Leica

MX 9400R
REFERENCE STATION

OPERATOR'S MANUAL

Prepared by

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ABOUT THIS MANUAL

Congratulations on your purchase of a Leica MX 9400R DGPS Reference Station. It represents the finest in reference station technology today.

As for this manual, it provides the information you'll need to operate your Leica Reference Station using the Leica CDU program. Besides step-by-step procedures, you'll find valuable information on what problems to avoid and how best to ensure trouble-free operation.

The instructions in this manual follow the order in which you're likely to use them. We suggest, however, that you read this manual through before proceeding. This will help you see the overall picture of what you must do. In this way, you'll be able to better anticipate installation requirements.

At the back of this manual you'll find a Reader Comment Sheet. On the inside back cover is a Limited Warranty Statement, along with a place to record the serial number of your unit.

If you'd like more in-depth information about the Leica DGPS products, refer to the referenced documents listed inside.

Navigation and Positioning Division

Leica reserves the right to make changes to
its products and specifications without notice.

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

ILLUSTRATIONS

ILLUSTRATIONS (Continued)

FOREWORD

Leica offers two lines of reference stations: the MX 9012R and MX 9112 are L1 Frequency C/A code receivers while the MX 9400R is a L1 Frequency C/A and P code receiver. Operation of all units is essentially identical with the exception of a few features that are not supported by the MX 9012R and MX 9112. The following additional features are supported in the MX 9400R:

- 30 cm navigation accuracy
- 2 Hz position and velocity computations
- 10 Hz code and phase measurements

The control commands associated with these features are not present on the DGPS output and CDU Initialization screens for the MX 9012R and MX 9112.

This manual is a tutorial for learning the operational capabilities of the Reference Station, when controlled by the Leica developed Control and Display Utility (CDU) program, operating on an IBM PC or compatible PC.

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The U.S. Government has the right to modify or terminate the operation of the satellites at any time. Leica reserves the right to change the capabilities and specifications of the Reference Station without notice.

REFERENCED DOCUMENTS

- Leica MX 9400 Installation and Service Manual, P/N 10136: Contains procedures for installing and maintaining the Leica MX 9400 DGPS Navigators. Provides details of the electrical characteristics of the data interfaces.

- Leica MX 9400 Navigator Operator's Manual, P/N 10137: Contains information for operating a Leica MX 9400N DGPS Navigator.

- Leica DGPS 12 Channel Technical Reference Manual, P/N 10139: Contains information for programming the Leica DGPS Navigators and Reference Stations.

- NMEA-0183 Specification: Defines the hardware and software requirements for an NMEA 0183 data interface.

- EIA RS-232C Specification: Defines the hardware and software requirements for an RS-232 data interface.

- EIA RS-422 Specification: Defines the hardware and software requirements for an RS-422 data interface.

- RTCM-104 Specification: Defines the record structure for the standard RTCM-104 messages used for differential GPS correction data:

  RTCM Special Committee No. 104, *RTCM Recommended Standards for Differential NAVSTAR GPS Service, Version 2.0,* Washington, D.C.:
  Radio Technical Commission for Maritime Services, 1990.

- ICD-GPS-200 Specification: Defines the GPS satellite data format.

INSIDE THIS MANUAL

This manual will allow you to `browse' through the capabilities of the Leica Differential GPS Reference Station, using the CDU program. As you browse, you will be able to familiarize yourself with satellite navigation, generally, and the Reference Station capabilities, specifically. The information is organized functionally by Sections, so the Table of Contents will be your basic guide for finding information. When you find a term that is unfamiliar to you, refer to the Glossary of Terms in back of this guide for clarification. We have prepared the manual contents for maximum reader convenience and clarity. We welcome your suggestions for manual improvement by letter or the tear-out reader comment sheet at the back of this manual.

SECTION I

ABOUT THE REFERENCE STATION

The MX 9400R DGPS Reference Station is part of a family of Leica 12 Channel DGPS receivers that use the signals transmitted from GPS satellites to produce a highly accurate three dimensional position and time. The particular family member operates at a known location and produces corrections for other DGPS receivers within radio range.

GENERAL CAPABILITIES AS A REFERENCE STATION

The Reference Station, as shown in Figure 1-1, is housed in a small box containing a three color LED as a status indicator. Since the Reference Station does not have a readable display, the Leica developed Control and Display Utility (CDU) is used to perform both the control and display functions.

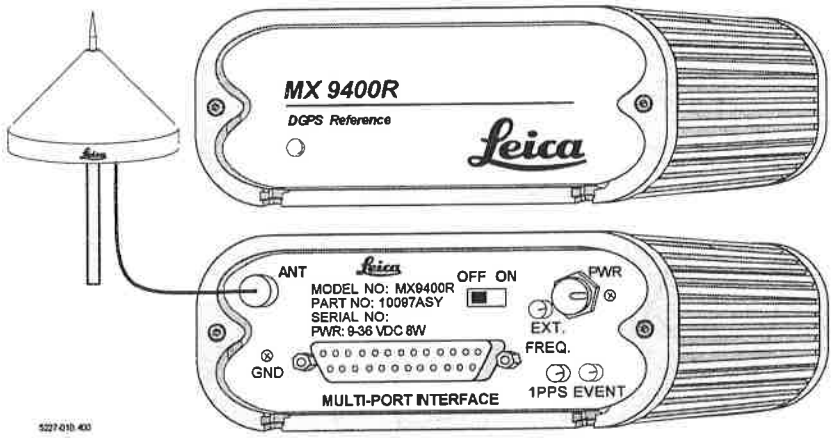

Figure 1-1. MX 9400R Reference Station

Reference Station Functions:

- Output of DGPS Corrections: 1/second update rate
- Differential Accuracy: 30 cm
- Satellite Health Status Control
- Navigation Quality Control
- RTCM Port Configuration and Control
- Output of Information for Logging, Display, and Analysis

CDU Functions:

- Satellite Data Display
- Control of Differential Correction Parameters
- Serial Port Control
- Control of Data Logging and Viewing

WHAT IS GPS?

The Global Positioning System (GPS) is a satellite-based radio navigation system. It provides precise, continuous, all-weather, world-wide navigation capability for sea, land, and air applications. The satellites in the GPS constellation (see Figure 1-2) orbit the earth about once every 12 hours at a distance of roughly 10,900 nautical miles. Unlike ground-based navigation signal generators (for example, Omega or Loran-C), the satellites are able to cover a very large area of the earth because of their altitude and the fact that their signals are free of interference from local geography. The satellites are positioned in an orbit so that when the constellation is complete, at least four satellites will always be visible simultaneously to GPS receivers at any location on or above the earth, 24 hours a day. The number of visible satellites is important because four satellites are needed for a GPS receiver to calculate position (latitude, longitude, altitude) and time. The complete GPS constellation will consist of 21 operational satellites and three spares.

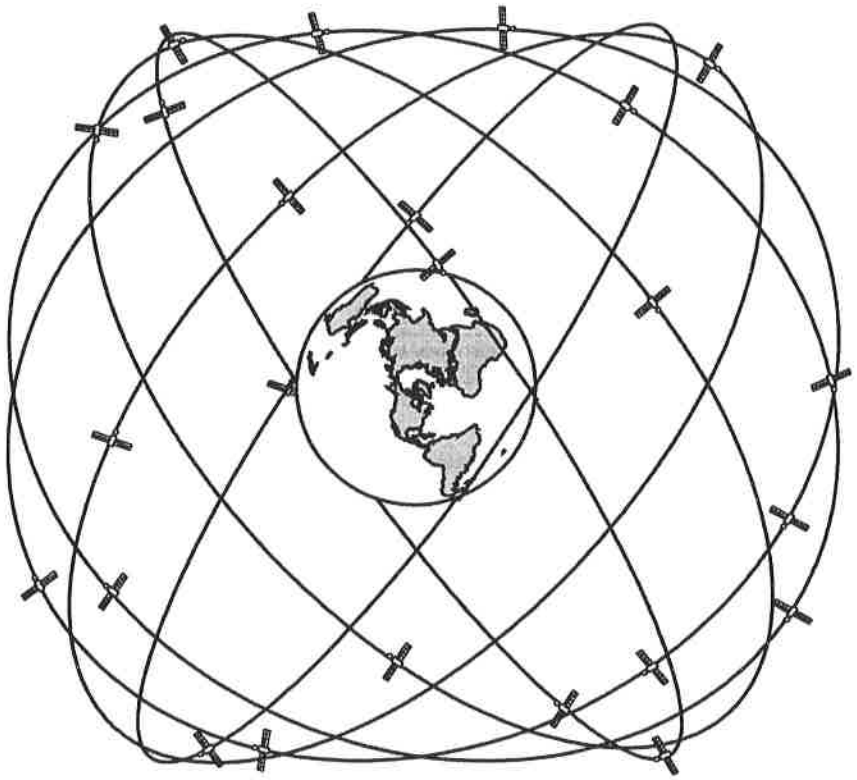

Figure 1-2. GPS Satellites Around the World

WHAT IS DIFFERENTIAL GPS?

A technique referred to as Differential GPS (DGPS), allows users to obtain increased accuracy from the GPS system. By receiving signals from orbiting GPS satellites, authorized military users are able to continuously navigate with an accuracy on the order of 16 meters or better, while civilian users are limited to accuracies of approximately 100 meters 2-D RMS. DGPS requires the use of two GPS receivers. One receiver, referred to as the GPS Reference Station, is placed at a surveyed location, the coordinates of which are precisely known. The purpose of the DGPS system is to use the Reference Station to measure the errors in the GPS signals and to compute corrections to remove the errors. The corrections are then communicated in real-time to the GPS Navigators, where they are combined with the satellite signals received by the Navigators, thereby improving their navigation or positioning. This technique is effective because many of the errors at the Reference Station and Navigators are locally common. The geographic validity of these corrections decreases with distance from the Reference Station, but the corrections are valid for Navigators hundreds of kilometers away. Figure 1-3 shows the DGPS scenario.

