In tenths of PDOP (40 – 120). Default 60
<GPS Signal Level>	In tenths of AMUs (10 – 80). Default 10
<GPS Dynamics Mode>	5=Automobile. Default 5

Table 11, AT+CTKG Query

AT+CTKY VAM-only Application Configuration

The AT+CTKY command configures the application parameters specific to the Vehicle Adapter Module.

AT+CTKY=\<HPA Idle Timeout, T11\>,\<MPA Idle Timeout, T12\>,\<HPA Delay Timeout, T13\>,\<MPA Delay Timeout, T14\>,\<HPA Transmit Timeout, T15\>,\<MPA Transmit Timeout, T16\>,\<HPA Query Timeout, T17\>,\<HPA Transmit Attempts, N5\>,\<MPA Transmit Attempts, N6\>,\<LPA Transmit Attempts, N7\>,\<Ignore HPA\>,\<Ignore MPA\>,\<Ignore LPA\> OK	
\<HPA Idle Timeout, T11\>	In Seconds (10-999990). Default 10
\<MPA Idle Timeout, T12\>	In Seconds (10-999990). Default 10
\<HPA Delay Timeout, T13\>	In Seconds (10-86400). Default 10
\<MPA Delay Timeout, T14\>	In Seconds (10-86400). Default 10
\<HPA Transmit Timeout, T15\>	0=Infinity; Else in Seconds (10-999990). Default 0
\<MPA Transmit Timeout, T16\>	0=Infinity; Else in Seconds (10-999990). Default 120
\<HPA Query Timeout, T17\>	In Seconds (10-3600). Default 60
\<HPA Transmit Attempts, N5\>	0=Until T15 Expires; 1-255=Number of Tx Attempts before T15 expires. Default 0
\<MPA Transmit Attempts, N6\>	0=Until T16 Expires; 1-255=Number of Tx Attempts before T16 expires. Default 0
\<LPA Transmit Attempts, N7\>	0=Until T3 Expires; 1-255=Number of Tx Attempts before T3 expires. Default 0
\<Ignore HPA\>	0=Do NOT Ignore; 1=Ignore. Default 0
\<Ignore MPA\>	0=Do NOT Ignore; 1=Ignore . Default 0
\<Ignore LPA\>	0=Do NOT Ignore; 1=Ignore. Default 0

Table 12, AT+CTKY Assignment

Default Setting: AT+CTKY=10,10,10,10,0,120,60,0,0,0,0,0,0

AT+CTKY?	
CTKY: <HPA Idle Timeout, T11>,<MPA Idle Timeout, T12>,<HPA Delay Timeout, T13>,<MPA Delay Timeout, T14>,<HPA Transmit Timeout, T15>,<MPA Transmit Timeout, T16>,<HPA Query Timeout, T17>,<HPA Transmit Attempts, N5>,<MPA Transmit Attempts, N6>,<LPA Transmit Attempts, N7>,<Ignore HPA>,<Ignore MPA>,<Ignore LPA>	
OK	
<HPA Idle Timeout, T11>	In Seconds (10-999990). Default 10
<MPA Idle Timeout, T12>	In Seconds (10-999990). Default 10
<HPA Delay Timeout, T13>	In Seconds (10-86400). Default 10
<MPA Delay Timeout, T14>	In Seconds (10-86400). Default 10
<HPA Transmit Timeout, T15>	0=Infinity; Else in Seconds (10-999990). Default 0
<MPA Transmit Timeout, T16>	0=Infinity; Else in Seconds (10-999990). Default 120
<HPA Query Timeout, T17>	In Seconds (10-3600). Default 60
<HPA Transmit Attempts, N5>	0=Until T15 Expires; 1-255=Number of Tx Attempts before T15 expires. Default 0
<MPA Transmit Attempts, N6>	0=Until T16 Expires; 1-255=Number of Tx Attempts before T16 expires. Default 0
<LPA Transmit Attempts, N7>	0=Until T3 Expires; 1-255=Number of Tx Attempts before T3 expires. Default 0
<Ignore HPA>	0=Do NOT Ignore; 1=Ignore. Default 0
<Ignore MPA>	0=Do NOT Ignore; 1=Ignore . Default 0
<Ignore LPA>	0=Do NOT Ignore; 1=Ignore. Default 0

Table 13, AT+CTKY Query

AT+CTKO? Retrieve Message Log Command

The AT+CTKO? command will retrieve all messages stored in the log while in the service mode, in the order of protocol sequence number.

```
AT+CTKO?
+CTKO:
{message}
OK
```

Table 14, AT+CTK0 Query

Note: When using AT+CTKO? in HyperTerminal, use the "Capture Text" command under the "Transfer" menu. Otherwise, some messages may be partially truncated as they are retrieved from the TrimTrac locator.

ATI Retrieve Firmware Version Command

The ATI command will retrieve the firmware version. Note that no "?" mark is used in this query

```
ati
Trimble Navigation Ltd
TrimTrac (tm)
Revision: {message}
OK
```

Table 15, ATI Query

Use Guidelines

Introduction

The TrimTrac locator is a completely self-contained end-user device. As such no specific installation is required. There are no external connections required for antennas or power when used in its standard battery-powered configuration. Like all GPS and wireless devices, the TrimTrac locator will work best where it can have a relatively unobstructed view of the sky and wireless base station antenna. Nonetheless, the TrimTrac locator employs advanced GPS technology that increases its ability to acquire weak GPS signals. This allows the device to be deployed in environments where traditional GPS receivers may not be able to determine location.

General Guidelines

Initial Use after Provisioning

The TrimTrac locator comes from the factory without current time being set and without GPS almanac or location stored in memory. As a consequence, it is important that when the TrimTrac locator is first activated that it be given sufficient time to calculate its first position fix and to collect a complete GPS almanac.

After the TrimTrac locator has been configured per the instruction provided in the TrimTrac Locator Configuration chapter, it is recommended that the TrimTrac be powered up, using either batteries or a Vehicle Adapter Module, and the unit remaining stationary with a clear, unobstructed view of the sky. This will allow the TrimTrac locator to calculate a position fix in the shortest possible time and allow it to collect a GPS almanac. During this first session, the TrimTrac locator up to fifteen (15) minutes beyond the expiration of FIX Timeout, T2 (default 300 seconds) before sending the next SMS message.

Placement and Orientation

Generally, the TrimTrac will perform best when used as close as possible to horizontal plane, preferably with reasonably unobstructed clearance around the unit. Field tests indicate that the TrimTrac locator performs reasonably well when placed in the glove box or under the front passenger seat in many contemporary automobiles. It should not be installed in the trunk of a vehicle unless it can be placed near or under the rear window package shelf. Try to avoid placing the unit where its view of the sky is obstructed by metal or surfaces coated with metallic paint or films.

Field data indicates that a TrimTrac locator placed in the glovebox of a vehicle will get approximately 50% fewer position fixes than a identically configured unit placed on the dashboard with a clear view of the sky. Actual results will vary from vehicle to vehicle and based on the level of obstruction outside the vehicle itself.

Another important consideration is that battery life will be shorter for units placed in obscured locations since it will take longer to compute new position fixes. Units with a clear view of the sky will typically take 40-50 seconds to compute a new position fix as shown in Figure 7, Warm Start TTFFs on page 82. If the GPS signal level drops to –136 dBm due to obscuration, then the time to compute typically increases to over 6 minutes. During this additional time, the unit is powered up and battery life will decrease accordingly.

RF Jamming

The TrimTrac locator should be installed as far away as possible from transmitting antennas, including satellite communication, radar, VHF and cellular. These transmitters may emit jamming signals that interfere with the GPS receiver's ability to track GPS satellite signals. Generally, the stronger the other transmitting device, the wider the distance required between antennas. For the TrimTrac locator, a minimum clearance of 45 cm (approximately 18 in.) from these transmitting devices, including other TrimTrac locators, is recommended.

Mounting

Optional mounting brackets are available for the TrimTrac locator. A metal bracket is available for more permenant installations and is typically used whent the TrimTrac is equipped with a Vehicle Adapter Module. A quick-release, plastic holster-style bracket available for battery-powered installations or when a TrimTrac locator is to be moved from vehicle to vehicle.

Environmental Conditions

The TrimTrac locater mounting location must not exceed the environmental specifications of the device. For instance, it cannot be installed inside a vehicle's engine compartment, wheel well, chassis or any other location in which the conditions can reasonably be expected to exceed the device environmental specifications. Do not leave the TrimTrac locator in direct sunlight on the dashboard of a vehicle on hot, sunny days.

Exposure to RF Radiation

As noted in the Safety First and Detailed Safety Information chapters, on pages 1 and 2, respectively, the TrimTrac locator is not to be used in direct contact with the body. A minimum separation distance of 0.6 inch (15 mm) must be maintained during operation. The TrimTrac locator is not intended for body-worn applications.

Interference with Other Devices

The TrimTrac locator includes a GSM modem that may interfere with other electronic systems, such as car stereos, when it is transmitting. To avoid such interference, it is recommended that the TrimTrac locator not be placed in close proximity to any other electronic systems or devices. Conversely, other electronic systems or devices may jam the TrimTrac locator, especially the GPS receiver. Placing two or more operating TrimTrac locators in close proximity to one another may cause interference, especially when some TrimTrac locators are transmitting to the GSM network while others are trying to get a GPS position fix. The GSM transmissions may very well prevent surrounding units from being able to compute GPS positions until the offending transmissions have stopped.

Batteries

The TrimTrac locator is designed to work with four standard AA alkaline batteries. Insert the batteries with the positive and negative polarities as indicated on the battery pack label. Do not reverse polarities or use non-alkaline AA batteries; otherwise, permanent damage to the TrimTrac locator may result or there may be a risk of explosion or fire. Dispose of used batteries in accordance with the battery manufacturer instructions.

Theory of Operation

Introduction

In most applications, motion-based reporting is the fundamental operating premise of the TrimTrac locator as shown in Figure 1. This generally means that the unit computes and reports new GPS position fixes only if the unit is in motion and once more after coming to rest.

To conserve power and minimize communication costs, the TrimTrac attempts to be in a sleep mode as much as possible. Sleep modes occur both during the IDLE and DELAY states. In general, the TrimTrac locator will spend a majority of its time in the IDLE state during periods of no motion. How frequently the unit computes a new position fix while in motion is determined predominantly by the setting of the DELAY Timeout, T4.

Two configurable software-based motion filters determine how much movement it takes to trigger a new position or report. During the IDLE state, for instance, the IDLE Wakeup Motion Timeout, T7, and its associated IDLE Wakeup Motion Second Count parameter, are the primary means to filter detected movement. During the TRANSMIT (TX), QUERY and DELAY states, the Rolling Motion Window, T21, and its associated Rolling Motion Second Count parameter, are applied to any detected movement.
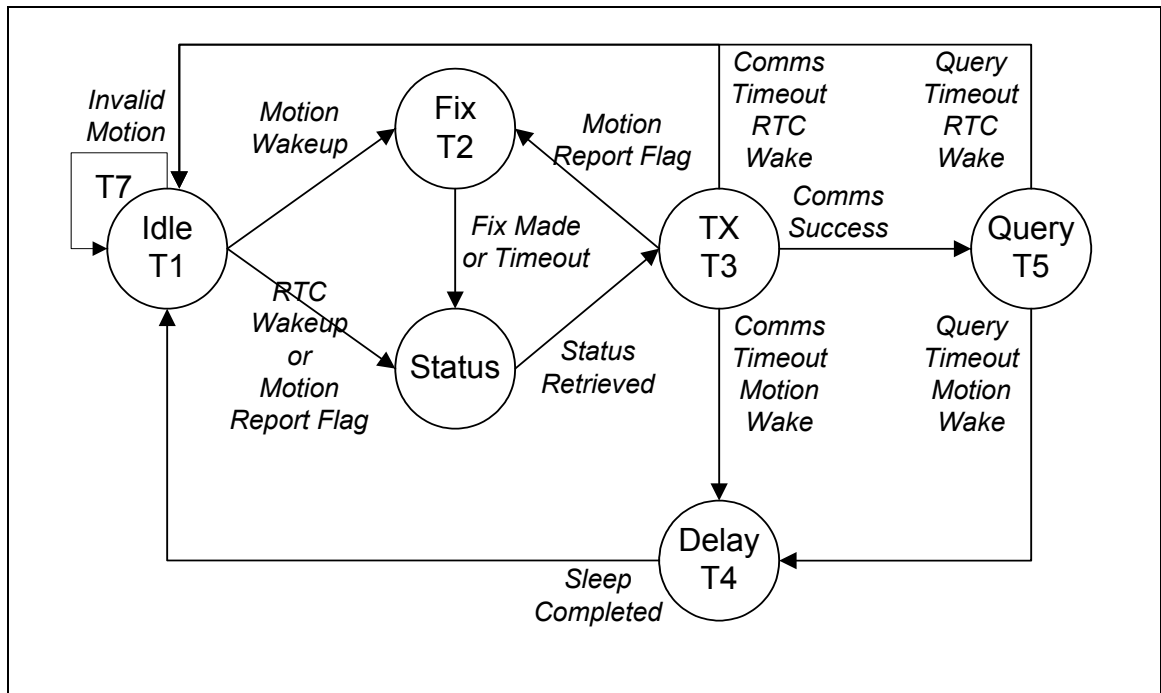
Figure 1, Summary TrimTrac Operational State Diagram

The TrimTrac state machine transitions through each state shown in Figure 1 based on motion, external inputs, timeouts, and as a result of completing defined actions (i.e communicating to the server), as follows:

IDLE: The TrimTrac device spends the majority of its time in the IDLE state. Detection of Motion results in a transition to the FIX state if the Motion Report Flag is set "0=Disabled". If the Motion Report Flag is set "1=Enabled" then motion will cause a transition to STATUS. Expiration of IDLE Timeout, T1, causes a transition to the STATUS state. The programmable IDLE Timeout, T1, is stored as seconds and is typically on the order of 12 to 48 hours. There are also optional IDLE State Polling Mode settings that allow the device to run the communications protocol stack during the IDLE state to receive and process incoming messages.

FIX: The device attempts to fix a position until expiration of FIX Timeout, T2. If a fix is achieved, the position is read by the application, the internal real-time clock (RTC) is updated, and the TrimTrac locator transitions to the STATUS state.. If no position fix is achieved prior to expiration of the FIX Timeout, T2, the TrimTrac locator transitions to the STATUS state with status of "no new fix". The FIX Timeout, T2, parameter is programmable and is stored as seconds and is typically on the order of 3 to 5 minutes, except during almanac collection.

STATUS: The TrimTrac device retrieves the latest status information and then transitions to the TRANSMIT state. In addition to any position and associated information, the status information includes various operational metrics such as conditional alerts, battery condition, battery change events and other such information.

TRANSMIT: The device attempts to transmit alert, position and/or status information to the server. First, the latest status information is combined with the position information in messages per the TrimTrac Application Protocol. Such messages are then sent to the GSM protocol stack to attempt transmission. If the Motion Report Flag is set "1=Enabled" and the message was a Motion Report Message then the TrimTrac locator transitions back to the FIX state. If the message was not a Motion Report Message then it does not transition to the FIX state, instead if the transmission was successful, the TrimTrac locator transitions to the QUERY state. If the transmission fails, the TrimTrac locator transitions to the DELAY state or, if the TriggerType was an IDLE timeout, to the IDLE state. The programmable TRANSMIT Timeout, T3, is stored in seconds and is typically on the order of 1 to 5 minutes.

QUERY: The device waits to receive any requests from the server for a programmable QUERY Timeout, T5. If any requests are received, they are processed in order and responses are sent if requested. After expiration of the QUERY Timeout, T5, the device transitions to the DELAY state if the TriggerType was motion, or to IDLE state if the TriggerType was an IDLE timeout. The programmable QUERY Timeout, T5 is stored as seconds and is typically on the order of 1 to 2 minutes.

Normally, the TrimTrac locator can only receive and process SMS messages sent from the server application while in the QUERY state; however, it can receive such messages during the IDLE and DELAY states as well if polling capabilities are

enabled. The unit can be polled for information, including new or logged position information during the IDLE and DELAY states if so configured.

DELAY: The device disables the motion sensor wakeup and goes to sleep for a programmable DELAY Timeout, T4. When the unit wakes up it transitions to the IDLE state by enabling the motion sensor and going back to sleep. The programmable DELAY Timeout, T4, is stored as seconds and is typically on the order of 10 to 20 minutes. If DELAY State Polling Mode is set "1=OnDemand", then the GSM modem will remain operational during DELAY and the unit will be able to receive and process SMS messages.

Application State Machine Design Details

As seen in Figure 1 the application state machine has six primary states that represent the operation of the device. This section gives a detailed description of each state, what events trigger transitions from each state, and the processing that occurs within each state and its transitions.