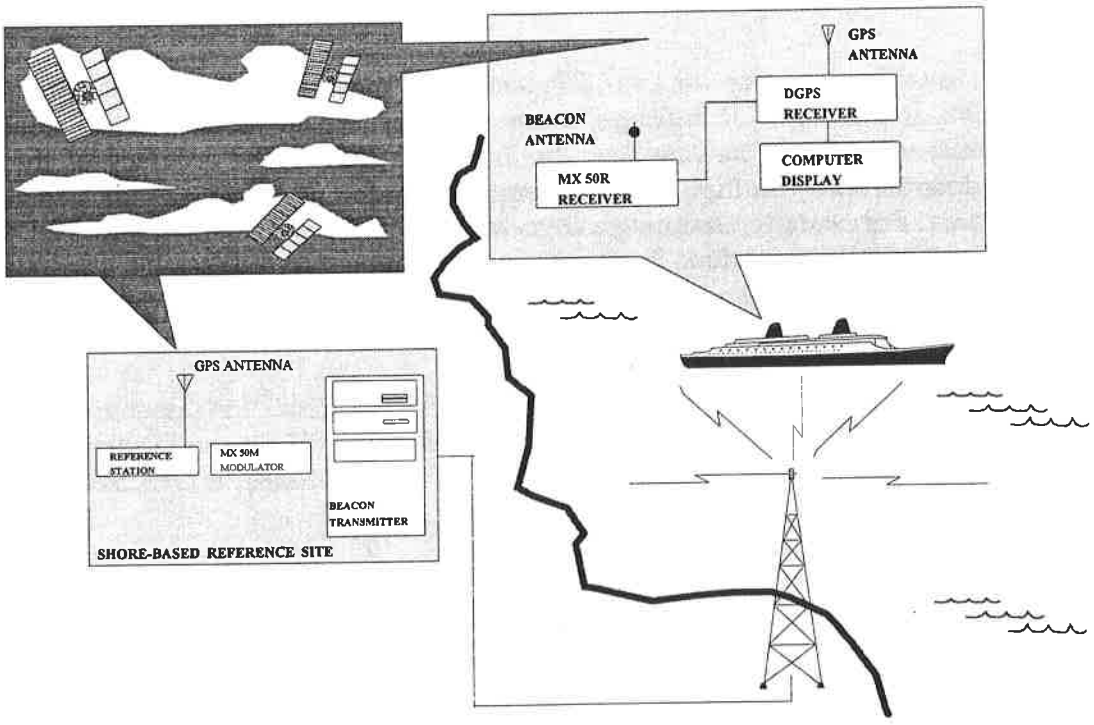

Figure 1-3. DGPS Scenario

ABOUT THE REFERENCE STATION

GPS ACCURACY

The navigation accuracy of a GPS receiver is characterized by multiplying the satellite range measurement (pseudorange) error by the satellite geometry factor (Dilution of Precision, or DOP).

Pseudorange Errors

Pseudorange errors which are common between local receivers may be corrected with the differential GPS technology, while errors particular to an individual receiver are not. The major common error sources affecting the pseudoranges and their approximate sizes are:

1.	Selective Availability (SA):	30m
2.	Ionospheric delays:	20-30m by day, 3-6m by night
3.	Tropospheric delays:	up to 30m
4.	Ephemeris:	less than 3m (without SA)
5.	Satellite Clock:	less than 3m (without SA)

Selective availability errors are caused by the deliberate distortion of the GPS signals imposed by the U.S. Government to reduce the inherent accuracy of GPS for security reasons. When SA enabled becomes the predominant error source in the GPS measurement, the resulting accuracy of the GPS position will be approximately 50 meters RMS.

DOPs

The effect of the satellite geometry on the GPS position is measured in terms of Dilution of Precision, or DOP. A smaller DOP indicates better geometry, which yields a better solution. Generally, the more spread out the satellites, the lower the DOP. The accuracy of the GPS solution may be determined by multiplying the estimated pseudorange error (as indicated above) times the DOP value. For example, assuming a 40 meter error in the measurement times a DOP of 2 would yield 80 meter RMS navigation. Furthermore, when more than four satellites are used for navigation (the receiver can track a maximum of twelve) the DOPs, in this over-determined solution, are generally lower still.

The DOPs play an important part in the accuracy of the GPS position. It is imperative that you continually monitor the DOPs and control the maximum allowable DOPs used for navigation to ensure a high degree of quality in the position solution. The DOPs used in GPS navigation are defined below.

NDOP - Dilution of Precision in the North axis
EDOP - Dilution of Precision in the East axis
VDOP - Dilution of Precision in the Vertical axis
TDOP - Dilution of Precision with Respect to Time
HDOP - Horizontal Dilution of Precision
PDOP - Position Dilution of Precision

GDOP - Geometric Dilution of Precision

$$GDOP = \sqrt{TDOP^2 + PDOP^2}$$
$$PDOP = \sqrt{HDOP^2 + VDOP^2}$$
$$HDOP = \sqrt{NDOP^2 + EDOP^2}$$

Accuracy with Differential GPS

With the application of differential corrections, the SA errors can be reduced to a very small level, and the ionospheric and tropospheric errors are almost completely removed when the Reference Station and the Navigator are at close range. Ephemeris and clock errors are essentially removed as well, resulting in navigation accuracy of approximately 2 meters RMS.

Using differentially corrected measurements, a 40 meter measurement error could be reduced to 1 meter, thereby reducing the RMS navigation to (assuming a DOP of 2). With Leica's patented GPS technology, the measurement error is reduced further to less than 1 meter 2D RMS.

The application of differential corrections, however, may be another source of error in the GPS position. Figure 1- 4 shows the relationship between the age of the differential correction and the resulting position error. The differential corrections received at the navigator are propagated forward using the correction rate term sent by the Reference Station. As the correction ages, the error in the propagated value increases.

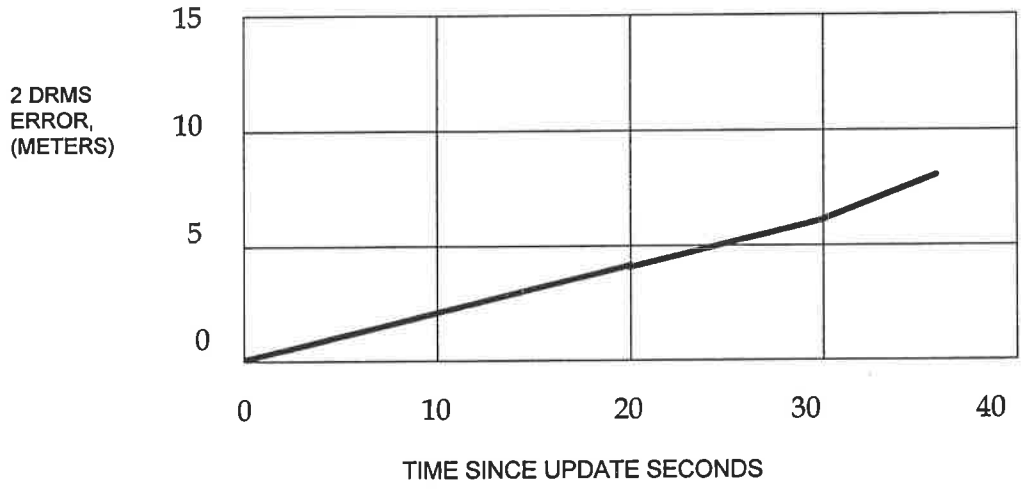

Figure 1-4. Differential GPS Error Growth

SECTION II

THE MULTI-PORT INTERFACE

This section shows you how to connect your PC controller to the appropriate port of the receiver. A cable is provided with the equipment, but in the event that you may have to construct a cable to interface to the receiver, a complete wiring diagram has been included. We are assuming that you have completed installation of the receiver and its antenna prior to interfacing to the PC controller.

The Leica MX 9400R DGPS Reference Station supports communication on four serial, bi-directional, asynchronous data ports. Each of these ports has a unique function as shown in Figure 2-1.

	CONTROL PORT	RAW DATA PORT	RTCM PORT	EQUIPMENT PORT
INPUT	Reference Station Control Messages	Not Used	Not Used	Not Used
OUTPUT	Proprietary Data Messages	Data for Logging	Differential Correction Data to Navigators	NMEA Messages to External equipment

Figure 2-1. Multi-Port Interface Function Assignments

Control Port This port is used to send commands and setup information to the receiver and to receive status information from the receiver for display on the PC controller. This is fixed at Port 1 (RS-232).

Raw Data Port This port is used to output raw and processed satellite information, including raw satellite measurements, almanac data, ephemeris data, dilution of precision, satellite geometry, differential corrections and RTCM information. The default is Port 2 (RS-232), however the raw data can be generated and interleaved with other data on any of the 4 ports.

RTCM Port This port is used for transmission of binary differential correction messages sent to a DGPS navigator. It is typically connected to a modem data link or a beacon modulator to transmit the corrections. The default is Port 3 (RS-232), however the RTCM port can be assigned to ports 2 - 4, but cannot share assignments with any other function.

Equipment Port This port is used to send position, track and speed information to external equipment that communicates with standard NMEA-0183 messages. The default is Port 4 (RS-422), however the data can be generated and interleaved with other data on any of the 4 ports.

USING THE RS-422/RS-232 CONVERTER

The interface signals for ports 1, 2 and 3 of the receiver are RS-232. The interface signals for port 4 is RS-422. Most PCs communicate using the RS-232 electrical specification. If the receiver port assignments cannot be re-assigned to meet your requirements, you may need to obtain the optional converter kit, part number 10236. Figure 2-2 shows how to cable your MX 9400R to the PC controller and beacon modulator.

Connect the cable labeled Port 1 to communication port COM1 of the PC. If you are using a separate serial port to log raw data, then connect the cable labeled Port 2 to communication port COM2 of the PC. All PC connections are provided with 25 pin DB25S connectors. If your PC uses 9 pin connectors, obtain a 9 to 25 adapter from your computer supplier. Since the receiver is wired the same as a modem (DCE), the standard `modem' adapter is correct. Figure 2-2 shows the cabling from the receiver to its peripherals.

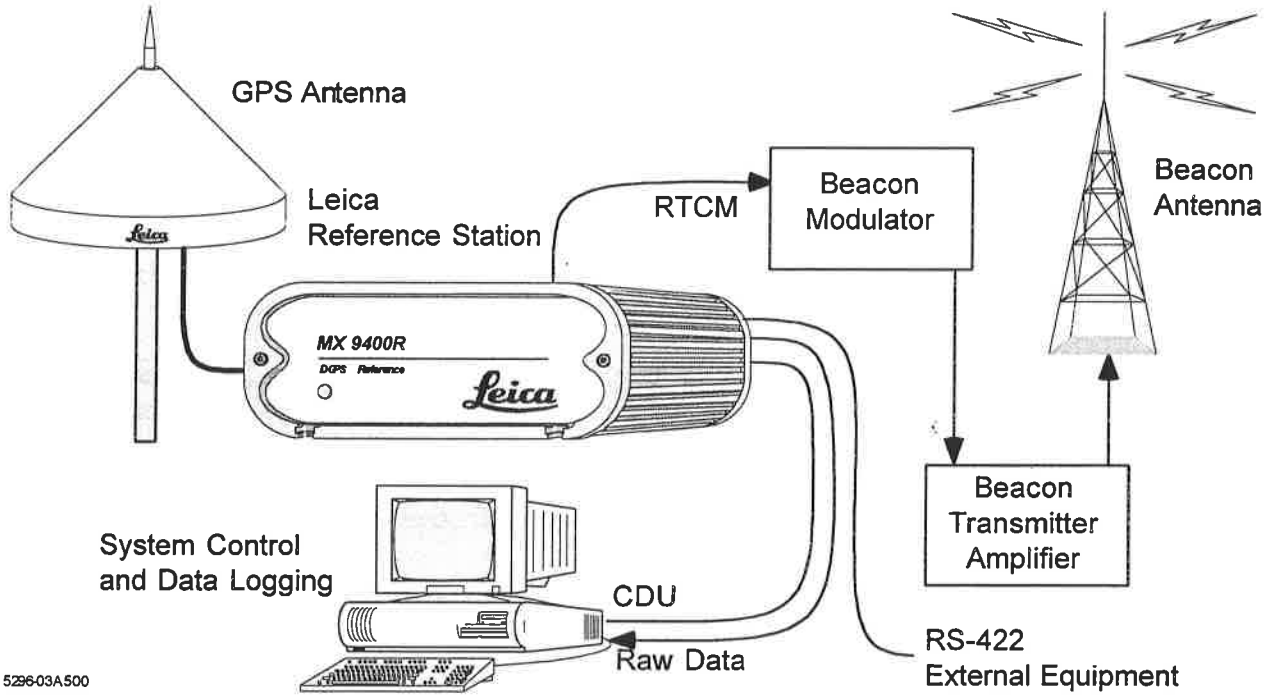

Figure 2-2. Typical Cabling Diagram

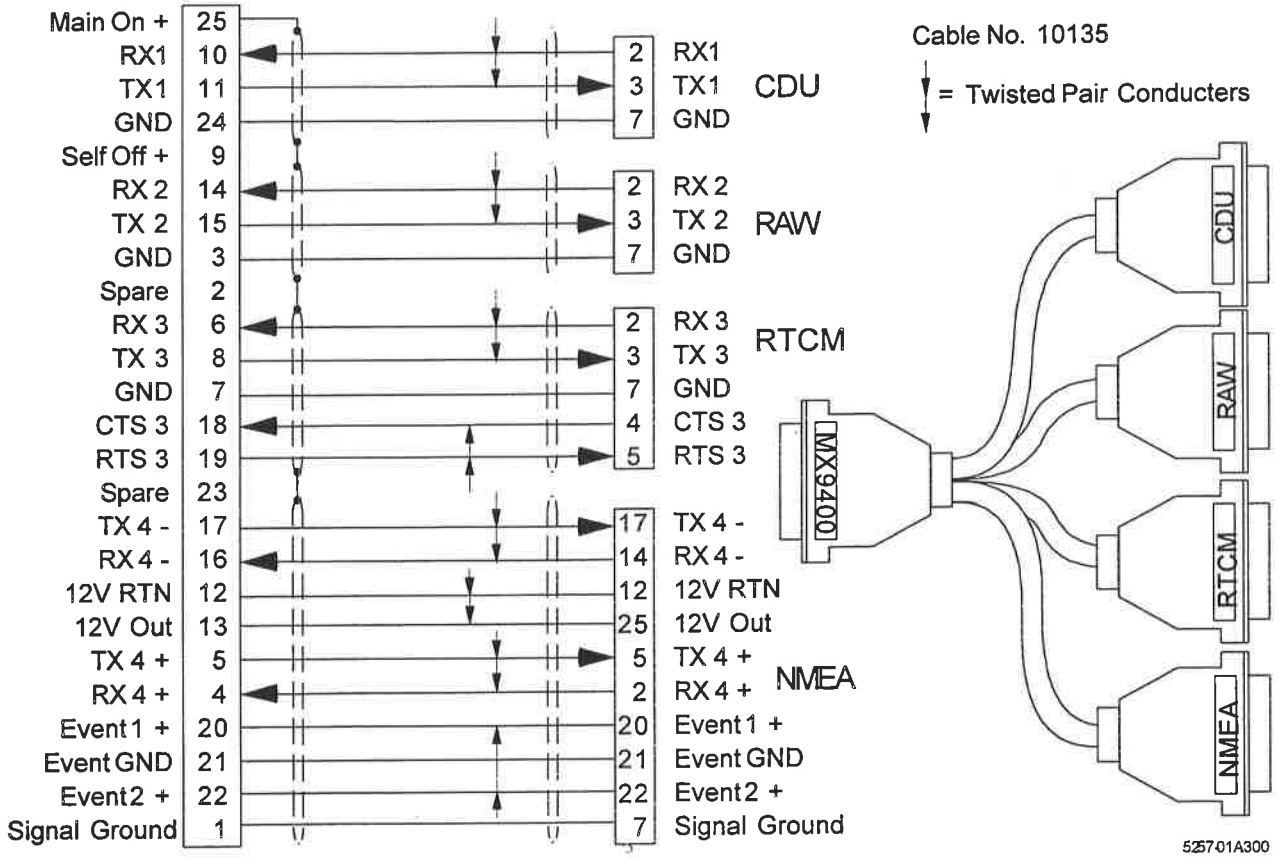

Figure 2-3. MX 9400R Interface Cable Wiring Diagram

SECTION III

USING THE CDU

The CDU program developed by Leica is designed to allow you to control and monitor the Leica DGPS Reference Station. The CDU is structured in a menu and display fashion. The main *CDU* screen contains the information required for quality control as well as a list of the available screens for data entry and viewing.

This section will take you through the necessary steps to install your CDU software on your PC, initialize the CDU for operation with the receiver, and monitor the results.

PROGRAM ENVIRONMENT

The CDU program is designed to operate on an IBM PC, AT, PS/2 or compatible computer using DOS (MS-DOS, PC-DOS, or DR-DOS) version 3.1 or higher. It requires 512K bytes of free memory and an 80 column x 25 line display, either color or monochrome. Two serial communications ports are supported by the CDU (COM1 and COM2); however, only one is required for basic operation. The second port may be used as a data logging port.

Operation at 19200 baud is not recommended for PC/XT (8088) class computers. Some PC/XT (8088) and AT (80286) class computers may require a high performance serial port to avoid data loss. Refer to the section on PC Data Logging for more information.

For applications where data is to be recorded, a hard disk is recommended. The receiver generates approximately 1.5 megabytes of raw data information every 40 minutes. However, this amount may be reduced significantly by disabling raw data outputs which are not required, as described under the *Receiver Raw Data Control* screen. If the CDU program is to be executed from a floppy disk, the disk must be write-enabled and remain in the drive, since the CDU program saves setup information to disk. Data logging to a floppy disk may result in loss of data.

BACKUP FILE PREPARATION

The CDU program is not copy-protected, and we recommend that you make a backup copy and store it in a safe place. You can copy it using the DOS copy command or any other standard file copy utility.

USING THE CDU

INSTALLING THE CDU PROGRAM

Assuming that you are installing the program on your hard drive in a directory named `CDU', that your hard drive is c:, and your source drive is a:, type the sequence below in response to the c: prompt:

CD\	(return to root directory)
MD CDU	(create directory named `CDU')
CD CDU	(change to `CDU' directory)
COPY A:*.*	(copy contents of floppy on A drive to current directory)

DOS will copy the CDU program file from the disk in your A drive onto your hard drive into the CDU directory.