There are two status variables used along with the state of the TrimTrac locator:

> TriggerType; and
> ReportType

The TriggerType variable refers to what event caused the device to transition from the IDLE state. There are five TriggerTypes:

> 0=IDLE Timeout, T1
> 1=Motion Detected
> 2=Alert (VAM-only)
> 3=Query
> 4=Scheduled Report

The ReportType variable can be either a:

> STATUS_MSG or
> REPORT_POS.

The principal difference between a STATUS_MSG and a REPORT_POS is that a REPORT_POS contains position and related information whereas a STATUS_MSG does not contain such information. Please see page 65 for complete details.

A Position Age flag is set depending upon whether motion has been detected since the most recent position fix. The Position Age flag is set as follows:

> 0=Current (i.e.no motion since last position)
> 1=Aged (i.e. motion has occurred since last position)

Alert Handling – Vehicle Adapter Module

When a Vehicle Adapter Module is used with the TrimTrac locator, the device is able to monitor and report on High, Medium and Low priority inputs as shown in Figure 8, VAM Alert Wiring Diagram, on page 93. Regardless of priority, each input must be in one of the following states at any given time:

> 0=Normal
> 1=Activated
> 2=Sent
> 3=Acknowledged

General Alert Handling

Alerts are processed in descending order of priority. High Priority Alerts, for instance, will always take precedence over Medium and Low Priority Alerts and so on. Other than having their status included in any outgoing SMS messages, lower priority alert alarms are ignored until all higher priorty alerts have been either cleared to "0=Normal" or set "3=Acknowledged".

When a VAM equipped TrimTrac detects activation of a monitored switch or device, loss of external power or tampering with the external wiring, it will set the appropriate priority alert to "1=Activated". The one exception to this, as more fully described below, is a Low Priority Alert for which the TrimTrac locator needs to also detect motion in addition to activation of the switch before the Low Priority Alert is set "1=Activated".

Resetting of the local switch or device will not reset any activated alert unless the TrimTrac locator has also received from the server application an SET_ALERT_STATE message (See page 56).

Furthermore, activated alerts can only be cleared back to "0=Normal" after the fault or activated device has been restored to normal AND the TrimTrac locator has received from the server application the appropriate SET_ALERT_STATE message. This will help guard against an unauthorized person disabling the TrimTrac locator and Vehicle Adapter Module inputs.

Whenever an alert changes to "1=Activated" from "0=Normal" (and all higher priority alerts, if any, are set to either "0=Normal" or "3=Acknowledged" and the activated alert is not otherwise set to be ignored), the TrimTrac locator will transition from its currect state as follows:

1. If HPA Status becomes set "1=Activated", then terminate the current state and go to STATUS immediately; else

2. If MPA Status becomes set "1=Activated", then, if not in TRANSMIT state, terminate the current state and go to STATUS immediately. If in TRANSMIT, then go to STATUS upon completion of current TRANSMIT state; else

3. If LPA Status becomes set "1=Activated", then, if not in FIX or TRANSMIT state, terminate the current state and go to STATUS immediately. If in FIX or TRANSMIT, then go to STATUS upon completion of current FIX of TRANSMIT state.

Alerts can be changed to:

1. "2=Sent" from "1=Activated" during the TRANSMIT state if and only if the GSM protocol software has confirmed that the message has been successfully transmitted to the GSM network.

2. "3=Acknowledged" from "1=Activated" or "2=Sent" only upon the receipt of an appropriate SET_ALERT_STATE message.

3. "0=Normal" from "1=Activated", "2=Sent" or , "3=Acknowledged" only upon the receipt of an appropriate SET_ALERT_STATE message; provided, however, whatever condition that triggered the original alert has been cleared.

IDLE State

The IDLE State is the state that the device enters when it goes to sleep waiting for a TriggerType event to occur. Upon the occurrence of any TriggerType event, the unit will transition from IDLE in accordance with TriggerType and current configuration settings. While in the IDLE state all hardware is turned off except for the Motion Sensor Wakeup Logic and the RTC; provided, however, if the IDLE State Polling Mode is set to either "1=Cycled" or "2=OnDemand", then the GSM hardware and software will operate some or all of the time and the unit is able to receive and process SMS messages during IDLE.

1. When the unit enters the IDLE State it checks if motion since the last position fix attempt has been detected. If yes, the TriggerType is set "1=Motion Detected" and the device immediately transitions to the FIX State bypassing all of the other IDLE state checks detailed below.

2. When the unit enters the IDLE State and no motion has been detected, it starts the IDLE Timeout, T1, and waits for a TriggerType event to occur.

3. Upon the occurrence of a TriggerType event, the unit will wake up and transition out of the IDLE state based upon the TriggerType event and the current configuration settings.

4. Upon expiration of the IDLE Timeout, T1, the TriggerType is set "0=IDLE Timeout, T1", the TrimTrac locator will transition to the STATUS state (bypassing the FIX state).

5. If motion is detected while in the IDLE state, the TrimTrac locator will activate the IDLE Wakeup Motion Timeout, T7, and apply the IDLE Wakeup Motion Second Count. If there is sufficient continued motion, the TriggerType becomes set "1=Motion Detected" and the unit will transition to the FIX State if the Motion Report Flag is set "0=None" or to the STATUS state if the Motion Report Flag is set "1=Report IDLE Motion". If there is insufficient motion to satisfy the IDLE Wakeup Motion Second Count while the IDLE Wakeup Motion Timeout, T7, is running, then the unit will return to the IDLE state sleep mode and wait for a subsequent TriggerType event to occur.

6. If the IDLE State Polling Mode is set to "2=OnDemand", the unit keeps the GSM modem operational and the device is ready to receive messages from the sever at any time while the IDLE Timeout, T1, is running. Upon receipt of any SMS messages, the TriggerType is set "3=Query" and the unit transitions immediately to the QUERY state to process any such received messages.

7. If the IDLE State Polling Mode is set to "1=Cycled", the TrimTrac locator will power duty-cycle the GSM modem on and off during the IDLE state.

Each time the IDLE State Polling Cycle Interval, T19, timer expires, the GSM modem will power up and the IDLE State Polling Cycle Duration, T20, timer will start. The GSM modem hardware will remain on until the expiration of IDLE State Polling Cycle Duration, T20, or an SMS message is received. Upon receipt of any SMS messages, the TriggerType is set "3=Query" and the unit transitions immediately to the QUERY state to process any such received messages; else it goes back into IDLE sleep until the next TriggerType event occurs or the next time the IDLE State Polling Cycle Interval, T19, timer expires.

8. If the Scheduled Reporting Mode is set to either "1=Daily" or "2=Weekly" the TriggerType will be set "4=Scheduled Report" upon expiration of Scheduled Report Time, T18, timer regardless of the Report Delay Flag setting. If the Position Age flag is set "0=Current", then the device transitions to the STATUS state; else if Position Age flag is set "1=Aged", then the device transitions to the FIX state.

Alert Processing in the IDLE State:

Whenever one or more Vehcile Adatper Module alerts are in some condition other than "0=Normal" or "3=Acknowledged", and not otherwise set to be ignored, alert processing during IDLE state shall be in the following order:

1. If HPA Status is set:

    a. Or becomes set to"1=Activated", then set TriggerType to "2=Alert" and go to STATUS state;

    b. "2=Sent":

        i. To FIX state if Position Age flag is set "1=Aged"; or

        ii. If Position Age flag is set "0=Current", start HPA Idle Timeout, T11. Upon expiration HPA Idle Timeout, T11, or upon detection of subsequent motion, transition to STATUS or FIX states, respectively.

2. If MPA Status is set:

    a. Or becomes set to"1=Activated", then set TriggerType to "2=Alert" and go to STATUS state;

    b. "2=Sent":

        i. To FIX state if Position Age flag is set "1=Aged"; or

        ii. If Position Age flag is set "0=Current", start MPA Idle Timeout, T12. Upon expiration MPA Idle Timeout, T12, or upon detection of subsequent motion, transition to STATUS or FIX states, respectively.

3. If LPA Status is set or becomes set to"1=Activated", then set TriggerType to "2=Alert" and go to STATUS state.

FIX State

The FIX State is the state where the GPS engine is running trying to get a fix. While in this state the GPS hardware is turned on and the GSM radio hardware is turned off.

1. When the unit enters the FIX State it enables the GPS hardware and starts the FIX Timeout, T2.

2. Upon completion of a successful position fix, the relevant position related information is extracted and the internal the RTC is updated.

3. After the position fix is achieved, or upon expiration of the FIX Timeout, T2, the GPS engine is turned off and the unit transitions to the STATUS state if the TrimTrac has a complete valid almanac. If the unit does not have a complete, valid almanac after computing the position fix, or if Almanac Timeout, T6, has expired, the TrimTrac locator will leave the GPS engine operational for up to fifteen (15) minutes more to collect almanac. Upon collection of a complete, valid almanac or expiration of the fifteen (15) minute almanac collection timer, the unit will then transition to the STATUS state after powering off the GPS engine.

Alert Processing in the FIX State:

Should either the HPA Status or MPA Status become set "1=Activated" during the current FIX state, the TrimTrac locator will terminate the current fix attempt and go immediately to the STATUS state.

All other alert conditions shall have no effect on the FIX state.

STATUS State

The TrimTrac locator enters the STATUS State based upon the occurrence of TriggerType events or, if entering from the FIX state, upon the computation of a new position fix or expiration of the FIX Timeout, T2.

1. When the unit enters the STATUS State it retrieves the battery, alert and operational status information and stores it in the report structure to be used during the TRANSMIT state.

2. If entering from the FIX state and the positioin fix attempt was successful, the Position Age flag is set "0=Current".

3. It then transitions to the TRANSMIT State.

The TrimTrac locator dwells in the STATUS state only long enough to update the report structure. This process is virtually instantaneous and all alerts shall have no effect on STATUS state.

TRANSMIT State

Upon entering the TRANSMIT state from the STATUS state, the TrimTrac locator will:

1. Power up the GSM hardware;

2. Start the TRANSMIT Timeout, T3;

3. Attempt find a suitable 900, 1800 or 1900 MHz GSM network, establish SIM communication and register on the network; AND

4. If a suitable GSM network connection is made, transmit the latest queued messages before expiration of the TRANSMIT Timeout, T3.

The TrimTrac locator will transition from the TRANSMIT state whenever any of the following occurs:

1. The GSM protocol stack confirms successful transmission of queued TrimTrac locator messages; OR

2. The TrimTrac locator has made Position Report Transmit Attempts, N1, or Status Message Transmit Attempts, N2, whichever the case may be, before the GSM protocol stack has confirmed successful transmission of queued TrimTrac locator messages; OR

3. Expiration of TRANSMIT Timeout, T3.

Upon occurrence of any of the foregoing, the TrimTrac locator will transition from the TRANSMIT state to either the IDLE, FIX, QUERY or DELAY states as follows:

1. To the IDLE state if:

   a. The TriggerType had become set "0=IDLE Timeout, T1" during the most recent IDLE state; AND

   b. The TRANSMIT Timeout, T3, expires or the TrimTrac locator has made Status Message Transmit Attempts, N2, before the GSM protocol stack has confirmed successful transmission of queued TrimTrac locator messages.

2. To the FIX state if:

   a. The TriggerType had become set "1=Motion Detected" during the most recent IDLE state; AND

   b. Motion Report Flag is set "1=Motion in IDLE"; AND

   c. The GSM protocol stack confirms that the attempt to send the queued Motion Report succeeded; the TRANSMIT Timeout, T3, has expired or Status Message Transmit Attempts, N2, have been made.

3. To the QUERY state if the GSM protocol stack confirms that the attempt to send queued TrimTrac locator messages, other than a Motion Report, succeeded.

4. To the DELAY state if the TriggerType is set "1=Motion Detected"and:

a. The TrimTrac locator has already cycled through the FIX state due to the Motion Report Flag being set "1=Report Motion in IDLE"; OR

b. The TRANSMIT Timeout, T3, expires or the TrimTrac locator has made Position Report Transmit Attempts, N1, or Status Message Transmit Attempts, N2, whichever the case may be, before the GSM protocol stack has confirmed successful transmission of queued TrimTrac locator messages.

Alert Processing in TRANSMIT State

Should either the HPA Status or MPA Status become set "1=Activated" during the current TRANSMIT state, the TrimTrac locator will terminate the current transmission attempt and go immediately to the STATUS state.