STARTING THE CDU PROGRAM

In response to the DOS prompt, type `CDU' to execute the CDU program. If your current directory is not the directory in which you installed the CDU program, you must specify the appropriate drive and path name, example: C:\CDU\CDU.

When the CDU program is first executed, it creates a small (300 bytes) file to save setup information. This file has the same base name as the CDU program file, with an extension of .DEF (i.e., CDU.DEF) and is created on the same drive and directory where the program file is stored. If the program file is moved or renamed, this file should be moved or renamed with it. On subsequent executions, the CDU program uses the setup from the .DEF file.

CDU SCREEN OPERATION

The CDU program is organized as a Main Menu/Display with several subordinate data entry forms and displays.

In the Main Menu, and any screen with data entry, a cursor is indicated by a highlighted or inverse video data field or label. This cursor may be moved by using the PC's cursor control (arrow) keys and the *Tab, Home* and *End* keys. In the Main Menu only, the cursor may also be moved by pressing the first letter of the screen name. Multiple screens with the same first letter are selected by successive presses of the same key. The *Enter* key activates the selected screen.

Data entry screens have two types of entry fields, normal and selection. In normal data entry fields, the operator simply enters the required data. The cursor control keys, and the *Insert/Delete* keys may be used to edit the field. These fields are identified by a single-lined box surrounding the data.

Selection data entry fields have a limited number of values from which the operator may select. The various selections may be cycled through by using +, - , or the *Space Bar*. A selection may also

be made by entering the first letter of the available choices. These fields are identified by a double-lined box surrounding the data.
Modified data entry fields become effective when the user presses *Enter*. Changes may be discarded by pressing *Esc* (before *Enter* is pressed). If the operator modifies a field, and then moves the cursor away from the field before pressing either *Esc* or *Enter*, the field will flash, indicating that the value displayed has not been sent to the receiver. If *Enter* is pressed, all changed values will be sent. If *Esc* is pressed (to leave the screen), the user is warned that the changes will be discarded. You will be prompted to either press *Esc* to exit or *Enter* to save/send the changes.

The exceptions to these rules are the screens which affect only CDU program operation and not the receiver: the *PC Setup* and *PC Logging* screens. In these screens, changes are effective immediately when the cursor is moved away from the field. *Enter* and *Esc* still function as before.

ORGANIZATION OF THE PC SCREEN

Figure 3-1 shows the overall layout of the PC screen during execution of the CDU program. The window at the top of the screen, labeled `Reference Information', contains a display of the key operating parameters of the Reference Station. The reference information is displayed whenever the user is viewing the Main Menu. This window is always available except when the view output screens (*F5* or *F6*) are selected. The values displayed are automatically updated every few seconds.

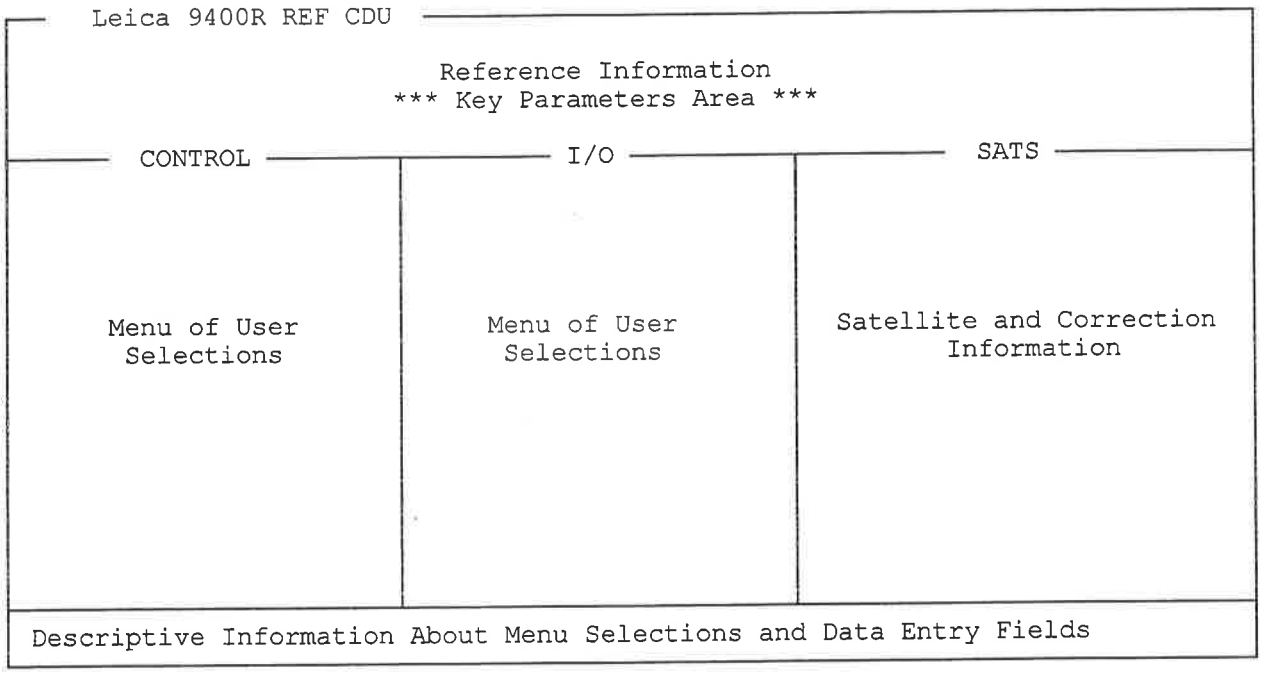

Figure 3-1. CDU Overall Screen Layout

The left and center windows of the screen show the possible menu selections available to the user. These selections enable the user to access additional screens to modify and examine operating parameters and to select alternative displays. The operator makes a selection by positioning the highlighted bar using the cursor control keys on the menu choice and pressing *Enter*. The selections within each column have been divided into two functional areas: Control and I/O. The menu selections located in the Control column enable the user to alter parameters related to the maintenance of a reference station. Those selections location in the I/O column enable the user to define baud rates, port configurations and data logging functions which generally are only setup once.

The window on the right portion of the screen, labeled `Satellite and Correction Information', is used to show the satellites being tracked, their elevation, carrier to noise ratio, the DGPS correction, and their status.

Figure 3-2 shows the available menu selections.

```
LEICA 9400R REF  CDU
Latitude    N 33 48.86768              UTC    01:37:08   03/12/1996
Longitude W 118 20.94890               Station ID      42
Ellipsoid Ht     35.22  meters         Frequency Offset   5.3178 PPM
Mode Corrections Out
```

CONTROL	I/O	9400R REF				
Initialization	PC Setup	PRN	El	C/N0	Corr	Status
Ref Station Control	NMEA Message Control					
Differential Output	Receiver Port Config					
Position Projection	Receiver Port Assign	16	17	40	-21	+
Time Recovery		7	12	36	-8	+
Event Output Control	Rcvr Raw Data Control	5	61	55	3	+
Beacon Modulator Setup	PC Raw Data Logging					
Beacon Almanac Entry	View PC Raw Data <F6>					
GPS Channel Status <F2>	PC CDU Data Logging					
Send RTCM Message	View PC CDU Data <F5>					
Satellite Health	PC Modem Control					
	About					
	Restart CDU					
	Dos Shell					
	Exit	Sats Visible 7		Used 7		

Figure 3-2. CDU Menu Selections

On-line help is available by using the F1 Softkey. Highlight the menu selection or field within a screen and press F1. A new screen will be presented which contains detailed information regarding the menu or field previously highlighted. Pressing the ESC key while in the On-line Help screen will return to the previous screen.

AT THE TOP: KEY OPERATING PARAMETERS

The top portion of the CDU screen is used to present a continuous display of the key operating parameters of the receiver. An example of a reference station's screen is given in Figure 3-3.

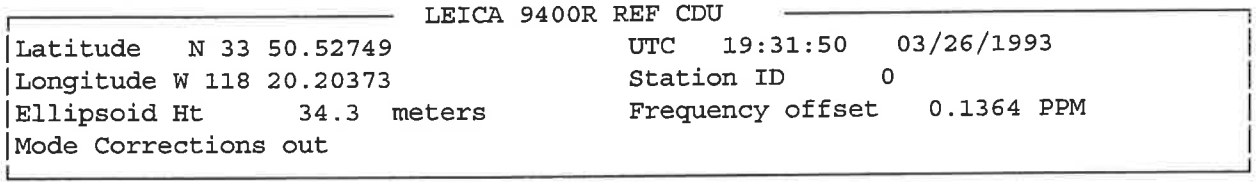

Figure 3-3. Example of Reference Station's Screen

The display fields located at the top of the screen, are separated into two columns:

COLUMN #1

Lat/Lon Location of the receiver antenna in the WGS-84 datum.

Altitude Height of the receiver antenna, in meters. The height reference may be Ellipsoid or MSL (mean sea level) as selected by the user in the *Initialization* screen.

Mode This field reports the status of the receiver. The possible values are:

- *Initial Acq* — The receiver is searching for visible satellites using a previously stored almanac. The receiver requires approximately 2 minutes to begin tracking the satellites.
- *Search the Sky* — The receiver is searching for visible satellites by tuning to different frequencies on each channel since no almanac information is available. The receiver should locate the first satellite within 2 minutes and the remainder of the satellites will be acquired within 12 minutes.
- *Corrections Out* — The receiver is producing differential corrections. This is the normal operating mode of the reference station.

COLUMN #2

UTC/Local The Universal Coordinated Time (or local time) in hours, minutes and seconds and the date are displayed. The time reference is selected by the user on the *Initialization* screen.

Station ID	The identification number assigned to this reference station entered on the *Differential Output* screen.
Frequency Offset	The local oscillator error, in ppm.