Unless alerts are otherwise set to be ignored, alert processing during TRANSMIT state shall be per the flowchart shown in Figure 2 through Figure 5.
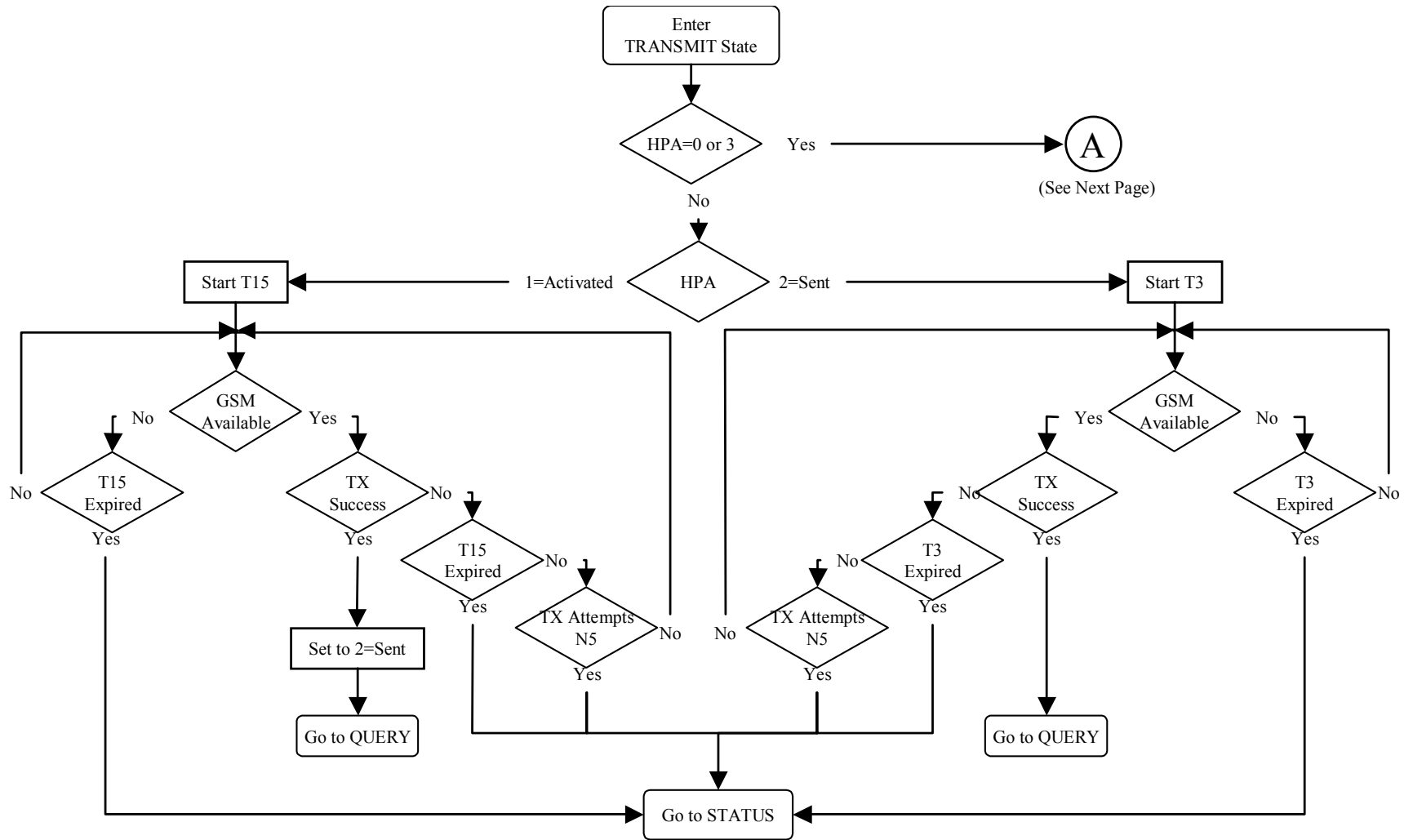
Figure 2, HPA Processing in TRANSMIT
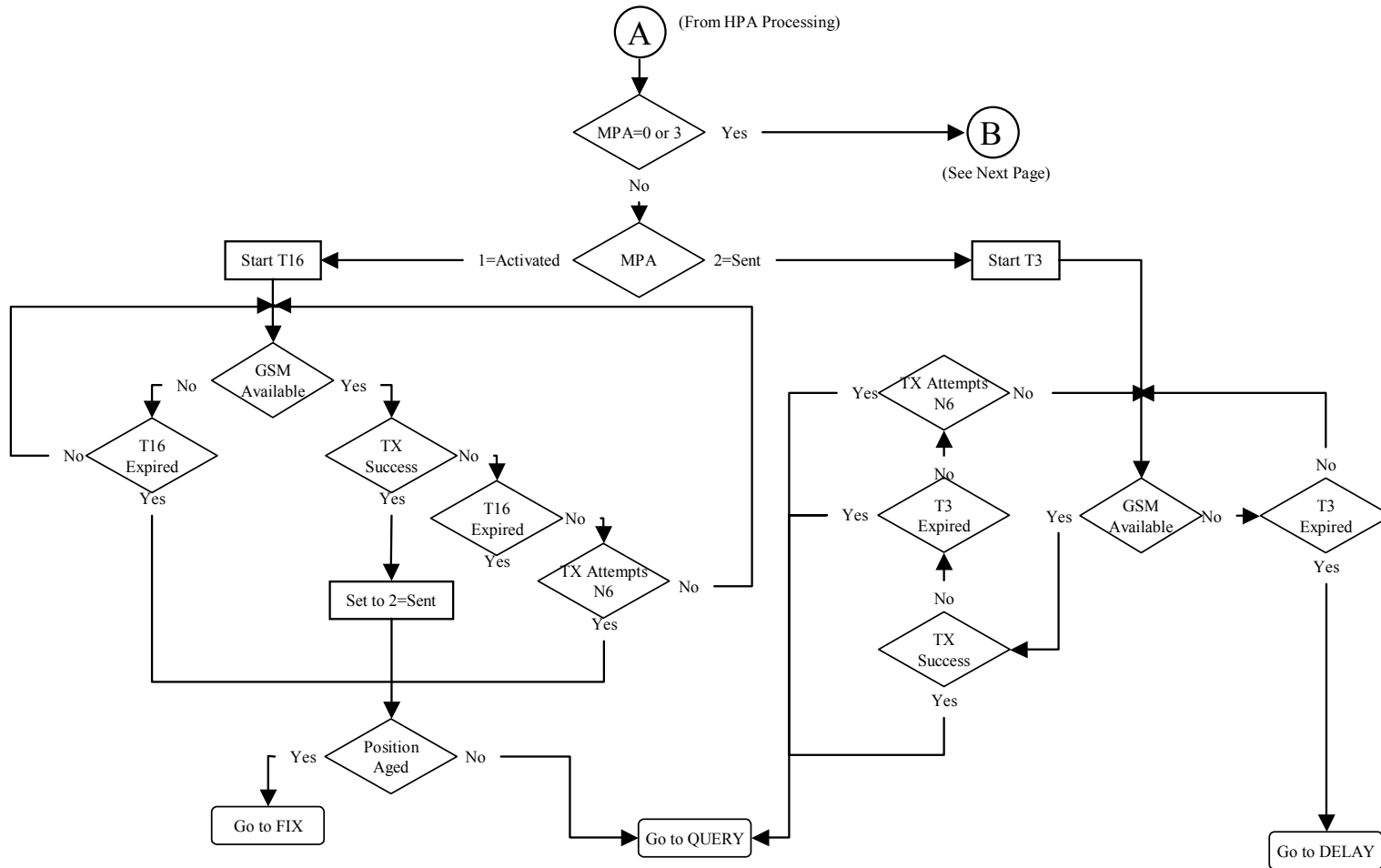
Figure 3, MPA Processing in TRANSMIT
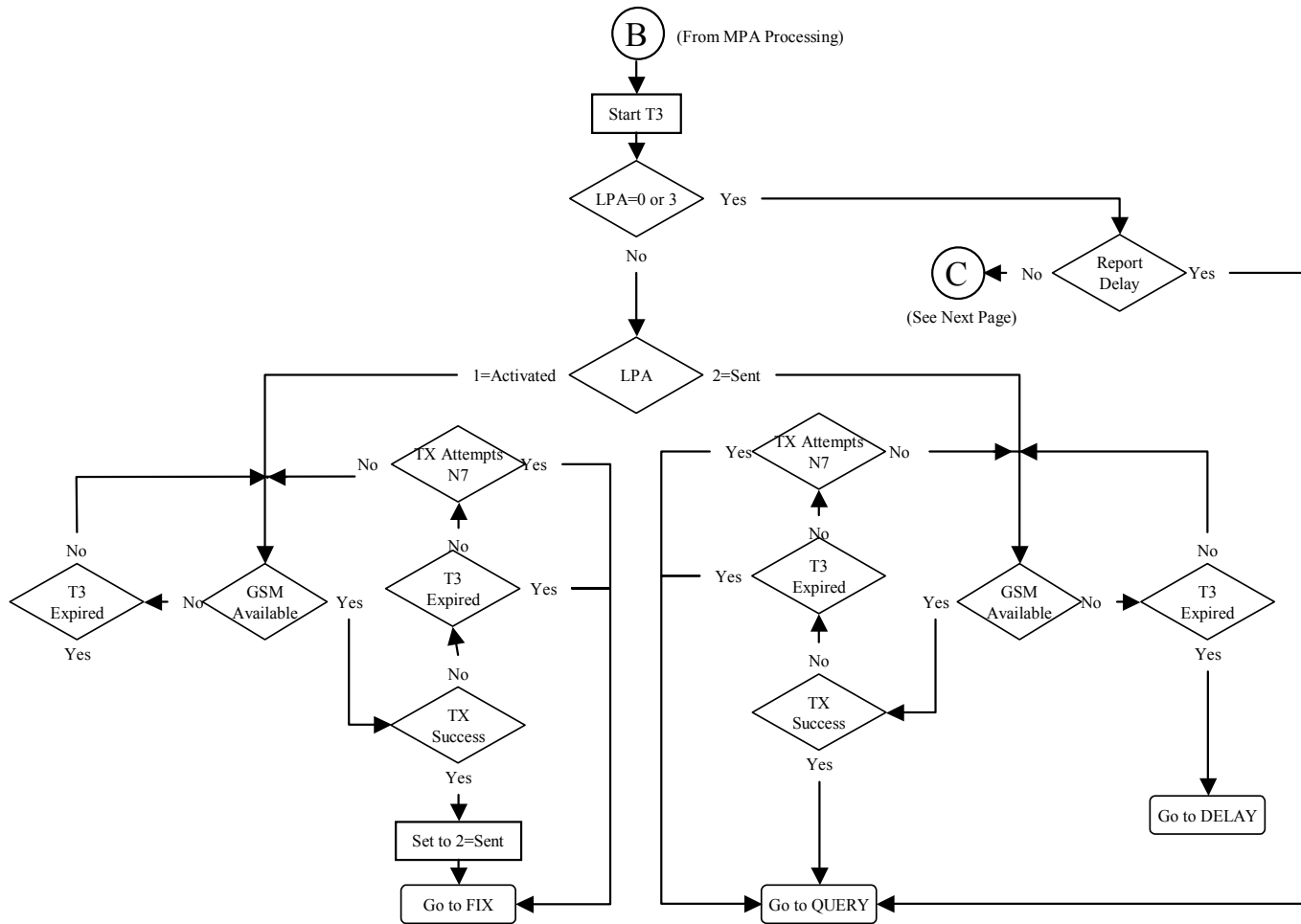
Figure 4, LPA Processing in TRANSMIT
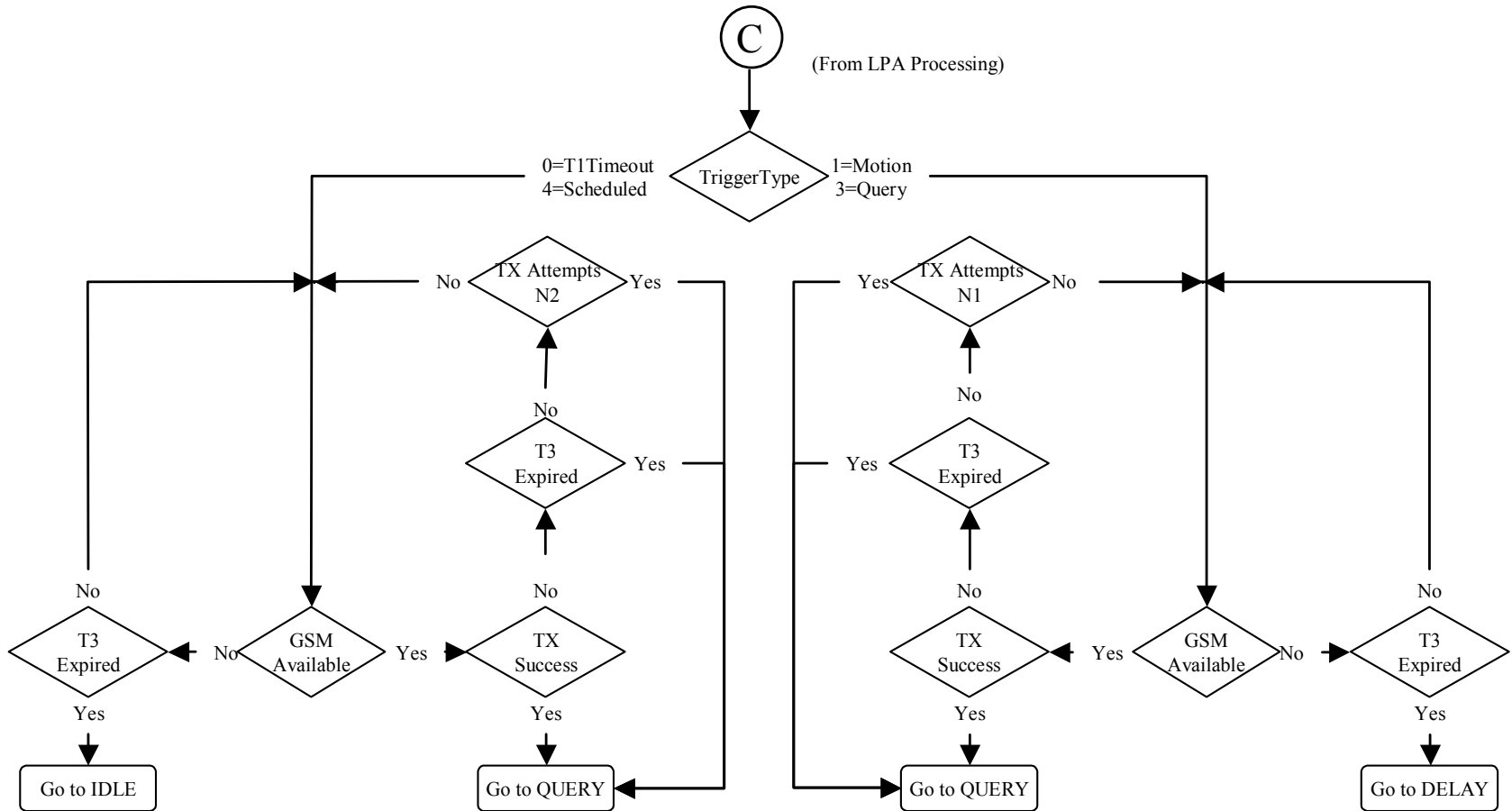
Figure 5, Other Message Processing in TRANSMIT

QUERY State

The QUERY State is where the Application waits for incoming messages from the server. During this state the GPS hardware is powered off and the GSM radio is powered on.

1. Upon entering the QUERY state, the TrimTrac locator starts QUERY Timeout, T5.

2. The application then waits until the QUERY Timeout, T5, expires or a valid SMS message arrives.

3. If a valid SMS message arrives it is processed and one or more messages may be generated in response to the received query. If the QUERY Timeout, T5, changes due to a received message the current QUERY state is terminated.

4. For each of the responses the TrimTrac locator waits for a conformation from the GSM protocol stack that it was sent.

5. If the QUERY Timeout, T5, expires while the application is sending responses to the received query the TrimTrac locator will continue to send the responses and accept new queries.

6. When the QUERY Timeout, T5, has expired and there are no messages waiting to be sent then the TrimTrac locator transitions to the DELAY State if the TriggerType was set "1=Motion Detected". If the TriggerType was set "0=IDLE Timeout, T1" then the TrimTrac locator transitions to the IDLE state.

7. If Query Hold Flag is set "1=Enabled", the TrimTrac locator will attempt to re-establish any GSM network connection that may have been lost prior to the expiration of QUERY Timeout, T5. It will continue attempting to re-establish the lost GSM network connection until the QUERY Timeout, T5, has expired.

8. If DELAY State Polling Mode is set "1=OnDemand", the QUERY Timeout, T5, is automatically set to 10 seconds..

Alert Processing in QUERY State

Whenever one or more Vehcile Adatper Module alerts are in some condition other than "0=Normal" or "3=Acknowledged", and not otherwise set to be ignored, alert processing during QUERY state shall be in the following order:

1. If HPA Status is set:

    a. "1=Activated", then go to immediately to the IDLE state;

    b. "2=Sent", then ignore all SMS messages received prior to the receipt of SET_ALERT_STATE message and:

i. If Position Age is set "1=Aged", then go immediately to the IDLE state; or

ii. If Position Age is set "0=Current", then go to the IDLE state upon expiration of HPA Query Timeout, T17.

2. If MPA Status is set:

    a. "1=Activated", then go to immediately to the IDLE state;

    b. "2=Sent" then ignore all SMS messages received prior to the receipt of SET_ALERT_STATE message and go immediately to the IDLE state.

3. If LPA Status is set:

    a. "1=Activated", then go to immediately to the IDLE state;

    b. "2=Sent" then ignore all SMS messages received prior to the receipt of SET_ALERT_STATE message and go immediately to the IDLE state.

4. During the QUERY state, any alert (High, Low, Medium) status can be changed from "2=Sent" or "3=Acknowledged" to "0=Clear", "3=Acknowledged", or "X=Do not care" upon receipt of the appropriately configured SET_ALERT_STATE message.

DELAY State

The DELAY State is where the TrimTrac locator normally dwells after a state machine cycle and ignores any detected motion. This effectively restricts the unit to reporting no more often than the DELAY Timeout, T4; provided, however, all Vehicle Adapter Module alerts are in the "0=Normal" condition or otherwise set to be ignored.

1. The unit will transitition from DELAY state as follows:

    a. To the IDLE state upon the earlier of:

        i. Expiration of DELAY Timeout, T4; or

        ii. Expiration of Scheduled Report Time, T18, if Scheduled Reporting Mode is set "1=Enabled".

    b. To the QUERY state upon receipt of an SMS message if DELAY State Polling Mode is set "1=OnDemand".

2. To further conserve power during the DELAY state, the software filtering of the motion sensor can be disabled by setting DELAY State Extended Motion Detection to "0=Disabled". While in this disabled condition, the Rolling Motion Window, T21, and Rolling Motion Second Count parameters are ignored.

Alert Processing in DELAY State

Whenever one or more Vehcile Adatper Module alerts are in some condition other than "0=Normal", and not otherwise set to be ignored, alert processing during DELAY state shall be in the following order:

5. If HPA Status is set:

    a. "1=Activated", then go to immediately to the IDLE state;

    b. "2=Sent":

        i. If Position Age is set "1=Aged", then go immediately to the IDLE state; or

        ii. If Position Age is set "0=Current", then go to the IDLE state upon expiration of HPA Delay Timeout, T13.

6. If MPA Status is set:

    a. "1=Activated", then go to immediately to the IDLE state;

    b. "2=Sent":

        i. If Position Age is set "1=Aged", then go immediately to the IDLE state; or

        ii. If Position Age is set "0=Current", then go to the IDLE state upon expiration of MPA Delay Timeout, T14.

  c. "3=Acknowledged", then go to the IDLE state upon expiration of DELAY Timeout, T4.

7. Proceed immediately to the IDLE state whenever:

  a. The LPA switch is in its "armed" closed position regardless of how the LPA Status is set.

  b. LPA Status is set "1=Activated" regardless of the LPA switch position ("unarmed" open or "armed" closed).

8. All Delay Timeouts (T4, T13 and T14) are immediately terminated whenever any alert state (HPA Status, MPA Status or LPA Status) is or becomes set to "1=Activated" and the unit immediately transitions to the IDLE state.

TrimTrac Application Protocol

Introduction

The TrimTrac Application Protocol is used to communicate with and control TrimTrac locators that have already been provisioned and deployed to the field.

The TrimTrac locator communicates with the server application by sending and receiving SMS messages based on an ASCII-like protocol (in lieu of the AT+commands used during initial provisioning). This TrimTrac Application Protocol uses the same message structure as the Trimble ASCII Interface Protocol (TAIP) even though no TAIP messages defined for Trimble products other than the TrimTrac locator are used. It is used to communicate with and control TrimTrac locators that have already been provisioned and deployed to the field.

For security reasons, the only parameters that cannot be changed over-the-air using the TrimTrac Application Protocol are the Unit ID, Security Password, and SIM PIN.

Message Format

Basic Message

All TrimTrac Application Protocol messages use printable ASCII characters. Upper case and lower case alpha characters are generally interchangeable, i.e., lower case characters are converted to upper case alpha in the TrimTrac locator before parsing.