SATELLITE AND CORRECTION DISPLAY

The right-most block in the center of the CDU screen contains information related to the satellites currently being tracked by the receiver. Figure 3-4 shows the satellite information displayed.

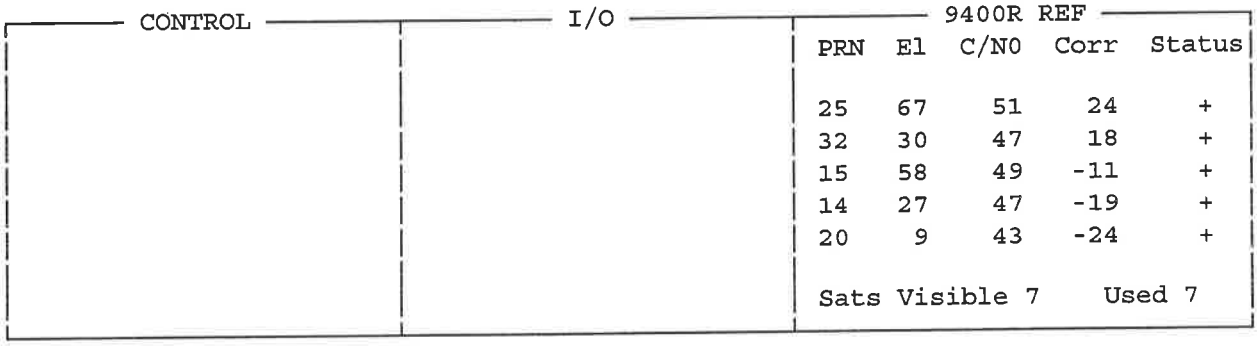

Figure 3-4. Satellite And Correction Display

The items displayed are in receiver channel number order. The first line is channel 1, 2, 3 .. 12. The line at the bottom of the display shows the number of satellites visible to the receiver (based on location, satellite almanac and elevation limit set by the user), and the actual number used in the correction computation.

PRN Satellite identification number.

EL Elevation of the satellite, in degrees.

C/N0 Carrier to noise ratio, in dB.

Corr Differential correction, in meters.

Status Current status of the satellite signal. The possible values are:

+	Satellite signal good.
-	Satellite forced unhealthy.
EPH	A satellite ephemeris is being collected. No current ephemeris information is available yet.
FRAM	The receiver has not yet synchronized with the satellite message.
LOW	The satellite elevation is below the user specified Elevation Mask. (see *Reference Station Control* screen)
REAQ	The satellite signal has been lost (C/NO is too low).
SRCH	The satellite signal has not yet been detected.
WAIT	Correction output filter not yet full.

INITIALIZATION PROCEDURE

1) CDU SETUP

The *PC Setup* screen is displayed whenever the CDU program is executed the very first time. This screen sets the baud rate for the 2 PC COM ports used to communicate with the receiver. If you have followed the cabling instructions in the Installation and Maintenance Manual, then COM1 will be connected to the CDU port of the receiver and COM2 will be used for data logging. Enter the values as shown:

CDU Port:	*COM1*
DATA Port:	*COM2*
CDU Port Baud Rate:	*9600*
DATA Port Baud Rate:	*9600*

Press *Enter* to accept these changes and then *Esc* to go to the Main Menu.

2) SYSTEM TIME

Verify that the System Time field in the Key Parameters Area of the Main Menu is continuously updating. If the time is ok, proceed to step 3. If the time is not updating, then either the cabling is not correct or the baud rate at the receiver end is different than that at the PC. Verify the proper cabling before continuing.

If the time is still not updating, go to the *PC Setup* screen. Select each baud rate for the CDU Port until the receiver responds by updating the system time. Remember to press *Enter* after each baud rate selection.

3) SYSTEM POSITION

Go to the *Initialization* screen and enter the surveyed coordinates of the latitude, longitude, antenna height, and the date and time. The time should be accurate to within 2 minutes. Set the Operating Mode to *Reference Station.*

IMPORTANT

The position must be initialized before the Operating Mode can be changed to Reference Station. The entered position must be accurate to within 1000 meters for reference station operation.

4) SATELLITE TRACKING

Proceed to the *Reference Station Control* screen. Set the Sat Elev Mask to 0 degrees so that all satellites will be tracked.

Go to the *Satellite Health* screen and verify that all of the Satellite User Setting fields are set to blanks. This enables the receiver to track all of the satellites. Even satellites marked as unhealthy in the almanac and ephemeris are attempted to be tracked.

The Mode field in the Key Parameters Area should contain one of the following messages:

- *Initial Acq* — The receiver is searching for visible satellites using a previously stored almanac. The receiver requires approximately 2 minutes to begin tracking the satellites.
- *Search the Sky* — The receiver is searching for visible satellites by tuning to different frequencies on each channel since no almanac information is available. The receiver should locate the first satellite within 2 minutes and the remainder of the satellites will be acquired within 12 minutes.
- *Corrections Out* — The reference station is computing differential corrections.

5) DIFFERENTIAL CORRECTIONS

Differential corrections can be transmitted from a marine beacon using a beacon modulator compatible with an MX 50M or another type of data link using a modem. Verify the cabling of your equipment in the Installation and Maintenance Manual and follow the instructions below for the beacon modulator or modem setup, as appropriate.

Beacon Modulator

Go to the *Receiver Port Assignment* screen. Based on the system configuration, determine which port is connected to the beacon modulator. Set the RTCM Output Port to the number.

Go to the *Receiver Port Configuration* screen. Set the baud rate for the RTCM Output Port to *9600.*

Proceed to the *Beacon Modulator Setup* screen. Set the Beacon Modulator Present field to *Yes.* An error box may be displayed which indicates `Beacon Modulator Data Underrun' which may be safely ignored AT THIS POINT. Enter the appropriate Frequency, Bit Rate, and EDAC Encoding values.

If an error box containing the message `Data Not Available' appears at this point, then the beacon modulator is not responding to the setup commands generated by the reference station. Verify the port assignment, port configuration, cabling and power to the beacon modulator. Repeat step (5). Contact the Leica service representative should this error continue. If no error messages are generated, then the beacon modulator accepted the configuration.

Modem Connection

Go to the *Beacon Modulator Setup* screen. Set the Beacon Modulator Present field to *No*. Proceed to the *RTCM Output* screen. Set the RTCM Max Avg Data Rate field to match the bandwidth of the communication link. Go to the *Receiver Port Configuration* screen. Set the baud rate to match that of the modem.

INITIALIZATION SCREEN

This menu selection provides fields to setup the date and time, the surveyed location of the antenna, and to specify the operating mode of the receiver. The MX 9400R can operate as either a reference station or a navigator. This screen also contains fields to reset the unit and to download an almanac, stored on disk, to the receiver.

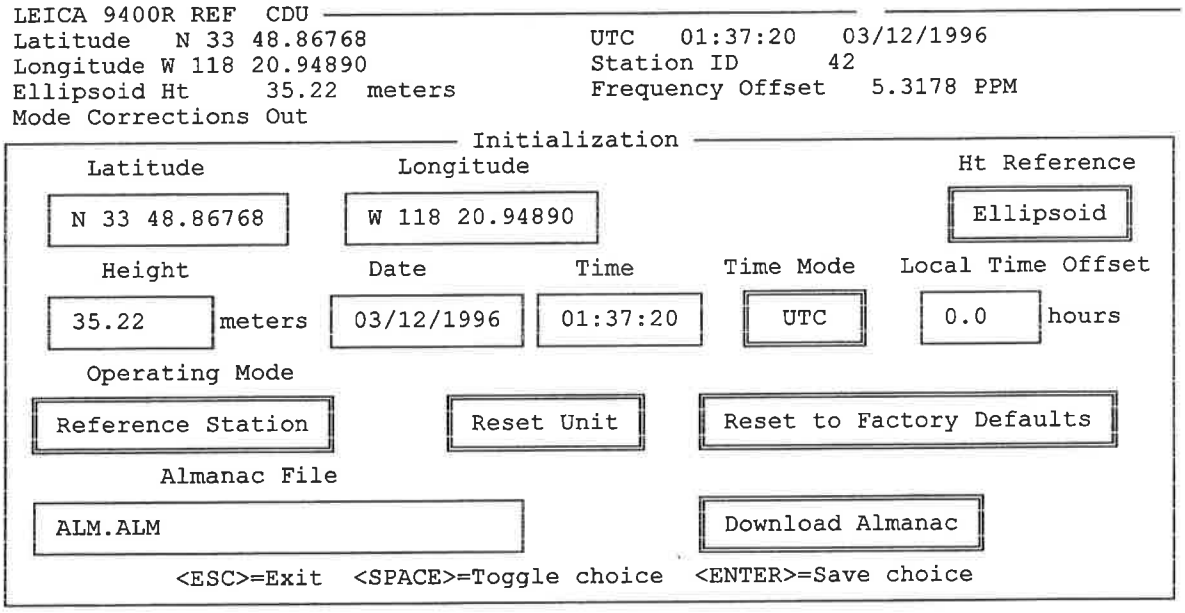

Figure 3-5. Initialization Screen

Latitude, Longitude Enter the surveyed coordinates of the GPS antenna in the WGS-84 datum.. Any error in position will affect navigation results. For best results, the position should be known to within a few centimeters for reference station operation. Latitude and longitude may be entered in degrees; degrees and minutes; or degrees, minutes and seconds. Values will be converted to degrees and minutes. Spaces must be used to separate degrees from minutes and minutes from seconds.