Each message has the following general format with the contents of the data string being message dependant. Valid messages are limited to 128 characters.

>ABB{C}[;PW=PPPPPPPP];ID=YYYYYYYY;*ZZ<

Element	Meaning
>	Start of new message
<	End of message
A	Message Qualifier (Q, R, or S)
BB	2-character Message Identifier (Must be TK)
C	Data string.
PPPPPPPP	Security Password. Always 8 alphanumeric characters, UPPER CASE ONLY. Default 00000000
YYYYYYYY	Unit ID. Always 8 alphanumeric characters, UPPER CASE ONLY. Default 00000000
ZZ	2-character checksum.
{x}	Signifies that x can occur zero or more times

Element	Meaning
[x]	Signifies that x may optionally occur once

Table 16, Basic Message Format

Message Framing

Each TrimTrac Application Protocol message is framed by the start, end ASCII characters '>', '<', respectively. These characters are not allowed other than as start-of-message and end-of-message indicators.

Message Qualifiers

A one-character Message Qualifier is used to describe the action to be taken on the message. The following table lists the valid qualifiers:

Qualifier	Action
Q	Query for data or parameters (sent to TrimTrac locator)
S	Set or configure parameters (sent to TrimTrac locator)
R	Response to a query or a scheduled or autonomous report (from the TrimTrac locator)

Table 17, Message Qualifiers

Data String

The Message Qualifier and the Message Identifier dictate the format and length of the data string. The Data String can consist of any printable ASCII characters with the exception of the > and < characters. Most messages are length sensitive and many use the ';' character as field separator. Data fields are fixed length regardless of the values entered.

Security Password

A Security Password (denoted as "PW" in messages) must be used in all communications with the TrimTrac locator. The default Security Password is set to "00000000"; however, the TrimTrac locator may be assigned any numeric password of up to eight characters while the TrimTrac locator is connected to a Provisioning Module.

The TrimTrac locator checks all incoming messages for a Security Password and all incoming message must include a Security Password. If the Security Password included in a message sent to TrimTrac locator does not match the Security Password configured in the TrimTrac device, then the message is ignored.

Unit ID

The Unit ID must be used in all communications with the TrimTrac locator. The TrimTrac locator may be assigned a alphanumeric Unit ID of eight characters only

while the TrimTrac locator is connected to a Provisioning Module (available separately). The default Unit ID is set to 00000000.

The TrimTrac locator checks all incoming messages for a Unit ID and all incoming message must include a Unit ID. If the Unit ID included in a message sent to TrimTrac locator does not match the Unit ID configured in the TrimTrac device, then the message is ignored.

Checksum

The checksum field is always required and provides for a two-digit hexadecimal checksum value, which is computed by XOR'ing all characters from the beginning of the message up to and including the * character. See Table 18, Sample XOR Checksum Source Code. The checksum is always the last element of the message before the end-of-message delimiter.

```
/*****************************************************************************
 * Function:      AppProtocolCalcTAIPChecksum
 * Parameters:    pszTAIPMsg, checksum
 * Returns:       Pointer to Checksum Header ;* if found, NULL otherwise.
 * Description:   This function checks for the presense of the TAIP checksum
 *                header.  If it exists it calculates the checksum and
 *                places it in the checksum parameter and returns a pointer
 *                to the checksum header.
 *                Otherwise it returns NULL without changing checksum.
 ****************************************************************************/
char* AppProtocolCalcTAIPChecksum(char *pszTAIPMsg, unsigned char *checksum)
{
    char *pcEnd;
    char *pc;
    unsigned char cs;

    if((pcEnd = strstr(pszTAIPMsg, ";*")) != NULL) {

        pc = pszTAIPMsg;            // Start of the checsumed chars.
        pcEnd += 2;                 // Move to the first non-checksumed char.
        cs = 0;

        while(pc < pcEnd) {

            cs ^= *pc;
            pc++;

        }

        *checksum = cs;

        return pcEnd-2;
    } else {
        return NULL;
    }
}
```

Table 18, Sample XOR Checksum Source Code

TrimTrac Application Protocol Message Summary

The following over-the-air TrimTrac Application Protocol Messages are used to communicate with and control the TrimTrac locator.

Message	Description	See Page
QUERY_CONFIG	Requests current Application, Communication or GPS parameters	62
QUERY_LOG	Requests logged messages (REPORT_POS and STATUS_MSG)	63
QUERY_POSITION	Requests current or logged position information	64
REPORT_POS	Basic position message	65
RESP_ALERT_STATE	Confirms SET_ALERT_STATE message receipt and processing	67
RESP_APP_CONFIG	Reports current Basic Application parameters	67
RESP_EXT_APP_CONFIG	Reports current Extended Application parameters	68
RESP_GPS_CONFIG	Reports current GPS parameters	69
RESP_PROV_CONFIG	Reports current Communication parameters	70
RESP_QUERY_AGGR	Reports summary of two logged messages	70
RESP_QUERY_LOG	Reports requested logged messages	70
RESP_VAM_APP_CONFIG	Reports current VAM application parameters	72
SET_ALERT_STATE	Acknowledges or clears VAM alerts	56
SET_APP_CONFIG	Changes Basic Application parameters	57
SET_EXT_APP_CONFIG	Changes Extended Application parameters	58
SET_GPS_CONFIG	Changes GPS parameters	60
SET_PROV_CONFIG	Changes Communication parameters	60
SET_VAM_APP_CONFIG	Changes VAM application paramaters	61
STATUS_MSG	Same as REPORT_POS except no location/velocity data	65

Table 19, TrimTrac Application Protocol Messages

TrimTrac Message Commands and Responses

Command	Response
SET_APP_CONFIG (Page 57)	RESP_APP_CONFIG (Page 67)
SET_EXT_APP_CONFIG (Page 58)	RESP_EXT_APP_CONFIG (Page 68)
SET_PROV_CONFIG (Page 60)	RESP_PROV_CONFIG (Page 70)
SET_GPS_CONFIG (Page 60)	RESP_GPS_CONFIG (Page 69)
QUERY_CONFIG (Page 62)	RESP_APP_CONFIG (Page 67)
QUERY_LOG (Page 63)	RESP_QUERY_LOG (Page 70) or RESP_QUERY_AGGR (Page 70)
QUERY_POSITION (Page 64)	REPORT_POS or STATUS_MSG and REPORT_POS (Page 65)
SET_VAM_APP_CONFIG (Page 61)	RESP_VAM_APP_CONFIG (Page 72)
SET_ALERT_STATE (Page 56)	RESP_ALERT_STATE (Page 67)

Table 20, TrimTrac Application Protocol Command/Response Summary

TrimTrac Message Headers and Names

Message Header	Message Name	See Page
>QTKA	QUERY_CONFIG (APPLICATION)	62
>QTKD	QUERY_POSITION	64
>QTKG	QUERY_CONFIG (GPS)	62
>QTKR	QUERY_LOG	63
>QTKV	QUERY_CONFIG (PROVISIONING)	62
>RTK{1-4}	RESP_QUERY_AGGR	70
>RTKA	RESP_APP_CONFIG	67
>RTKG	RESP_GPS_CONFIG	69
>RTKL	RESP_ALERT_STATE	67
>RTKP	REPORT_POS	65
>RTKR	RESP_QUERY_LOG	70
>RTKS	STATUS_MSG	65
>RTKV	RESP_PROV_CONFIG	70
>RTKX	RESP_EXT_APP_CONFIG	68
>RTKY	RESP_VAM_APP	72
>STKA	SET_APP_CONFIG	57
>STKG	SET_GPS_CONFIG	60
>STKL	SET_ALERT_STATE	56
>STKV	SET_PROV_CONFIG	60
>STKX	SET_EXT_APP_CONFIG	58
>STKY	SET_VAM_APP_CONFIG	61

Table 21, Message Header Look-up Table

Configuration Messages

The following messages are sent to the TrimTrac locator to configure application, GPS and GSM parameters and to set Vehicle Adapter Module alert and application parameters.

SET_ALERT_STATE

This message is sent to the TrimTrac locator to acknowledge or clear alert states.

>STKABCD;PW=PPPPPPPP;ID=YYYYYYYY;*ZZ<	
A	**Always 'L':** Indicates alert state setting
B	**HPA state:** 'X' = Do not care, '3' = Ack, '0' = Clear
C	**MPA state:** 'X' = Do not care, '3' = Ack, '0' = Clear
D	**LPA state:** 'X' = Do not care, '3' = Ack, '0' = Clear
PPPPPPPP	**Security Password.** Always 8 alphanumeric characters, UPPER CASE ONLY. . Default 00000000
YYYYYYYY	**Unit ID.** Always 8 alphanumeric characters, UPPER CASE ONLY
ZZ	**Checksum.**

Table 22, SET_ALERT_STATE Message

SET_APP_CONFIG

The SET_APP_CONFIG message is used by the server application to set the TrimTrac Application parameters in the TrimTrac locator. When received the TrimTrac locator will send a RESP_APP_CONFIG message in response.

`>STKABBBBBBCCCCCCDDDDDDEEEEEEFFFFFFGGGTTHIJK;PW=PPPPPPPP;ID=YYYYYYYY;*ZZ<`
`A`	TrimTrac Configuration Set: 'A' = Application Parameters
`BBBBBB`	**IDLE Timeout, T1**. In seconds (10 – 999990). Default 43200
`CCCCCC`	**FIX Timeout, T2**. In seconds (10 – 3600). Default 300
`DDDDDD`	**TRANSMIT Timeout, T3**. In seconds (10 – 3600). Default 120
`EEEEEE`	**DELAY Timeout, T4**. In seconds (10 – 86400). Default 900
`FFFFFF`	**QUERY Timeout, T5**. In seconds (10 – 3600). Default 60
`GGG`	**Almanac Timeout, T6**. In hours (10 – 990). Default 168
`TT`	**IDLE Wakeup Motion Timeout, T7**. In seconds (0 – 90). Note: T7 is used exclusively while in the IDLE state; however, it is superseded by the Rolling Motion Window, T21, whenever IDLE State Polling Mode is set "2=OnDemand" OR while IDLE State Polling Cycle Duration, T20, is running due to IDLE State Polling Mode being set "1=Cycled". WARNING: IDLE Wakeup Motion Timeout, T7, must always be set greater than or equal to IDLE Wakeup Motion Second Count; else unit may not exit IDLE state due to motion. Default 15
`H`	**Motion Report Flag**. 0=None; 1=Report Motion in IDLE (before attempting new GPS fix. Default 0
`I`	**Report Delay Flag**. 0=Transmit All Messages; 1=Transmit NO Messages; 2=Transmit Motion-related Messages-only; 3= Transmit IDLE Timeout, T1 Status Messages-only. Default 0
`J`	**Diagnostics Mode**. 0= None; 1= LED. Default 1
`K`	**Communication Mode**. 0= SMS; 1= Future. Default 0
`PPPPPPPP`	**Security Password**. Always 8 alphanumeric characters, UPPER CASE ONLY. Default 00000000
`YYYYYYYY`	**Unit ID.** Always 8 alphanumeric characters, UPPER CASE ONLY
`ZZ`	**Checksum.**

Table 23, SET_APP_CONFIG Message

SET_EXT_APP_CONFIG

This message is used to set the Extended Application parameters in the TrimTrac device. When received the TrimTrac device will send a RESP_EXT_APP_CONFIG message in response.

`>STKABCCCCCCDEFFFFFFGGGGGGHIJJJKKKLLMMNNO;PW=PPPPPPPP;` `ID=YYYYYYYY;*ZZ<`		
A	**TrimTrac Configuration Set**: 'X' = Extended Application Parameters	
B	**Scheduled Reporting** Mode. 0=None; 1=Daily; 2=Weekly	
CCCCCC	**Scheduled Report Time, T18**. In Seconds (0-604799). Note: This is either the seconds into the day or into the week for the device to schedule a report when this feature is enabled. If Scheduled Reporting Mode is set "0=None", then enter 0. Default 0.	
D	**DELAY State Polling** Mode. 0=Disabled; 1=OnDemand. Note: If set to "1=OnDemand", the unit is able to receive and process SMS commands during the QUERY and DELAY states. Default 0	
E	**IDLE State Polling Mode.** 0=Disabled; 1=Cycled; 2=OnDemand. Default 0. Note: DELAY State Polling Mode is treated as always "1=Enabled" when IDLE State Polling Mode is set to "2=OnDemand".	
FFFFFF	**IDLE State Polling Cycle Interval, T19.** In Seconds (10-999990). Note: Determines the interval at which the IDLE State Polling Cycle Duration, T20, timer is started if and only if the IDLE State Polling Mode is set to "1=Cycled". WARNING: IDLE State Polling Cycle Interval, T19, must always be set greater than IDLE State Polling Cycle Duration, T20, or QUERY Timeout, T5, whichever applies. Default 3600.	
GGGGGG	**IDLE State Polling Cycle Duration, T20.** In Seconds (0, 10-3600). Note: Determines how long the unit is able to receive and process SMS messages each time IDLE State Polling Cycle Interval, T19, expires. A value of zero causes the QUERY Timeout, T5, value to be used WARNING: IDLE State Polling Cycle Interval, T19, must always be set greater than IDLE State Polling Cycle Duration, T20, or QUERY Timeout, T5, whichever applies. Default 60.	
H	**Query Hold Flag.** 0=Disabled; 1=Enabled. Note: Unit attempts to reconnect to the GSM network if the connection is lost during the QUERY state prior to the expiration of QUERY Timeout, T5. Default 0.	
I	**DELAY State Extended Motion Detection.** 0=Disabled; 1=Enabled. Note: Allows the unit to filter spurious motion detections in DELAY state when set to "1=Enabled". The unit does not power off during DELAY state and power consumption will increase. Default 1.	
JJJ	**Position Report Transmit Attempts,** N1. 0=Until T3 Expires; 1-255=Number of Tx Attempts. Default 1.	
KKK	**Status Message Transmit Attempts,** N2. 0=Until T3 Expires; 1-	

	255=Number of Tx Attempts. Default 1.
LL	**IDLE Wakeup Motion** Second Count**.** In Seconds (1-90). Note: This parameter is used only while IDLE Wakeup Motion Timeout, T7, is running. It is superseded by Rolling Motion Second Count whenever IDLE State Polling Mode is set "2=OnDemand" OR while IDLE State Polling Cycle Duration, T20, is running due to IDLE State Polling Mode being set "1=Cycled". WARNING: IDLE Wakeup Motion Second Count must always be set equal to or less than IDLE Wakeup Motion Timeout, T7; else unit may not exit IDLE state due to motion. Default 1.
MM	**Rolling Motion Window, T21.** In Seconds (1-90). Note: T21 applies in all states except IDLE and FIX; provided, however, that is also automatically enabled for IDLE state whenever IDLE State Polling Mode is set "2=OnDemand" OR when IDLE State Polling Cycle Duration, T20, is running due to IDLE State Polling Mode being set "1=Cycled". WARNING: Rolling Motion Window, T21, must always be set equal to or greater than Rolling Motion Second Count; else the unit may not exit QUERY state. Default 20.
NN	**Rolling Motion Second Count.** In Seconds (1-90). Note: This parameter is enabled only when Rolling Motion Window, T21, is active. Default 10.
O	**Motion Override.** 0=Normal; 1=Motion Always; 2=Motion Never. Note: Overrides the motion sensor if set to a value other than "0=Normal". If set to "1=Motion" Always, then the TrimTrac locator will override the motion sensor such that the unit operates as if motion is always present. If set to "2=Motion Never", then the TrimTrac locator will ignore all motion and never generate a fix until the configuration is changed or otherwise commanded to do so (see QUERY_POSITION message). Default 0.
PPPPPPPP	**Security Password.** Always 8 alphanumeric characters, UPPER CASE ONLY. . Default 00000000
YYYYYYYY	**Unit ID.** Always 8 alphanumeric characters, UPPER CASE ONLY
ZZ	**Checksum.**

Table 24, SET_EXT_APP_CONFIG Message

SET_GPS_CONFIG

The SET_GPS_CONFIG message is used by the server application to set the TrimTrac GPS parameter values in the TrimTrac locator. When received the TrimTrac locator will send a RESP_GPS_CONFIG message in response. Please note that these GPS configuration parameters will seldom need to be changed from default values. It is NOT recommended that they be changed without first consulting with your Trimble representative.

>STKABBCCCDDDEEEF;PW=PPPPPPPP;ID=YYYYYYYY;*ZZ<	
A	**TrimTrac Configuration Set**: 'G' = GPS Parameters
BB	**GPS Elevation Mask**. In degrees (0-30). Default 5
CCC	**GPS PDOP Mask**. In tenths of PDOP (60 – 200). Default 120
DDD	**GPS PDOP Switch**. In tenths of PDOP (40 – 120). Default 60
EEE	**GPS Signal Level**. In tenths of AMUs (10 – 80). Default 10
F	**GPS Dynamics Mode**. 5=Automobile. Default 5
PPPPPPPP	**Security Password**. Always 8 alphanumeric characters, UPPER CASE ONLY. . Default 00000000
YYYYYYYY	**Unit ID.** Always 8 alphanumeric characters, UPPER CASE ONLY
ZZ	**Checksum.**

Table 25, SET_GPS_CONFIG Message

SET_PROV_CONFIG

The SET_PROV_CONFIG message is used by the server application to set the Communication values in the TrimTrac locator. When received by the TrimTrac locator, the unit will send a RESP_PROV_CONFIG message in response.

>STKABBBBBBBBBBBBBBBBBBBBBBBBBB;PW=PPPPPPPP;ID=YYYYYYYY;*ZZ<	
A	**TrimTrac Configuration Set:** 'V' = Provisioning Parameters
BBBBBB **BBBBBB** **BBBBBB** **BBBBBB**	**Destination Address.** 24 characters including international dialing "+" sign and country code. Field padding is in spaces before the international dialing "+" sign. Default <Empty>.
PPPPPPPP	**Security Password.** Always 8 alphanumeric characters, UPPER CASE ONLY. Default 00000000
YYYYYYYY	**Unit ID.** Always 8 alphanumeric characters, UPPER CASE ONLY
ZZ	**Checksum.**

Table 26, SET_PROV_CONFIG Message

SET_VAM_APP_CONFIG

This message is used by the server to set the VAM-only Application Parameter Values in the TrimTrac device. When received the TrimTrac device will send a RESP_VAM_APP_CONFIG message in response. The message is ignored by TrimTrac locators not equipped with a VAM.

`>STKABBBBBBCCCCCCDDDDDDEEEEEEFFFFFFGGGGGGHHHHHHIIIJJJK KKLMN;PW=PPPPPPPP;ID=YYYYYYYY;*ZZ<`	
`A`	**VAM-only Configuration Set:** 'Y' = VAM-only Parameters
`BBBBBB`	**HPA Idle Timeout, T11.** In Seconds (10-999990) Default 10
`CCCCCC`	**MPA Idle Timeout, T12.** In Seconds (10-999990). Default 10
`DDDDDD`	**HPA Delay Timeout, T13.** In Seconds (10-86400). Default 10
`EEEEEE`	**MPA Delay Timeout, T14.** In Seconds (10-86400). Default 10
`FFFFFF`	**HPA Transmit Timeout, T15.** 0=Infinity; Else in Seconds (10-999990). Default 0
`GGGGGG`	**MPA Transmit Timeout, T16.** 0=Infinity; Else in Seconds (10-999990). Default 120
`HHHHHH`	**HPA Query Timeout, T17.** In Seconds (10-3600). Default 60
`III`	**HPA Transmit Attempts, N5.** 0=Until T15 Expires; 1-255=Number of Tx Attempts before T15 expires. Default 0.
`JJJ`	**MPA Transmit Attempts, N6.** 0=Until T16 Expires; 1-255=Number of Tx Attempts before T16 expires. Default 0
`KKK`	**LPA Transmit Attempts, N7.** 0=Until T3 Expires; 1-255=Number of Tx Attempts before T3 expires. Default 0
`L`	**Ignore HPA.** 0=Do NOT Ignore; 1=Ignore. Default 0
`M`	**Ignore MPA.** 0=Do NOT Ignore; 1=Ignore . Default 0
`N`	**Ignore LPA.** 0=Do NOT Ignore; 1=Ignore. 0
`PPPPPPPP`	**Security Password.** Always 8 alphanumeric characters, UPPER CASE ONLY. . Default 00000000
`YYYYYYYY`	**Unit ID.** Always 8 alphanumeric characters, UPPER CASE ONLY
`ZZ`	**Checksum.**

Table 27, SET_VAM_APP_CONFIG Message

Query Messages

QUERY_CONFIG

This QUERY_CONFIG message is used by the server application to request the TrimTrac locator send its TrimTrac Application, GPS or Communication parameters in the appropriate RESP_APP_CONFIG, RESP_PROV_CONFIG or RESP_GPS_CONFIG message.

>QTKA;PW=PPPPPPPP;ID=YYYYYYYY;*ZZ<	
A	**TrimTrac Configuration Set**: 'G' = GPS Parameters 'A' = Application Parameters 'V' = Provisioning Parameters
PPPPPPPP	**Security Password.** Always 8 alphanumeric characters, UPPER CASE ONLY. . Default 00000000
YYYYYYYY	**Unit ID.** Always 8 alphanumeric characters, UPPER CASE ONLY
ZZ	**Checksum.**

Table 28, QUERY_CONFIG Message

QUERY_LOG

This message is used by the server application to request Report Sequence Number past REPORT_POS or STATUS_MSG messages that may not have been received at the server application. The TrimTrac locator will send the corresponding messages to the server application in response to this message at the rate of REPORT_POS or STATUS_MSG per message. At the end of the messages a RESP_QUERY_LOG or RESP_QUERY_AGGR is sent.

`>QTKABBBBCCCC[DE[FGHIJJJK[LLLLMMMMM[NNNNOOOOOO]]]];PW` `=PPPPPPPP;ID=YYYYYYYY;*ZZ<`
`A`	**Always 'R':** Indicates a query for old REPORT messages
`BBBB`	**Beginning Protocol Sequence Number.** 16-bit Hex (0000-FFFF) incrementing by 1 for each logged report.
`CCCC`	**Ending Protocol Sequence Number.** 16-bit Hex (0000-FFFF) incrementing by 1 for each logged report
`PPPPPPPP`	**Security Password.** Always 8 alphanumeric characters, UPPER CASE ONLY. . Default 00000000
`YYYYYYYY`	**Unit ID.** Always 8 alphanumeric characters, UPPER CASE ONLY
`ZZ`	**Checksum.**
`Optional`	
`D`	**Aggregate Log Reporting Flag**: 'T' = enabled, 'F' = disabled. When enabled, aggregate reports may be returned.
`E`	**Stop RESP_QUERY_LOG** message from being sent: 'T' = do not send, 'F' = send. Used to stop the unit from fulfilling previous QUERY_LOG requests.
`F`	**Filter 1:** 'Z' = All, 'U' = Unsent only.
`G`	**Filter 2:** 'Z' = All, 'P' = Position only, 'S' = Status only.
`H`	**Filter 3:** 'Z' = All, 'A' = Alert only
`I`	Time range: 'Z' = Unused, 'N' = Newest, 'O' = Oldest
`JJJ`	Maximum Number of Messages to be sent in response to the current QUERY_LOG message. If non-zero then this limits the total number of message that can be sent from the log. If zero then the number of messages sent from the log has no limit. Applicable if Time range is not 'Z'.
`K`	**Last Message:** '1' = automatically include the last message in the log regardless of the filter settings, '0' = don't automatically include the last message in the log.
`LLLL`	**GPS week number of starting date**
`MMMMM`	**GPS seconds into week of starting date**.
`NNNN`	**GPS week number of ending date.** 'Most recent' if not present.
`OOOOOO`	**GPS seconds into week of ending date.** 'Most recent' if not present.

Table 29, QUERY_LOG Message

QUERY_POSITION

This message is used to command the TrimTrac device to report either its current or its most recently logged position.

The unit will compute and report new position fix if the QUERY_POSITION Operation Mode is set "S=Compute" and there has been motion since the last position fix. The unit will respond by sending a new REPORT_POS message (with TriggerType set to '3'=Query); provided, however, that the TrimTrac locator was able to compute a new position fix prior to expiration of the GPS Fix Timeout specified in the QUERY_POSITION message.

The unit will send a single SMS message containing a new STATUS_MSG and the most recently logged REPORT_POS if:

      1.   1.   The QUERY_POSITION has the Operation Mode set 'L'=Logged; OR

      2.   The QUERY_POSITION has the Operation Mode set 'S'=Compute, but there has been no motion since the last logged position (i.e. Position Aged is set 0); OR

      3.   The QUERY_POSITION has the Operation Mode set 'S'=Compute and there has been motion since the last logged position (i.e. Position Aged is set 1), but the unit was unable to compute a new position fix prior to expiration of the GPS Fix Timeout specified in the QUERY_POSITION message.

The new STATUS_MSG will have the TriggerType set to "3"=Query and the Position Aged flag will be set '1'=Aged if there has been motion since the last logged position.

>QTKABCCCC;PW=PPPPPPPP;ID=YYYYYYYY;*ZZ<	
A	**Always 'D'**
B	**Position Query Mode.** S=Compute and report current position; L=Status Report with Last logged position
CCCC	**Position Query Fix Timeout.** In Seconds (10-3600). Note: Temporarily overrides current FIX Timeout, T2, if Position Query Mode set to "S=Compute" and report current position. Settings longer than 600 minutes are generally not recommended. No default value.
PPPPPPPP	**Security Password.** Always 8 alphanumeric characters, UPPER CASE ONLY. . Default 00000000
YYYYYYYY	**Unit ID.** Always 8 alphanumeric characters, UPPER CASE ONLY
ZZ	**Checksum.**

Table 30, QUERY_POSITION Message

Position, Status and Response Messages

REPORT_POS and STATUS_MSG

These two messages are the most common. The difference between the REPORT_POS and STATUS_MSG is that the REPORT_POS message contains position information. STATUS_MSG does not contain any position.

>RTKABBBBCDDDEFFFFGGGGGGSTVOPQRUUUUU[HHHIIIIIIIJJJJKKK KKKKLLLLLLLMMMNNN];ID=YYYYYYYY;*ZZ<	
A	**TrimTrac Report Type:** 'P' = Position Report 'S' = Status Report
BBBB	**Protocol Sequence Number.** 16-bit Hex (0000-FFFF) incrementing by 1 for each logged report.
C	**TriggerType** 0=IDLE Timeout, T1 1=Motion Detected 2=Alert (VAM-Only) 3=Query 4=Scheduled Report
DDD	**Battery Level.** 0-100%.
E	**Battery Changed Flag.** T=True F=False
FFFF	**GPS Week Number.** Always 4 Digits
GGGGGG	**GPS Seconds into Week.** Always 6 Digits.
S	**GPS Status Code.** 0=3D GPS Fix 1=2D GPS Fix 2=Fix Timeout, 0 SVs 3=Fix Timeout, 1 SV 4=Fix Timeout, 2 SVs 5=Fix Timeout, 3 SVs 6=GPS Error 7=No Fix attempted
T	**GSM Status Code** 0=Network Available 1=Message Logged (i.e. Report Delay Flag set=1) 2=Network Timeout 3=SIM Error / No SIM 4=SIM PIN Error 5=Pre-TX log (Low battery)
V	Position Age: 0=Current (i.e. no motion since last position) 1=Aged (i.e. motion has occurred since last position)
O	HPA Status: 0=Normal; 1=Activated; 2=Sent; 3=Acknowledged
P	MPA Status: 0=Normal; 1=Activated; 2=Sent; 3=Acknowledged
Q	LPA Status: 0=Normal; 1=Activated; 2=Sent; 3=Acknowledged
R	External Power: 0=Bad (Below 5 VDC); 1=Good (5 VDC or higher)
UUUUU	Reserved for future use
YYYYYYYY	**Unit ID.** Always 8 alphanumeric characters, UPPER CASE ONLY
ZZ	**Checksum.**

	Optional (Provided only if Position Report)
HHH.IIIIIII	**Latitude.** WGS-84 Coordinates. Units of Degrees to 7 decimal places plus '+' sign = North and '-' = South. (-90.0000000 to +90.0000000)
JJJJ.KKKKKKK	**Longitude.** WGS-84 Coordinates. Units of Degrees to 7 decimal places plus '+' sign = East and '-' = West. (-180.0000000 to +180.0000000)
LLLLLL	**Altitude.** WGS-84 Altitude reference to MSL. In Feet, always 5 Digits plus sign (-99999 to +99999)
MMM	**Horizontal Speed.** Miles Per Hour. Always 3 Digits.
NNN	**Heading.** Relative to True North, increasing Easterly. Units of Degrees. Always 3 Digits. (000-359).

Table 31, REPORT_POS and STATUS_MSG Messages

Each new outbound REPORT_POS and STATUS_MSG message is given a Report Sequence number. The sequence number is 16 bits and increments by one with each message created and rolls over to 0000 once the maximum 16 bit value of FFFF is reached. The TrimTrac Application saves the message in non-volatile memory each time one is created; this is called the Message Log. The Message Log is a FIFO log of the last 128 REPORT_POS or STATUS_MSG messages (whether transmitted or only logged) such that when it is full the oldest one is deleted. The Message Log can be queried with the QUERY_LOG message from the server application.

RESP_ALERT_STATE

This message is sent by the TrimTrac locator after a SET_ALERT_STATE request is received and processed.

>RTKABCD;ID=YYYYYYYY;*ZZ<	
A	**Always 'L':** Indicates operation mode setting
B	**HPA Status.** 0=Normal; 1=Activated; 2=Sent; 3=Acknowledged
C	**MPA Status.** 0=Normal; 1=Activated; 2=Sent; 3=Acknowledged
D	**LPA Status.** 0=Normal; 1=Activated; 2=Sent; 3=Acknowledged
YYYYYYYY	**Unit ID.** Always 8 alphanumeric characters, UPPER CASE ONLY
ZZ	**Checksum.**

Table 32, RESP_ALERT_STATE Message

RESP_APP_CONFIG

This is the response message to the SET_APP_CONFIG and QUERY_CONFIG messages containing the Application Parameter values.

>RTKABBBBBBCCCCCCDDDDDDEEEEEEFFFFFFGGGTTHIJKLLLLMMMMMMNP P;ID=YYYYYYYY;*ZZ<	
A	**TrimTrac Configuration Set:** 'A' = Application Parameters
BBBBBB	**IDLE Timeout, T1.** In seconds (10 – 999990)
CCCCCC	**FIX Timeout, T2.** In seconds (10 – 3600)
DDDDDD	**TRANSMIT Timeout, T3.** In seconds (10 – 3600)
EEEEEE	**DELAY Timeout, T4.** In seconds (10 – 86400)
FFFFFF	**QUERY Timeout, T5.** In seconds (10 – 3600)
GGG	**Almanac Timeout, T6.** In hours (10 – 990)
TT	**IDLE Wakeup Motion Timeout, T7.** In seconds (0 – 90). Note: T7 is used exclusively while in the IDLE state; however, it is superseded by the Rolling Motion Window, T21, whenever IDLE State Polling Mode is set "2=OnDemand" OR while IDLE State Polling Cycle Duration, T20, is running due to IDLE State Polling Mode being set "1=Cycled". WARNING: IDLE Wakeup Motion Timeout, T7, must always be set greater than or equal to IDLE Wakeup Motion Second Count; else unit may not exit IDLE state due to motion.
H	**Motion Report Flag.** 0=None; 1=Report Motion in IDLE (before attempting new GPS fix
I	**Report Delay Flag.** 0=Transmit All Messages; 1=Transmit NO Messages; 2=Transmit Motion-related Messages-only; 3= Transmit IDLE Timeout, T1 Status Messages-only
J	**Diagnostics Mode.** 0= None; 1= LED
K	**Communication Mode.** 0= SMS; 1= Future
LLLL	Battery Change Week.
MMMMMM	Battery Change Seconds into Week.
N.PP	Firmware version number.
YYYYYYYY	**Unit ID.** Always 8 alphanumeric characters, UPPER CASE ONLY
ZZ	**Checksum.**

RESP_EXT_APP_CONFIG

This is the response message to the SET_EXT_APP_CONFIG and QUERY_CONFIG message containing the Extended Application Parameter values.