Height Reference Select the height reference for the altitude shown on the Main Menu. The possible choices are: *Ellipsoid* (WGS-84 datum) or *MSL* (mean sea level).

Height Enter the surveyed GPS antenna height, in meters, according to your choice of Height Reference (above).

Date Enter the current date in month/day/year (MM/DD/YYYY) format.

Time Set the time accurate to within 15 minutes of UTC (GMT). Please note

that the time will be automatically corrected once a satellite has been tracked. If time has already been corrected from a satellite, this field is ignored when *Enter* is pressed.

Time Mode — Select the reference for the time shown on the Main Menu. The possible choices are: *UTC* or *Local.*

Local Time Offset — Enter the difference in hours between local time and UTC. This is required only if *Local* was selected for the Time Mode, otherwise leave this field at 0.

Operating Mode — For operation as a reference station, the *Reference Station* mode must be selected. The possible choices are:

- *Navigator* — The receiver is to perform navigation functions. Differential corrections will not be computed but can be received on the RTCM Differential Input Port (see *Port Configuration* screen).
- *Reference Station* — Navigation functions are NOT performed, differential corrections and time recovery are available. *Note: this selection requires that latitude and longitude also be entered otherwise the MX 9400R will not change configurations. The display will prompt you to this effect, should this be overlooked.*
- *Integrity Monitor* — The receiver is to perform navigation functions and will communicate using the RSIM protocol in addition to the Leica proprietary NMEA sentences. This function would be used when the receiver is setup as an independent system to perform quality checks on the corrections being broadcast by the reference station.

Reset Unit — Selecting this field will cause the receiver to restart navigation without modifying the current values stored in memory (warm start).

Reset To Factory Defaults — Selecting this field will cause the receiver to erase all of the information stored in memory including almanac and ephemeris. Since the receiver will not have ephemeris information available, satellite tracking will occur in Search-the-sky mode (cold start).

Almanac File — Enter the name of the file, stored on disk, containing an almanac of

satellite rise times. This file will be downloaded to the receiver when the Download Almanac field is selected.

Download Almanac

Press *Enter* if you wish to send an almanac to the receiver for quicker startup. After every 5 lines of almanac data has been downloaded to the receiver, the message `Sending Line X' will appear in this field. When the complete almanac has been sent, the message `Done Sending' will appear. You can collect almanac information periodically to download to multiple units to save start-up time. See *PC Raw Data Logging* screen for implementation of this feature.

REFERENCE STATION CONTROL SCREEN

This menu selection allows the user to control which elevation satellites will be used for the computation of differential corrections. The receiver tracking mode is selected here.

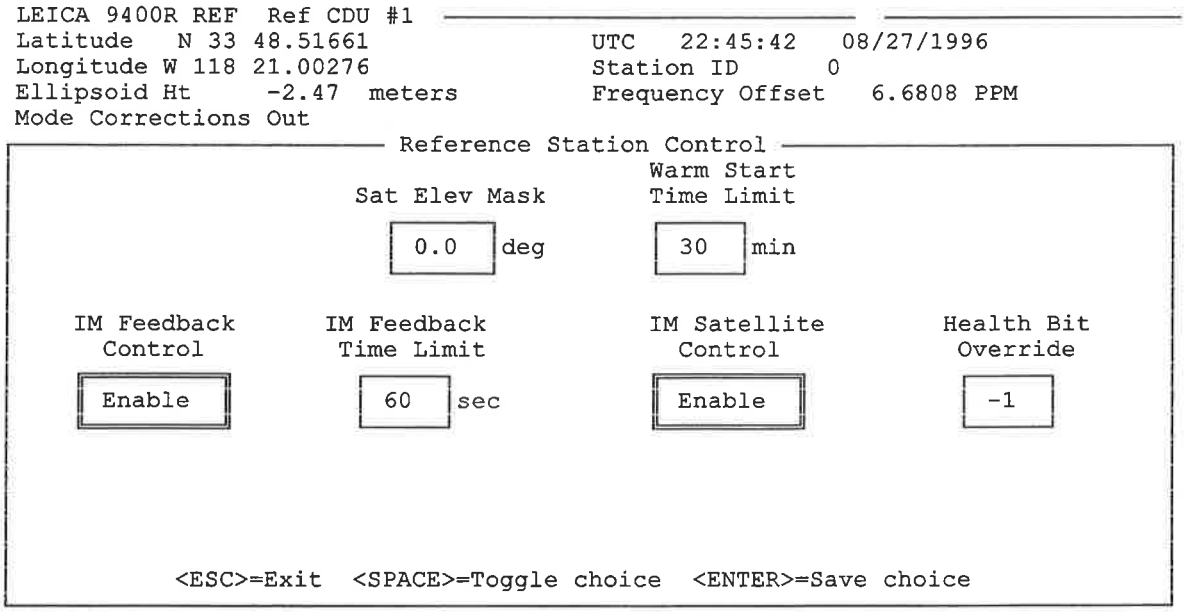

Figure 3-6. Reference Station Control Screen

Sat Elev Mask This is the minimum satellite elevation angle above the horizon for which the receiver will use the satellite measurement. The receiver will not select satellites with elevation angles below this value to be used in the correction computation. The recommended value is zero so that all satellites will be used.

Warm Start Time Limit This is the maximum period of time during a warm start that the receiver will wait to find at least 2 satellites before automatically transitioning to a tepid start

IM Feedback Control This selection causes the reference station to set the health bits in the RTCM message header to 'Unmonitored' if either the feedback message is not received within the Feedback Time Limit, or if the feedback message indicates that DGPS integrity checking could not be performed.

IM Feedback Time Limit This is the maximum amount of time the reference will wait to receive the IM feedback message before setting the RTCM health bits to 'Unmonitored'.

IM Satellite Control When enabled, the reference station will only output DGPS corrections for satellites being tracked by the IM.

Health Bit Override When IM Feedback Control is disabled, the operator may manually set the health bits in the RTCM header with this field. Enter a value between 0 and 7 to be sent in the header. A value of -1 disables operator control of the RTCM health bits.

DIFFERENTIAL OUTPUT SCREEN

This menu selection allows the user to control the output of RTCM messages. The user can specify how often RTCM type 3 (Reference Station Location), RTCM type 7 (Beacon Almanac), and Leica Proprietary type 671 (differential corrections) are output. Additionally, as in the case of the type 671 messages, the user is given the control to select where the information is to be sent. The RTCM type 3 and 7 messages are always output on the RTCM Port.

For Leica DGPS 12 Channel Navigators, additional accuracy may be obtained by using the high accuracy information contained in the RTCM Accucode™ message (type 59). Output of this information is enabled by setting the Accucode™ Smoothing Output Rate to a non-zero value.

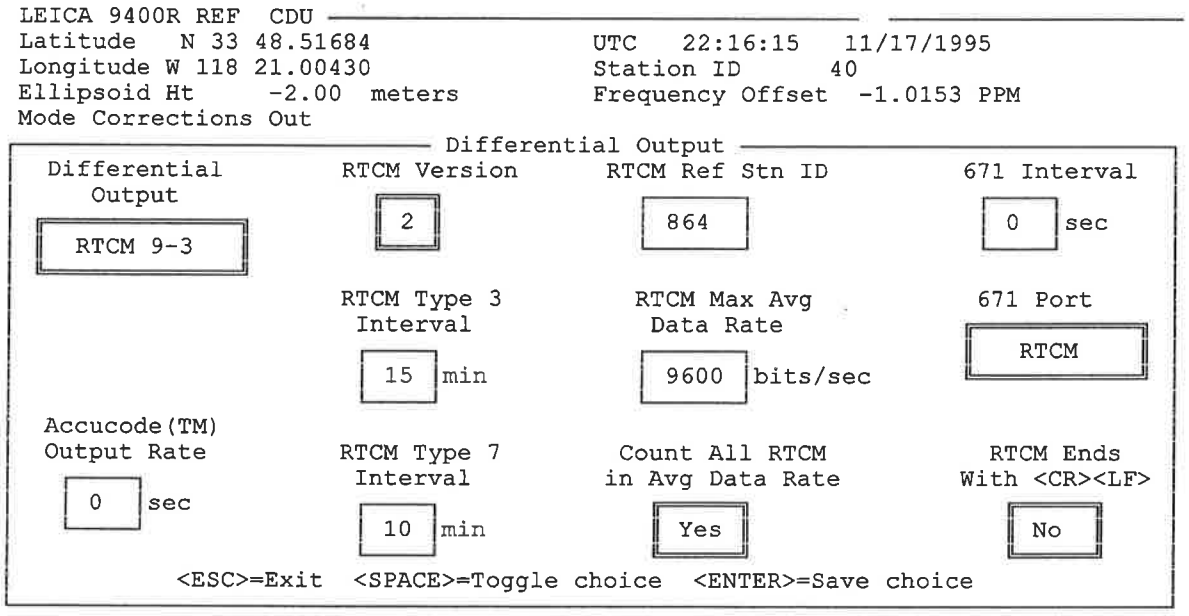

Figure 3-7. Differential Output Screen

Differential Output Select the RTCM differential correction message type to be generated. The possible choices are:

- ➢ *Disable* — No differential outputs are generated.
- ➢ *RTCM Type 1* — This selection causes the Reference Station to generate binary type 1 RTCM differential correction records. This message is generated 1/second and is sent to the RTCM Port.
- ➢ *RTCM Type 9-3* — This selection causes the Reference Station to generate binary type 9-3 RTCM differential correction records. Type 9-3 means that each RTCM

Type 9 record will contain a maximum of three DGPS corrections. This message is generated 1/second and is sent to the RTCM port.