>RTKABCCCCCCDEFFFFFFGGGGGGHIJJJKKKLLMMNNO;ID=YYYYYYYY; *ZZ<	
A	**TrimTrac Configuration Set**: 'X' = Extended Application Parameters
B	**Scheduled Reporting** Mode. 0=None; 1=Daily; 2=Weekly
CCCCCC	**Scheduled Report Time, T18**. In Seconds (0-604799). Note: This is either the seconds into the day or into the week for the device to schedule a report when this feature is enabled. If Scheduled Reporting Mode is set "0=None", then enter 0.
D	**DELAY State Polling** Mode. 0=Disabled; 1=OnDemand. Note: If set to "1=OnDemand", the unit is able to receive and process SMS commands during the QUERY and DELAY states.
E	**IDLE State Polling Mode.** 0=Disabled; 1=Cycled; 2=OnDemand. Default 0. Note: DELAY State Polling Mode is treated as always "1=Enabled" when IDLE State Polling Mode is set to "2=OnDemand".
FFFFFF	**IDLE State Polling Cycle** Interval, **T19.** In Seconds (10-999990). Note: Determines the interval at which the IDLE State Polling Cycle Duration, T20, timer is started if and only if the IDLE State Polling Mode is set to "1=Cycled". WARNING: IDLE State Polling Cycle Interval, T19, must always be set greater than IDLE State Polling Cycle Duration, T20, or QUERY Timeout, T5, whichever applies. Default 3600. Note: Determines the frequency at which the QUERY state is enabled while in the IDLE state if and only if the IDLE State Polling Mode is set to "1=Cycled".
GGGGGG	**IDLE State Polling Cycle Duration, T20.** In Seconds (0, 10-3600). Note: Determines how long the unit is able to receive and process SMS messages each time IDLE State Polling Cycle Interval, T19, expires. A value of zero causes the QUERY Timeout, T5, value to be used WARNING: IDLE State Polling Cycle Interval, T19, must always be set greater than IDLE State Polling Cycle Duration, T20, or QUERY Timeout, T5, whichever applies. Default 60.
H	**Query Hold Flag.** 0=Disabled; 1=Enabled. Note: Unit attempts to reconnect to the GSM network if the connection is lost during the QUERY state prior to the expiration of QUERY Timeout, T5.
I	**DELAY State Extended Motion Detection.** 0=Disabled; 1=Enabled. Note: Allows the unit to filter spurious motion detections in DELAY state when set to "1=Enabled". The unit does not power off during DELAY state and power consumption will increase.
JJJ	**Position Report Transmit Attempts,** N1. 0=Until T3 Expires; 1-

	255=Number of Tx Attempts.
KKK	**Status Message Transmit Attempts,** N2**.** 0=Until T3 Expires; 1-255=Number of Tx Attempts.
LL	**IDLE Wakeup Motion** Second Count**.** In Seconds (1-90). Note: This parameter is used only while IDLE Wakeup Motion Timeout, T7, is running. It is superseded by Rolling Motion Second Count whenever IDLE State Polling Mode is set "2=OnDemand" OR while IDLE State Polling Cycle Duration, T20, is running due to IDLE State Polling Mode being set "1=Cycled". WARNING: IDLE Wakeup Motion Second Count must always be set equal to or less than IDLE Wakeup Motion Timeout, T7; else unit may not exit IDLE state due to motion. Default 1.
MM	**Rolling Motion Window, T21.** In Seconds (1-90). Note: T21 applies in all states except IDLE and FIX; provided, however, that is also automatically enabled for IDLE state whenever IDLE State Polling Mode is set "2=OnDemand" OR when IDLE State Polling Cycle Duration, T20, is running due to IDLE State Polling Mode being set "1=Cycled". WARNING: Rolling Motion Window, T21, must always be set equal to or greater than Rolling Motion Second Count; else the unit may not exit QUERY state. Default 20.
NN	**Rolling Motion Second** Count**.** In Seconds (1-90). Note: This parameter is enabled only when Rolling Motion Window, T21, is active. Default 10.
O	**Motion Override.** 0=Normal; 1=Motion Always; 2=Motion Never. Note: Overrides the motion sensor if set to a value other than "0=Normal". If set to "1=Motion" Always, then the TrimTrac locator will override the motion sensor such that the unit operates as if motion is always present. If set to "2=Motion Never", then the TrimTrac locator will ignore all motion and never generate a fix until the configuration is changed or otherwise commanded to do so (see QUERY_POSITION message). Default 0.
YYYYYYYY	**Unit ID.** Always 8 alphanumeric characters, UPPER CASE ONLY
ZZ	**Checksum.**

Table 34, RESP_EXT_APP_CONFIG Message

RESP_GPS_CONFIG

This is the response message to the SET_GPS_CONFIG and QUERY_CONFIG message containing the GPS Configuration.

>RTKABBCCCDDDEEEF;ID=YYYYYYYY;*ZZ<	
A	**TrimTrac Configuration Set:** 'G' = GPS Parameters
BB	**GPS Elevation Mask.** In degrees (0-30)

CCC	**GPS PDOP Mask.** In tenths of PDOP (60 – 200)
DDD	**GPS PDOP Switch.** In tenths of PDOP (40 – 120)
EEE	**GPS Signal Level.** In tenths of AMUs (10 – 80)
F	**GPS Dynamics Mode.** 5=Automobile
YYYYYYYY	**Unit ID.** Always 8 alphanumeric characters, UPPER CASE ONLY
ZZ	**Checksum.**

Table 35, RESP_GPS_CONFIG Message

RESP_PROV_CONFIG

This is the response message to the SET_PROV_CONFIG and QUERY_CONFIG message containing the provisioning information.

>RTKABBBBBBBBBBBBBBBBBBBBBBBB;ID=YYYYYYYY;*ZZ<	
A	**TrimTrac Configuration Set:** 'V' = Provisioning Parameters
BBBBBBBB BBBBBBBB BBBBBBBB	**Destination Address.** 24 characters including international dialing "+" sign and country code. Field padding in spaces before the international dialing "+" sign
YYYYYYYY	**Unit ID.** Always 8 alphanumeric characters, UPPER CASE ONLY
ZZ	**Checksum.**

Table 36, RESP_PROV_CONFIG Message

RESP_QUERY_AGGR

This message is sent by the TrimTrac locater after a QUERY_LOG request is received and processed, and if Aggregate Log Reporting Flag is 'enabled'. It will contain messages in aggregated format as shown below. The entire message can be no more than 160-byte SMS message.

>RTKA{B};ID=YYYYYYYY;*ZZ<	
A	'1' to '4': Indicates number of REPORT_POS messages contained in this RESP_QUERY_AGGR message.
B	Message fields from Report Type to the first semi-colon (excluded).
YYYYYYYY	**Unit ID.** Always 8 alphanumeric characters, UPPER CASE ONLY
ZZ	**Checksum.**

Table 37, RESP_Query_AGGR Message

RESP_QUERY_LOG

This message is sent after a QUERY_LOG request is received and processed. It will contain the number of messages actually retrieved from the Message Log and sent to the server application.

`>RTKABBBB;ID=YYYYYYYY;*ZZ<`	
`A`	Always 'R': Indicates a response to a QUERY_LOG
`BBBB`	Number of message sent from the log.
`YYYYYYYY`	**Unit ID.** Always 8 alphanumeric characters, UPPER CASE ONLY
`ZZ`	**Checksum.**

Table 38, RESP_QUERY_LOG Message

RESP_VAM_APP

This is the by the TrimTrac locator in response to the SET_VAM_APP_CONFIG and QUERY_CONFIG message.

`>RTKABBBBBBCCCCCCDDDDDDEEEEEEFFFFFFGGGGGGHHHHHHIIIJJJK KKLMN;ID=YYYYYYYY;*ZZ<`	
`A`	**VAM-only Configuration Set:** 'Y' = VAM-only Parameters
`BBBBBB`	**HPA Idle Timeout, T11.** In Seconds (10-999990)
`CCCCCC`	**MPA Idle Timeout, T12.** In Seconds (10-999990)
`DDDDDD`	**HPA Delay Timeout, T13.** In Seconds (10-86400)
`EEEEEE`	**MPA Delay Timeout, T14.** In Seconds (10-86400)
`FFFFFF`	**HPA Transmit Timeout, T15.** 0=Infinity; Else in Seconds (10-999990)
`GGGGGG`	**MPA Transmit Timeout, T16.** 0=Infinity; Else in Seconds (10-999990)
`HHHHHH`	**HPA Query Timeout, T17.** In Seconds (10-3600)
`III`	**HPA Transmit Attempts,** N5. 0=Until T15 Expires; 1-255=Number of Tx Attempts before T15 expires
`JJJ`	**MPA Transmit Attempts,** N6. 0=Until T16 Expires; 1-255=Number of Tx Attempts before T16 expires
`KKK`	**LPA Transmit Attempts,** N7. 0=Until T3 Expires; 1-255=Number of Tx Attempts before T3 expires
`L`	**Ignore HPA.** 0=Do NOT Ignore; 1=Ignore
`M`	**Ignore MPA.** 0=Do NOT Ignore; 1=Ignore
`N`	**Ignore LPA.** 0=Do NOT Ignore; 1=Ignore
`YYYYYYYY`	**Unit ID.** Always 8 alphanumeric characters, UPPER CASE ONLY
`ZZ`	**Checksum.**

Table 39, RESP_VAM_APP Message

Technical Tips and Troubleshooting

Introduction

The TrimTrac locator is designed to operate in the conditions outlined in the Specifications chapter on page 83.

When used and maintained properly, the TrimTrac locator provides years of trouble-free service. The TrimTrac locator has no user-serviceable parts other than its replaceable batteries.
Should the TrimTrac locator fail to operate properly, the user or service technician should troubleshoot the installation before returning any components for repair. If a component fails, return the TrimTrac locator to the authorized Service and Repair Center for repair.

This chapter provides some guidelines for troubleshooting common problems associated with the TrimTrac locator's operation. Potential operating problems might include:

>   Dead Batteries
>
>   Poor contact between the Battery Pack and TrimTrac
>
>   Poor GPS reception
>
>   Poor GSM coverage
>
>   Communication failure with base
>
>   TrimTrac locator Application programming errors

If the TrimTrac locator continues to operate poorly after you follow the troubleshooting guidelines described in this chapter, contact your TrimTrac locator supplier for assistance.

Battery Problems

Make sure your batteries are generating sufficient current to power your TrimTrac locator. Make sure the Battery Module is securely snapped into place and the cover screw is properly tighten.

GPS Reception Problems

Even though the TrimTrac locator uses enhanced GPS sensitivity technology, it is still advisable to position the device with as clear of a view of the sky as possible. Make sure that the TrimTrac locator is reasonably positioned to receive GPS signals.

GPS Almanac Collection

When the TrimTrac locator is used for the first time after being provisioned, the unit may not have a complete or current GPS almanac. The unit is allowed up to 15 minutes to collect an almanac after it has computed its first fix. In other words, the TrimTrac locator can dwell in the FIX state for up to 15 minutes plus T2 seconds before transitioning to the STATUS state. This will occur whenever the almanac is either incomplete or out of date (i.e. more than T6 seconds old). During this almanac collection process, users may notice that it takes longer than usual for the unit to transition through the FIX state. Under normal conditions, it may take on average 45-60 seconds to get a GPS position fix and complete the FIX state; however, this compares to as long as 20 minutes (15 minutes plus 5 minute default T2). To facilitate the process of almanac collection, it is recommended that the TrimTrac be placed in an area with a clear view of the sky and not be moved until it has completed its first FIX state.

Location

The TrimTrac locator should be installed as close as possible to horizontal plane, preferably with a reasonably clear view of the horizon and sky. If something on the vehicle—for example, the air conditioning unit on a cab or the trailer connected to a tractor—blocks a significant portion of the horizon and the GPS signals, the GPS receiver will take longer to acquire enough satellites for a position fix. If the TrimTrac locator frequently times out before completing a position fix, try moving the TrimTrac locator to a new location where it is not blocked as much.

GPS Jamming

The TrimTrac locator should be installed as far away as possible from transmitting antennas, including satellite communication, radar, VHF and cellular. These transmitters may emit jamming signals that interfere with the GPS receiver's ability to track GPS satellite signals. Generally, the stronger the other transmitting device, the wider the distance required between antennas. For the TrimTrac locator, Trimble recommends a minimum clearance of 46 cm (approximately 18 in.) from these transmitting devices.

Land-based transmitters, including microwave and television transmitters, can also interfere with GPS reception. If the TrimTrac locator is operating near an antenna farm, the TrimTrac locator may temporarily lose GPS reception while in the vicinity of the transmitters. Reception should return once the TrimTrac locator moves away from the transmitters. If your GPS signals are being jammed and moving does not correct the situation, the source of the jamming signal may be another antenna mounted too close to your TrimTrac locator. If possible, turn off the equipment using other nearby antennas to see if this corrects the problem. If turning off nearby equipment un-jams your GPS signals, you need to relocate one or more of the jamming antennas.

Poor GSM Coverage

Check to make sure the SIM is not missing or incorrectly installed, or the PIN number configured in the TrimTrac does not match the PIN in the SIM. Do the following:

1. Insert a SIM if none is present.

2. Remove and reinsert the existing SIM to verify proper installation.

3. Check the TrimTrac locator configuration to ensure the correct PIN is programmed.

4. Make sure that the SIM card hold-down latch is securely fasten and all four corners are locked down.

TrimTrac Locator Location

The TrimTrac locator should be used as close as possible to horizontal plane, preferably with reasonably unobstructed clearance around the unit. If the current location is suspect:

Try another location; and/or

Try a known-good TrimTrac locator or mobile phone

Even in areas with strong GSM service, there may be pockets where GSM service is poor or nonexistent due to how the carrier builds the network. Contact your local service provider for information on GSM coverage.

How to Evaluate TrimTrac Placement

The number one rule in GPS is that a GPS receiver with a clear view of the sky will have better performance than one that has a blocked view. For instance, a TrimTrac locator placed on the dashboard of a vehicle will almost certainly have more GPS fixes than a unit placed under the seat or in the glove box, everything else being equal. The real question is whether the TrimTrac locator will provide the level of performance required to meet the needs of the application.

The answer to this question is best derived from field-testing of the specific vehicle and placement options. The test plan should call for one unit on the dashboard with a clear view of the sky and at least one unit for each of the alternate locations of interest. For example, if one wishes to evaluate the relative performance of placing units in the glove box and under the front seat, then a minimum of three units, all identically configured, is needed. One unit would be placed on the dashboard, one in the glove box and one under the front seat.

To maximize the amount of data, we recommend using the factory default configuration, except the DELAY Timeout, T4, should be set to the minimum of 10 seconds. If an active SIM card is inserted in the TrimTrac, then this will result in a new message being logged every 3 to 4 minutes for the dashboard unit (See Figure 6, Expected Reporting Frequencies). If no SIM card is inserted, then the TRANSMIT and QUERY states are skipped, resulting in more frequent message logging.

The vehicle should be operated as one would expect in the actual application environment. The data logged by the dashboard TrimTrac will provide a performance baseline against which the other units will be compared. The analysis should compare the number of attempted position fixes versus the number of successful position fixes during the test period by unit.

In general, testing done to date indicates that a unit located in the glove box will on average get approximately 50% fewer position fixes than a unit located on the dashboard of the vehicle. Units placed under the front seat will performance about the same as units placed in the glove box unless the seat is a power seat. Power seats have considerably more metal than manually adjusted seats and the added metal attenuates the GPS signal that much more. It is not recommended that units be placed in the trunk of standard 3-box style sedans. Reasonable results may, however, be achieved in hatchback cars with a large, rearward slopping back window and non-metal rear package shelf.

GSM Jamming

The TrimTrac locator should be installed as far away as possible from other transmitting antennas including other TrimTrac locators, satellite communication, radar, and VHF radio. These transmitters may emit jamming signals that interfere with the GSM phone's ability to track the GSM signal. If there are other transmitting antennas located on the vehicle, try moving the TrimTrac locator farther away from these antennas. Generally, the stronger the other transmitting device, the wider the distance required between antennas.

No Data Communication with Base

If the TrimTrac is not communicating with the server application as expected, do the following:

1. Confirm that a SMS-enabled SIM is inserted in the unit and that the hold down latch is pressed all the way down and securely holding the SIM card at all four corners.

2. Confirm proper provisioning, including Unit ID, Destination Address, Security Password, and, if needed, SIM PIN;

3. Verify that the unit has its application parameters configured as desired. Pay particular attention to the Report Delay Flag, QUERY

Timeout, T5, and TRANSMIT Timeout, T3, settings. Default settings for QUERY Timeout, T5, and TRANSMIT Timeout, T3, are recommended.

4. Set the Diagnostics Mode to "1=Enabled" and observe the LED to confirm that the unit properly enters the TRANSMIT and QUERY states.

5. Use the AT+CTKO? command with a provisioning module to review logged messages while paying particular attention to the GSM Status field.

Base Modem Configuration

Consult your modem manual for configuration instructions. Each modem manufacturer has its own settings and control commands. Verify that your configuration, PIN numbers, and so on, are correct.

Defective TrimTrac Locator

To confirm that a TrimTrac locator is defective, do the following:

1. Try a known good TrimTrac locator.

2. Move into an area with strong GSM coverage.

3. Send the TrimTrac locator an SMS message requesting a response.

Note – Before returning the TrimTrac locator, be sure to save the TrimTrac locator's configuration settings, and remove your SIM.

No Modem Connection with Server Application

If it appears that you have no modem connection with the Server Application, confirm that the Server Application modem is configured correctly and that the TrimTrac locator is configured and operating correctly. Do the following:

1. Check to see if the Destination Address is programmed correctly.

2. Verify the Server Application software is calling the correct TrimTrac locator telephone number and using the correct Unit ID, Security Password and, if required by the SIM card, the SIM PIN.

TrimTrac Not Reporting

If it appears that the TrimTrac locator is not reporting to the server application as expected, diagnose as follows:

1. **Configuration.** Always confirm whether the TrimTrac locator is configured as appropriate for the particular application environment. More specifically, confirm that the provisioning parameters are correct. Correct and re-test as necessary.

2. **Lost Reports.** In this case, the TrimTrac locator has successfully created a new message (Position, Status, or Alert) and it has been sent to the GSM network. If such sent messages are not received by the

server application, then perhaps there is insufficient GSM coverage and/or the messages are getting lost in the GSM network.

Review the TrimTrac locator message log and Report Sequence Numbers compared to those received by the server application. If there are missing on inconsistent Report Sequence Numbers at the server application vis-à-vis the messages logged within the TrimTrac, then a problem associated with the GSM network is the likely culprit;

3. **Unsent Reports.** If the TrimTrac locator is correctly generating position and status messages as expected (as determined by reviewing the message log using the AT+CTKO? command with a provisioning module), then the reports may not be getting sent due to: no available GSM network, no SIM installed, or the Report Delay Flag is set to something other than "0=Transmit All Messages". (Note the Report Delay Flag has no effect on the sending of Alert messages);

4. **No Reports Generated.** The TrimTrac locator is expected to spend a majority of its time in either the IDLE or DELAY states, during which the unit will not send any messages until motion causes a transition, the appropriate RTC-based timeouts have expired, or if an Alert condition occurs. Another possible cause would be the motion detector and associated latches may not be recognizing Motion; in which case, the unit may dwell in IDLE until the IDLE Timeout, T1, expires even though there may have been Motion in the mean time. If missed motion is suspected, the sensitivity of the motion detector can be manipulated by adjusting IDLE Wakeup Motion Timeout, T7 and the associated IDLE Wakeup Motion Second Count settings and/or, if DELAY State Extended Motion Detection is set "1=Enabled", by adjusting the Rolling Motion Window, T21, and Rolling Motion Second Count. Generally speaking, increasing the ratio between IDLE Wakeup Motion Timeout, T7 and the associated IDLE Wakeup Motion Second Count will increase the motion detector sensitivity in the IDLE state; provided, however, that IDLE Wakeup Motion Timeout, T7, is not set to "0". If IDLE Wakeup Motion Timeout, T7, is set to "0", then the IDLE Wakeup Motion Second Count setting is ignored and the motion detector is undampened.

Unit Does Not Report Stopped Position

In its default configuration, the TrimTrac locator will attempt one additional position fix after the unit has come to rest. If, however, the unit is in a vehicle that has come to rest in a covered parking structure or garage, there may be insufficient GPS signal to compute a final position fix. The device will log a Status Message, but a new Position Report may not be available. In application server-based geo-fence applications, this may be problematic in that the application server will not know whether the device has entered the geo-fence area.

Continued Reporting After Coming to Rest

In the event a TrimTrac locator continues to report after coming to rest, it may be because the motion detector is overly sensitive for the given application environment. Fine tuning of the motion detector settings is achieved by changing the motion timeout and second count settings. These configuration parameters include the IDLE Wakeup Motion Timeout, T7, and associated IDLE Wakeup Motion Second Count and, if DELAY State Extended Motion Detection is set "1=enabled", the Rolling Motion Window, T21 and its associated Rolling Motion Second Count setting.

Server Application Software

Confirm the proper Server Application software setup. The Server Application software may not be correctly integrated with the TrimTrac locator. Contact your software vendor for assistance.

Verify Checksums when Analyzing Data

An easy way to analyze data received from The TrimTrac locator is to log the actual messages into a text file and verify that the messages are valid by checking the checksums. Available from www.trimtrac.com is a simple checksum checker executable that can be run against a text file containing messages sent from a TrimTrac locator. If the checksum contained in the message is "Bad" then the program will indicate it as "BAD" and return what the correct checksum should have been. Verifying checksums helps avoid wasted time spent evaluating invalid messages.

Updating Firmware in the Field

You can upload new firmware from a PC or laptop connected to the Provisioning Module. For more information on updating firmware in the field, please consult with your Trimble technical support representative.

LED Indicator

The LED indicator is useful for diagnosing problems. For more information, see LED States, page 12. If you detect a problem, then have the TrimTrac locator inspected by qualified service personnel.

Responding to Query SMS messages

The TrimTrac locator processes and responds immediately to any SMS message that it receives while in the QUERY state. It does not need to cycle back through the State Machine before a response is sent back to the server application.

The TrimTrac locator, however, will not respond to SMS messages that are invalid (i.e. incorrect format, checksum, Unit ID, Security Password and, if used, SIM PIN).

Different network operators may also handled queued up SMS messages differently. For instance, if the TrimTrac happens not to be in the QUERY state

when the server application sends a SMS message, this SMS message will be held at the network operator's Short Message Service Center (SMSC) for future delivery. In some cases, the longer the SMS is held at the SMSC, the lower in the delivery priority the message may become. As a consequence, the SMSC may not send the queued SMS message before the QUERY Timeout, T5, has expired. Therefore, if it can be reasonably expected that an application will have extended periods of time between QUERY states, then extending the QUERY Timeout, T5, should be considered.

Reporting Frequency

As shown in Figure 6**Error! Reference source not found.**, the frequency at which the TrimTrac locator will report a position, while the unit is in motion, is largely determined by:

> DELAY Timeout, T4, setting
>
> GPS Signal Strength

To a lessor extent, the reporting frequency in influenced by whether a GSM network is available.

The time it takes for a TrimTrac locator to compute a new position fix is inversely proportional to available GPS signal level. When the TrimTrac locator has an unobstructed view of the sky, GPS signal strength is approximately –130 dBm. This would equate to approximately 40 seconds to compute a new position fix as shown in Figure 7, Warm Start TTFFs on page 82. For the most part, this is equivalent to the unit being placed on the dashboard or rear package shelf of a vehicle; provided, however, the the window has no metallized coatings that would attenuate the GPS signal.

A unit placed in the glovebox of a typical vehicle, on the other hand, may only see –136 dBm of GPS signal. In this circumstance, the unit may take upwards of 400 seconds to compute a new position fix and this assumes that objects, such as buildings and trees, outside of the vehicle, do not further obscure view of the sky.

TrimTrac
Placement vs. Reporting Frequency

Assumptions:
1) Constant Motion
2) Good GSM Coverage
3) Factory Default Configuration, except DELAY State Timeout, T4

DELAY State, T4 = 900 Seconds

DELAY State, T4 = 600 Seconds

DELAY State, T4 = 300 Seconds

DELAY State, T4 = 120 Seconds

DELAY State, T4 = 10 Seconds

On Seat

Glovebox

On Dashboard

Expected Reporting Frequency (Minutes)

GPS Signal Strength (dBm)

Obscured Sky View

Clear, Unobstructed Sky View
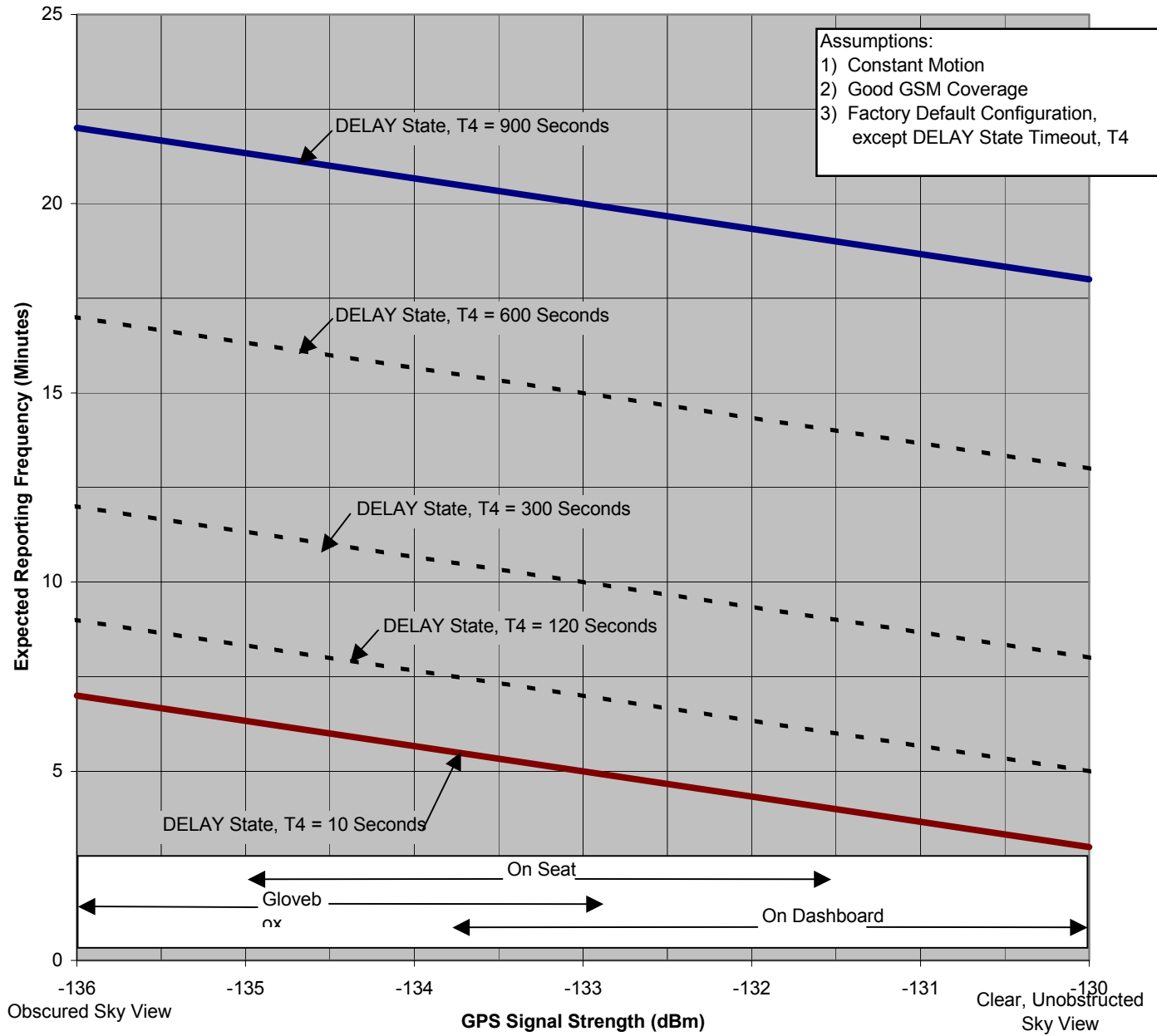
Figure 6, Expected Reporting Frequencies

TrimTrac

Typical GPS Fix Times
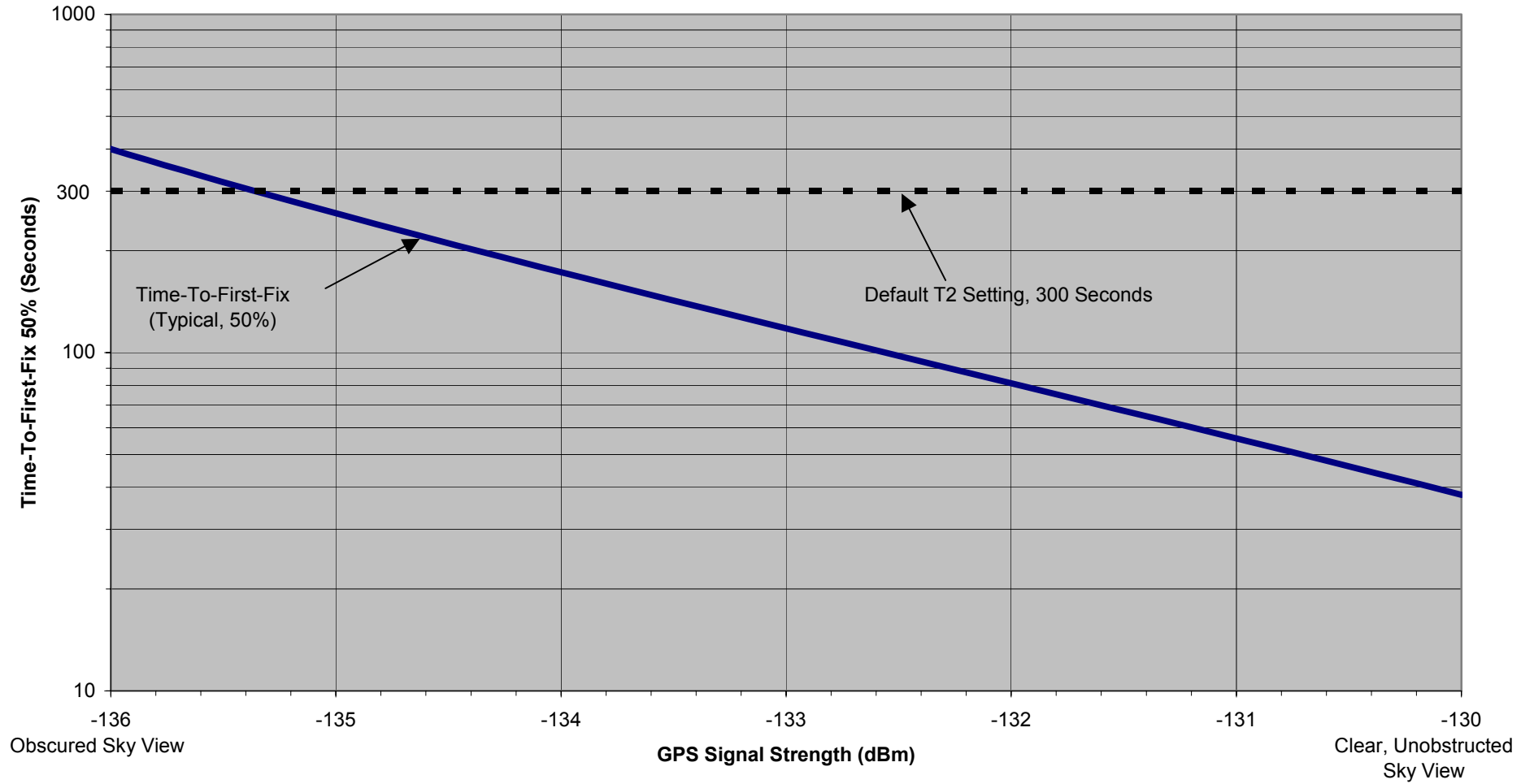**(Warm Start, 50%)**

Figure 7, Warm Start TTFFs

TrimTrac

Specifications

GSM Specifications

GSM 900/1800/1900 MHz

Normal MS – SMS Data Only
Class 4 (2W) @ 900 MHz
(EGSM)
Class 1 (1W) @ 1800 MHz
(GSM 1800) and 1900 MHz
(GSM 1900 PCS)

Subscriber Identity Module

1.8/3.0 Volt

Type Approvals

FCC Part 15, FCC Part 24
Industry Canada
CE MARK
EC R&TTE Type Examination

GPS Specifications

General

L1 (1575.42 MHz) frequency,
C/A code
12-Channels, 48 Correlators

Sensitivity

Minimum –136.0 dBm with
GSM coverage.

Accuracy

Horizontal: < 6 meters (50%)
Altitude: <11 meters (50%)

Acquisition

Signal Power   -130.0 dB -136.0 dB
Hot Start (50%)   <24 sec
Warm Start (50%)<38 sec <400 sec
Cold Start (50%) <90 sec

Dynamics

Acceleration: 4g (39.2 m/sec2)
Motional jerk: 20 m/sec3

Environmental Specifications

Temperature

Operating: -10°C to + 55°C

Humidity

5% to 95% RH non-
condensing @ +40oC

Vibration*

0.008 g2/Hz   5 Hz to 20 Hz
0.05g2/Hz   20 Hz to 100 Hz
-3 dB/octave 100 Hz to 900 Hz

Shock*

Operational: 40g for 11mSec
Non-operational:
            75g for 6 mSec

* = Requires Vehicle Adapter Module

Physical Specifications

Assembly

Injection molded plastic with
integrated battery pack

Size

143 mm x 76 mm x38 mm
5.78" x 2.99" x1.44"

Weight

205 grams (7.2 oz) not
including batteries

Bibliography

European Telecommunications Standards Institute (ETSI). ETSI is the standards body for GSM worldwide operations. Specifications on various aspects of GSM phone operations (AT commands, installation requirements, and terminology) are available for download from ETSI at: www.etsi.org

GPS, A Guide to the Next Utility, Trimble P/N 18239 (1992). A short, non-technical introduction to GPS. Explains what GPS does, how it works, and its capabilities and limitations. www.trimble.com

GSM Made Simple, by George Lamb published by Cordero Consulting and Regal Printing, Atlanta GA, 1997 (ISBN 0-966-57520-2).