➢ *$PMVXG,671* — This selection enables the reference station to generate a Leica proprietary message (type 671) which can be transmitted on any port. This message contains the RTCM differential correction information in a hex-ASCII format. The type 671 message is generated at the rate specified in the 671 Interval field. If the interval is set to zero, the output is disabled. Type 671 messages are typically used in situations which require the navigator to accept DGPS corrections via one of the control ports. Refer to the Leica DGPS 12 Channel Technical Reference Manual for a detailed description of this message.

RTCM Version — The reference station generates messages in the RTCM version 2 format. Any other choice will not be accepted by the receiver.

RTCM Ref Stn ID — Enter the identification number of this reference station. Each reference station within a network should have a unique ID. This number appears in the Key Parameters Area of the Main Menu and is transmitted in the header portion of each binary RTCM message. This value must be between zero and 1023.

671 Interval — Specify the interval, in seconds, that type 671 (hex-ASCII differential corrections) messages are to be generated. If a zero is entered then the output is disabled. Note that if the Differential Output field is not *$PMVXG,671*, then this field has no effect.

RTCM Type 3 Interval — Specify the interval, in minutes, that type 3 (Reference Station Location) messages are to be generated. If a zero is entered then the output is disabled. The default value is 15 minutes.

RTCM Max Avg Data Rate — Specify the effective bit rate for data transmission. Zero indicates that the data should be sent at the maximum rate the hardware can handle. Null records will be sent to fill up the hardware bandwidth. A non-zero entry also means that no more than one null record per second is sent when corrections are not available. This field has no effect when interfaced to a beacon modulator.

671 Port — Select to which port the type 671 (hex-ASCII differential corrections) message is to be sent. The possible choices are: *Control, RTCM,* or *Equipment.*

Accucode™ Output Rate	When set to non-zero, this field enables output of type 59 RTCM Accucode™ messages which contain high accuracy information which may be used by Leica 12 Channel DGPS Navigators to further improve their positional accuracy. Output of this message will use up the same bandwidth as RTCM type 1 (DGPS corrections) records. This output should be enabled ONLY when Leica 12 Channel DGPS Navigators are employed in the net to accept this data.
RTCM Type 7 Interval	Specify the interval, in minutes, that type 7 (Beacon Almanac) messages are to be generated. If a zero is entered then the output is disabled. This message is required only when the reference station is used as part of a DGPS Beacon System. The message is used by navigators to allow automatic transitioning between beacons. The default value is 11 minutes.
Count All RTCM in Avg Data Rate	If set to *No*, then only RTCM Type 1 records (differential corrections) are used when computing the RTCM Average Data Rate. This is useful only when transmitting RTCM data over a limited bandwidth link which can tolerate the "bursts" caused by occasional transmission of non-Type 1 RTCM records. If set to *Yes*, then all RTCM records are used to compute the RTCM Average Data Rate.
RTCM Ends With <CR><LF>	Select *Yes* if the receiver is to append a carriage return and line feed to the end of the RTCM message, or *No* if not.

POSITION PROJECTION SCREEN

This screen allows the user to select the datum in which position information will be displayed and output. The following datum shift parameters must be input for operator entered datums (datum numbers 1 - 5):
Semi-Major Axis (meters), Flattening Coefficient, Scale Factor, Delta X, Y, and Z (meters) from the WGS-84 spheroid, and the Rotation about X, Y, and Z in seconds. A detailed list of each of the 111 available datum numbers including the shift parameters is provided in the DGPS 12 Channel Technical Reference Manual, Appendix C.

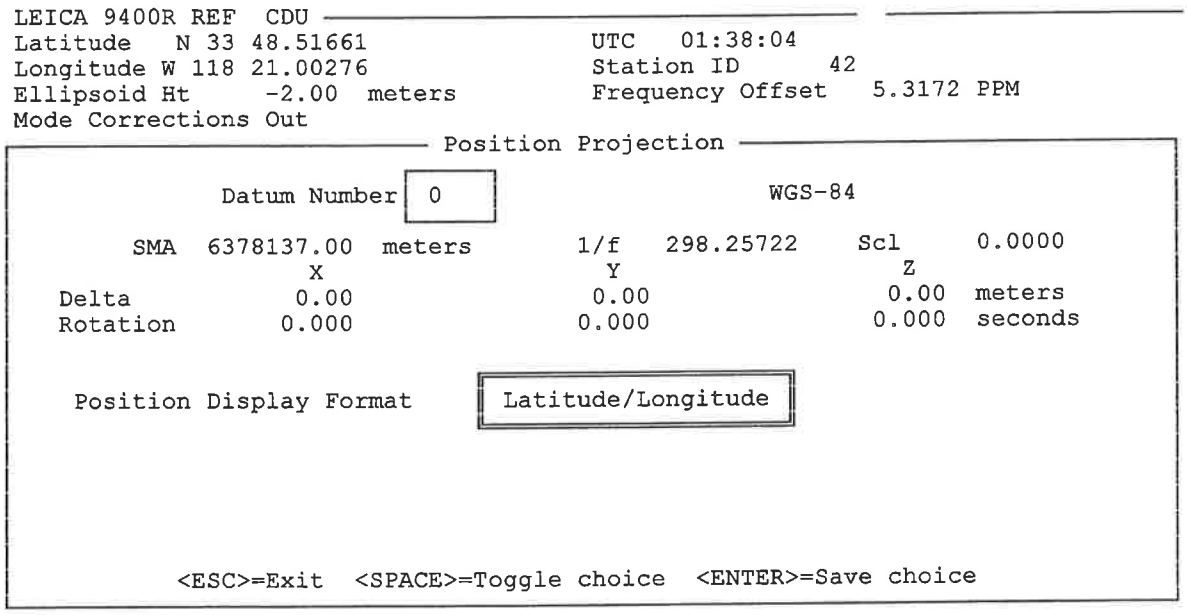

Figure 3-8. Position Projection Screen

Datum Number This field allows you to select from a pre-defined list of datums (0, and 6 - 111), or to enter 5 unique user datums (numbers 1 - 5). A detailed list of each of the 111 available datum numbers including the shift parameters is provided in the DGPS 12 Channel Technical Reference Manual, Appendix C.

SMA This field is used to report/enter the semi major axis; and alternates between a display field and a data entry field depending on the datum number chosen. Operator defined datums (1 - 5) will cause this field to allow data entry. For all other datums, this field will display the value from the datum data base.

1/F This field is used to report/enter the flattening coefficient; and alternates between a display field and a data entry field depending on the datum number chosen. Operator defined datums (1 - 5) will cause

this field to allow data entry. For all other datums, this field will display the value from the datum data base.

Scale

This field is used to report/enter the scale factor; and alternates between a display field and a data entry field depending on the datum number chosen. Operator defined datums (1 - 5) will cause this field to allow data entry. For all other datums, this field will display the value from the datum data base. The MX 9400 automatically multiplies the entered scale factor by 10^{-6} and adds 1. Therefore, for a desired scale factor of 1.0 the operator would enter 0.0. For a scale factor of 1.000321 the operator would enter 321.

Delta X, Y, Z

This field is used to report/enter the delta X, Y, and Z offset between the selected datum and WGS-84, in meters; and alternates between a display field and a data entry field depending on the datum number chosen. Operator defined datums (1 - 5) will cause this field to allow data entry. For all other datums, this field will display the value from the datum data base.

Rotation X, Y, Z

This field is used to report/enter the rotation about the X, Y, and Z axes between the selected datum and WGS-84, in seconds; and alternates between a display field and a data entry field depending on the datum number chosen. Operator defined datums (1 - 5) will cause this field to allow data entry. For all other datums, this field will display the value from the datum data base.

Position Display Format

The user can select the format for position output and display. The possible choices are: *Latitude/Longitude, UTM/UPS, or MGRS.* The records affected by this field are defined in the DGPS 12 Channel Technical Reference Manual, Appendix C, and are listed below:

Control Port Input Records: 400
Control Port Output Records: 412, 413, 414, 831
Instrumentation/Raw Data Records: 10, 13

TIME RECOVERY SCREEN

This screen allows the user to adjust the time synchronization of the 1PPS output. Since the synchronization of time is critical to many applications, you must carefully determine whether the output pulse is to occur at UTC or at GPS time, if there is a user time bias, and precisely what that bias should be. Measurement capture time is synchronized to the 1PPS output. Furthermore, you can specify the action to be taken when the pulse output does not occur within the specified error tolerance, or threshold.

In addition to the 1PPS output, an ASCII message may be sent on either the Control, Equipment, or Raw Data Port, which contains the time and date of the following pulse.