GSM World. The GSM World site has information on the technical and business aspects of GSM. Contact information is available for GSM carriers as well as GSM hardware manufacturers. www.gsmworld.com

ICD-GPS-200. *NAVSTAR GPS Space Segment: Navigation User Interfaces*, drawing number ICD-GPS-200 (3 July 1991). The official definition of the data formats used in NAVSTAR GPS satellite signals. www.navcen.uscg.gov/gps

> Commanding Officer
> USCG NAVCEN
> 7323 Telegraph Road
> Alexandria, VA 22315
> 703-313-5900

Proceedings of the Institute of Navigation, Washington DC. A series of three volumes of papers describing GPS Theory published between 1980 and 1986 by the Institute of Navigation. Essential source material for system designers. www.ion.org

SAE J1455 Joint SAE/TMC Recommended Environmental Practices for Electronic Equipment Design (Heavy Duty Trucks). www.sae.org

Glossary

The Glossary defines technical terms and abbreviations used in this manual. It includes terms from the fields of wireless communications and GPS technology.

0D	Time only in GPS terminology.
2D	Two dimensions and time in GPS terminology.
3D	Three dimensions and time in GPS terminology.
2D	GPS Two-dimensional GPS position fix and time.
3D	GPS Three-dimensional GPS position fix and time.
Altitude	Height above mean sea level (MSL).
ASCII	American Standard Code for Information Interchange.
C/A	Coarse Acquisition code used to receive GPS signals with receivers designed operate using SPS (Standard Positioning Service).
Checksum	The message checksum field provides for a two-digit hexadecimal checksum value, which is computed by XOR'ing all characters from the beginning of the sentence up to and including the * character. The checksum is always the last element of the sentence before the message < delimiter. The use of checksums can help in instances where the communication channel is noisy.
ETSI	European Telecommunications Standards Institute.
GPS	Global Positioning System.
GSM	Global System for Mobile communications.
HPA	High Priority Alert
IMEI	International Mobile Equipment Identity.
IMSI	International Mobile Subscriber Identity.
Latitude	Latitude coordinate of position fix with positive value indicating North.
LED	Light-Emitting Diode.
Longitude	Longitude coordinate of position fix with positive value indicating East.
LPA	Low Priority Alert

MPA	Medium Priority Alert
PC	Windows (2000, XP)-compatible Personal Computer.
PCS	Personal Communications Service.
PIN	Personal Identity Number.
RF	Radio Frequency.
SIM	Subscriber Identity Module.
SMPP	Short Message Peer to Peer.
SMS	Short Message Service.
SPS	Standard Positioning Service.
TAIP	Trimble ASCII Interface Protocol.

Basic Feature Parameter Ranges and Default Settings

Parameter	Unit/Notes	Default
Unit ID	Unique unit identifier. Always 8 alphanumeric characters, UPPER CASE ONLY, and can only be changed using Provisioning Module.	00000000
Destination Address	Valid destination address for SMS messages must be entered prior to initial deployment. 24 characters including international dialing "+" sign and country code.	\<Empty\>
SIM PIN	Entered only if required by SIM card and can be entered or changed using Provisioning Module. If used, must be between 4 and 8 digits.	\<Empty\>
Security Password	Always 8 alphanumeric characters, UPPER CASE ONLY. Non-default entries can only be made using Provisioning Module.	00000000
IDLE Timeout, T1	In seconds (10 – 999990)	43200
FIX Timeout, T2	In seconds (10 – 3600)	300
TRANSMIT Timeout, T3	In seconds (10 – 3600)	120
DELAY Timeout, T4	In seconds (10 – 86400)	900
QUERY Timeout, T5	In seconds (10 – 3600)	60
Almanac Timeout, T6	In hours (10 – 990)	168
IDLE Wakeup Motion Timeout, T7	In seconds (0 – 90). Note: T7 is used exclusively while in the IDLE state; however, it is superseded by the Rolling Motion Window, T21, whenever IDLE State Polling Mode is set "2=OnDemand" OR while IDLE State Polling Cycle Duration, T20, is running due to IDLE State Polling Mode being set "1=Cycled". **WARNING:** IDLE Wakeup Motion Timeout, T7, must always be set greater than or equal to IDLE Wakeup Motion Second Count; else unit may not exit IDLE state due to motion.	15
Motion Report Flag	0=None; 1=Report Motion in IDLE (before attempting new GPS fix)	0
Report Delay Flag	0=Transmit All Messages; 1=Transmit NO Messages; 2=Transmit Motion-related Messages-only; 3= Transmit IDLE Timeout, T1 Status Messages-only	0
Diagnostics Mode	0= None; 1= LED	1
Communication Mode	0= SMS; 1= Future	0
GPS Elevation Mask	In degrees (0-30)	5
GPS Signal Level Mask	In tenths of AMUs (10 – 80)	10
GPS PDOP Mask	In tenths of PDOP (60 – 200)	120
GPS PDOP Switch	In tenths of PDOP (40 – 120)	60
GPS Dynamics Mode	5=Automobile	5

Table 40, Basic Feature Parameters and Defaults

Enhanced Feature Parameter Ranges and Default Settings

Parameter	Unit/Notes	Default
Scheduled Reporting Mode	0=None; 1=Daily; 2=Weekly	0
Scheduled Report Time, T18	In Seconds (0-604799). Note: This is either the seconds into the day or into the week for the device to schedule a report when this feature is enabled. If Scheduled Reporting Mode is set "0=None", then enter 0.	0
DELAY State Polling Mode	0=Disabled; 1=OnDemand. Note: If set to "1=OnDemand", the unit is able to receive and process SMS commands during the QUERY and DELAY states.	0
IDLE State Polling Mode	0=Disabled; 1=Cycled; 2=OnDemand. Notes: If set to "2=OnDemand", the unit is able to receive and process SMS commands at anytime during the QUERY, IDLE and DELAY states regardless of how the DELAY State Polling Mode is set. If IDLE State Polling Mode is set "1=Cycled", unit is able to receive and process SMS commands at anytime in QUERY and during IDLE while IDLE State Polling Cycle Duration, T20, is running and during DELAY if DELAY State Polling Mode is set to "1=OnDemand".	0
IDLE State Polling Cycle Interval, T19	In Seconds (10-999990). Note: Determines the interval at which the IDLE State Polling Cycle Duration, T20, timer is started if and only if the IDLE State Polling Mode is set to "1=Cycled". **WARNING**: IDLE State Polling Cycle Interval, T19, must always be set greater than IDLE State Polling Cycle Duration, T20, or QUERY Timeout, T5, whichever applies.	3600
IDLE State Polling Cycle Duration, T20	In Seconds (0, 10-3600). Note: Determines how long the unit is able to receive and process SMS messages each time IDLE State Polling Cycle Interval, T19, expires. A value of zero causes the QUERY Timeout, T5, value to be used **WARNING**: IDLE State Polling Cycle Interval, T19, must always be set greater than IDLE State Polling Cycle Duration, T20, or QUERY Timeout, T5, whichever applies.	60
Query Hold Flag	0=Disabled; 1=Enabled. Note: Unit attempts to reconnect to the GSM network if the connection is lost during the QUERY state prior to the expiration of QUERY Timeout, T5.	0

DELAY State Extended Motion Detection	0=Disabled; 1=Enabled. Note: Allows the unit to filter spurious motion detections in DELAY state when set to "1=Enabled". The unit does not power off during DELAY state and power consumption will increase.	1
Position Report Transmit Attempts, N1	0=Until T3 Expires; 1-255=Number of Tx Attempts	1
Status Message Transmit Attempts, N2	0=Until T3 Expires; 1-255=Number of Tx Attempts	1
IDLE Wakeup Motion Second Count	In Seconds (1-90). Note: This parameter is used only while IDLE Wakeup Motion Timeout, T7, is running. It is superseded by Rolling Motion Second Count whenever IDLE State Polling Mode is set "2=OnDemand" OR while IDLE State Polling Cycle Duration, T20, is running due to IDLE State Polling Mode being set "1=Cycled". **WARNING:** IDLE Wakeup Motion Second Count must always be set equal to or less than IDLE Wakeup Motion Timeout, T7; else unit may not exit IDLE state due to motion.	1
Rolling Motion Window, T21	In Seconds (1-90). Note: T21 applies in all states except IDLE and FIX; provided, however, that is also automatically enabled for IDLE state whenever IDLE State Polling Mode is set "2=OnDemand" OR when IDLE State Polling Cycle Duration, T20, is running due to IDLE State Polling Mode being set "1=Cycled". **WARNING:** Rolling Motion Window, T21, must always be set equal to or greater than Rolling Motion Second Count; else the unit may not exit QUERY state.	20
Rolling Motion Second Count	In Seconds (1-90). Note: This parameter is enabled only when Rolling Motion Window, T21, is active. WARNING: Rolling Motion Second Count must always be set equal to or less than the setting for Rolling Motion Window, T21; else the unit may not exit QUERY state.	10
Motion Override	0=Normal; 1=Motion Always; 2=Motion Never. Note: Overrides the motion sensor if set to a value other than "0=Normal". If set to "1=Motion" Always, then the TrimTrac locator will override the motion sensor such that the unit operates as if motion is always present. If set to "2=Motion Never", then the TrimTrac locator will ignore all motion and never generate a fix until the configuration is	0

	changed or otherwise commanded to do so (see QUERY_POSITION message).	
Position Query Mode	S=Compute and report current position; L=Status Report with Last logged position.	None
Position Query Fix Timeout	In Seconds (10-3600). Note: Temporarily overrides current FIX Timeout, T2, if Position Query Mode set to "S=Compute" and report current position. Settings longer than 600 minutes are generally not recommended.	None

Table 41, Enhanced Feature Parameters and Defaults.

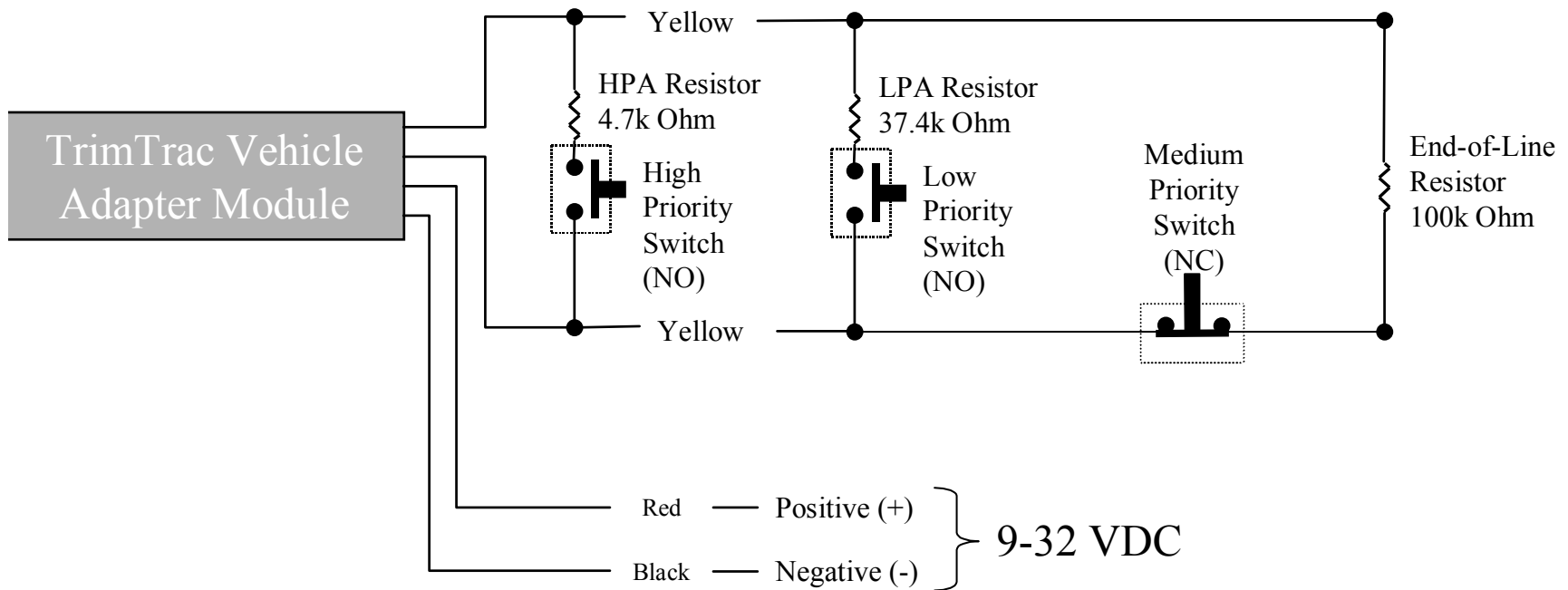## *Vehicle Adapter Module Parameter Ranges and Default Settings*

Parameter	Unit/Notes	Default
HPA Idle Timeout, T11	In Seconds (10-999990)	10
MPA Idle Timeout, T12	In Seconds (10-999990)	10
HPA Delay Timeout, T13	In Seconds (10-86400)	10
MPA Delay Timeout, T14	In Seconds (10-86400)	10
HPA Transmit Timeout, T15	0=Infinity; Else in Seconds (10-999990)	0
MPA Transmit Timeout, T16	0=Infinity; Else in Seconds (10-999990)	120
HPA Query Timeout, T17	In Seconds (10-3600)	60
HPA Transmit Attempts, N5	0=Until T15 Expires; 1-255=Number of Tx Attempts before T15 expires	0
MPA Transmit Attempts, N6	0=Until T16 Expires; 1-255=Number of Tx Attempts before T16 expires	0
LPA Transmit Attempts, N7	0=Until T3 Expires; 1-255=Number of Tx Attempts before T3 expires	0
Ignore HPA	0=Do NOT Ignore; 1=Ignore	0
Ignore MPA	0=Do NOT Ignore; 1=Ignore	0
Ignore LPA	0=Do NOT Ignore; 1=Ignore	0

Table 42, Enhanced Feature Parameters and Defaults.

Read-Only Parameters, Formats and Ranges

Parameter	Value
Protocol Sequence Number	16-bit Hex (0000-FFFF) incrementing by 1 for each logged report
TriggerType	0=IDLE Timeout, T1 1=Motion Detected 2=Alert (VAM-Only) 3=Query 4=Scheduled Report
Battery Level	0-100%
Battery Changed Flag	T=True F=False
GPS Week Number	Always 4 Digits
GPS Seconds into Week	Always 6 Digits
GPS Status Code	0=3D GPS Fix 1=2D GPS Fix 2=Fix Timeout, 0 SVs 3=Fix Timeout, 1 SV 4=Fix Timeout, 2 SVs 5=Fix Timeout, 3 SVs 6=GPS Error 7=No Fix attempted
GSM Status Code	0=Network Available 1=Message Logged (i.e. Report Delay Flag set=1) 2=Network Timeout 3=SIM Error / No SIM 4=SIM PIN Error 5=Pre-TX log (Low battery).
Position Age	0=Current (i.e. no motion since last position) 1=Aged (i.e. motion has occurred since last position)
HPA Status	0=Normal; 1=Activated; 2=Sent; 3=Acknowledged
MPA Status	0=Normal; 1=Activated; 2=Sent; 3=Acknowledged
LPA Status	0=Normal; 1=Activated; 2=Sent; 3=Acknowledged
External Power	0=Bad (Below 5 VDC); 1=Good (5 VDC or higher)
Latitude	WGS-84 Coordinates. Units of Degrees to 7 decimal places plus '+' sign = North and '-' = South. (-90.0000000 to +90.0000000)
Longitude	WGS-84 Coordinates. Units of Degrees to 7 decimal places plus '+' sign = East and '-' = West. (-180.0000000 to +180.0000000)
Altitude	WGS-84 Altitude reference to MSL. In Feet, always 5 Digits plus sign (-99999 to +99999)
Horizontal Speed	Miles Per Hour. Always 3 Digits
Heading	Relative to True North, increasing Easterly. Units of Degrees. Always 3 Digits. (000-359)

Table 43, Read-only Parameters

TrimTrac

Yellow

HPA Resistor
4.7k Ohm

LPA Resistor
37.4k Ohm

Medium
Priority
Switch
(NC)

End-of-Line
Resistor
100k Ohm

TrimTrac Vehicle
Adapter Module

High
Priority
Switch
(NO)

Low
Priority
Switch
(NO)

Yellow

Red — Positive (+)
Black — Negative (-)
} 9-32 VDC

Notes:
1) High and Low Priority switches must be Normally Open; Medium Priority switch must be Normally Closed
2) Switches can be either Momentary or Latching
3) High, Low and Medium Switches are optional and can be used in any combination
4) Multiple switches can be used in parallel in each branch circuit; provided, however that branch resistance values are maintained as shown.
5) End-of-Line Resistor is required unless Ignore MPA is set "1=Ignore"
6) If no Alert Switches are used, then set Ignore HPA, MPA and LPA all to "1=Ignore"
7) All resistors (+/- 5%, .250 Watt min.) and switches provided by installer.
8) Opens, shorts and ground faults on main circuit and loss of external VDC handled as "Medium Priority Alerts"
9) New High and Low Priority alerts may not be recognized if a Medium Priority alert caused by an open, short or ground fault is in already in effect.

Figure 8, VAM Alert Wiring Diagram