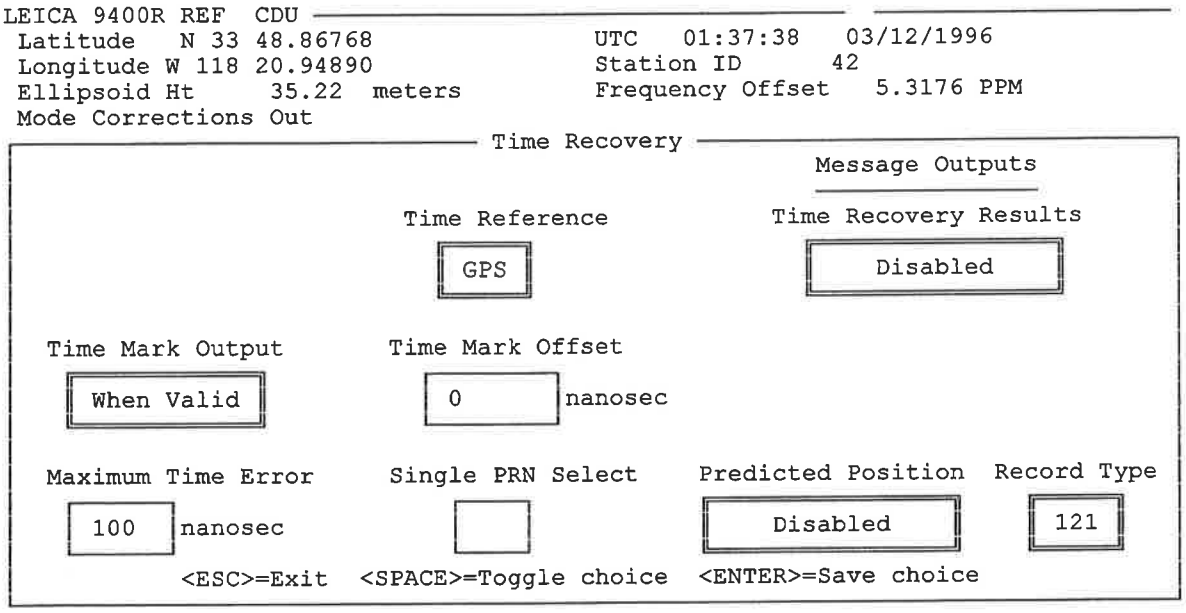

Figure 3-9. Time Recovery Screen

Time Reference This field allows you to synchronize the 1PPS output to either *UTC* or *GPS* time.

Time Recovery Results Specify where the ASCII time recovery message should be sent. The possible choices are:

- *Disabled* — Do not output the ASCII time recovery message.
- *Control Port* — Send the ASCII time recovery message to the Control Port.
- *Equipment Port* — Send the ASCII time recovery message to the Equipment Port.

	➢ *Raw Data Port*	Send the ASCII time recovery message to the Raw Data Port.
Time Mark Output	This field allows you to determine what the receiver will do when the 1PPS pulse is not within the specified tolerance. There are two possible choices:	
	➢ *When Valid*	The receiver emits a time pulse only when time is accurate to within the tolerance specified in the Maximum Error field.
	➢ *Always*	The receiver emits a time pulse regardless of the limit specified in the Maximum Error field.
Time Mark Offset	This field allows you to offset the time of the 1PPS pulse. For example, to generate a pulse 200 nanoseconds earlier, you would enter +200 in the field, to output a pulse later, you would enter a negative number.	
Maximum Time Error	This field allows you to specify the time within which the receiver will consider a time pulse to be valid. The entry can be between 50 and 1000 nanoseconds. The default value is 100 nanoseconds.	
Single PRN Select	A non-zero entry (1 - 32) will cause the receiver to perform time recovery functions from the identified satellite only. If the selected satellite is not currently being tracked, time recovery will be suspended. If the MX 9400R is operating as a navigator, then *Position Known* mode must be selected as the Operating Mode (see *Initialization* screen) in order for the data to be accepted by the CDU.	
Predicted Position	When operating with a reference station, enabling this field for output generates a record every second which contains the truth reference location. This field would generally be *disabled* for reference stations.	
Position Record Type	Choose either *121* or *123* as the sentence type to output. These sentences are output within a few milliseconds of the 1PPS output. Refer to the Leica 12 Channel Technical Reference Manual for a detailed description of these sentences.	

EVENT OUTPUT CONTROL SCREEN

This menu selection enables the user to setup the action to be taken by the receiver when any events are detected. A minimum time guard is also set which ensures that erroneous events or signal bounce will not be interpreted as an actual event.

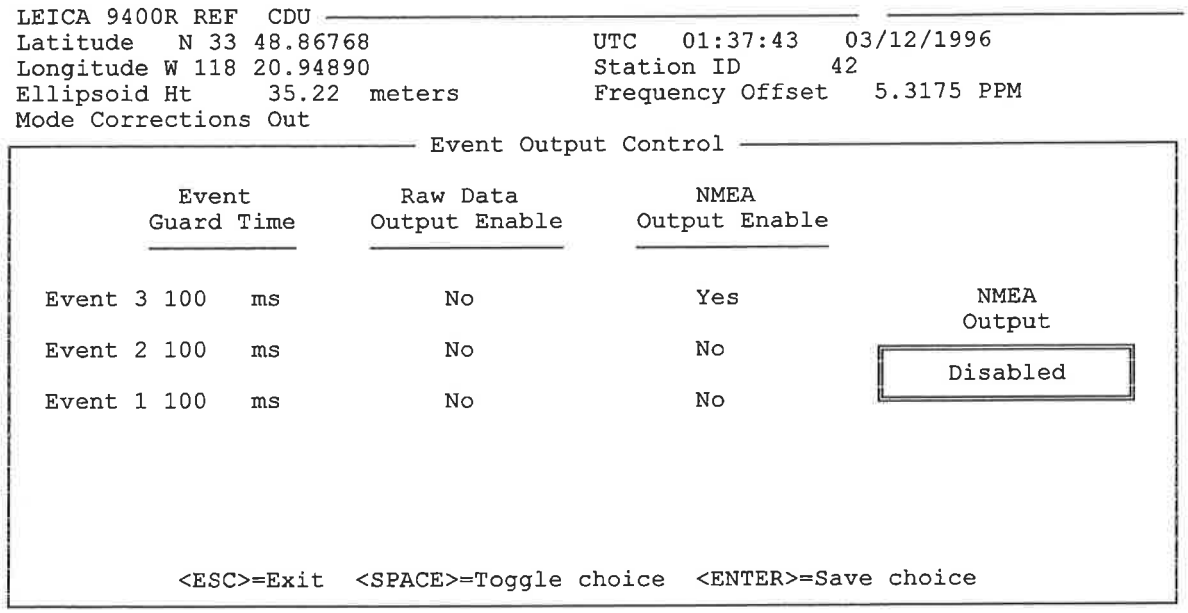

Figure 3-10. Event Output Control Screen

Event Guard Time Enter the minimum acceptable time between events, in msecs. If a signal is detected within this time period, it will be ignored.

Raw Data Output Enable Toggle the *Space* bar to enable output of the External Event message on the Raw Data port (message type 10).

NMEA Output Enable Toggle the *Space* bar to enable output of the NMEA External Event message, record type 831. This message is output to the port selected in the NMEA Output field.

NMEA Output Select which port the NMEA External Event message, record type 831, is to be output. The possible choices are: *Disabled, Control Port, Raw Data Port* or *Equipment Port.*

BEACON MODULATOR SETUP SCREEN

This menu selection enables the receiver to transmit differential corrections to a beacon modulator to be broadcast to beacon receivers. If the field labeled Beacon Modulator Present is set to *No*, the reference station will transmit differential corrections in the RTCM 6 of 8 bit format, which will not be recognized by the beacon modulator. It is imperative that the interface format at the beacon receiver be identical to that at the beacon transmitter. You must verify that the information entered for the Frequency, Bit Rate, and Error Detection and Correction (EDAC) Encoding are correct.

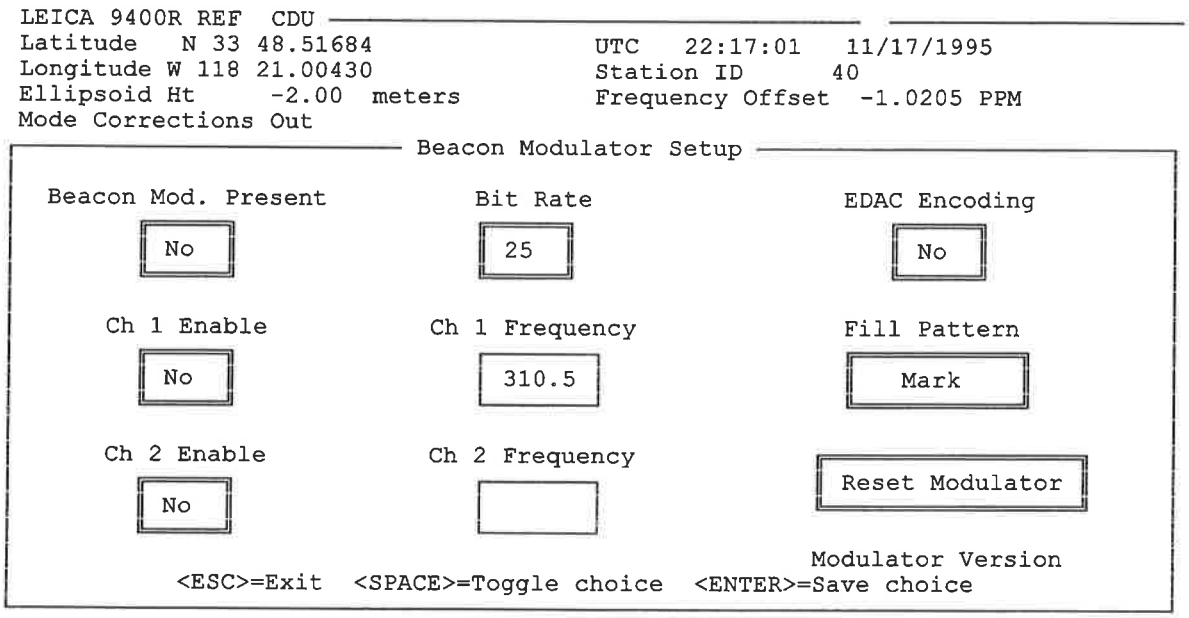

Figure 3-11. MX-50M Setup Screen

Beacon Modulator Select *Yes* if a beacon modulator is connected to the receiver for transmission of differential corrections, otherwise select *No.*

Bit Rate Select the effective bit rate, in bits/second, at which the data is transferred. This value must be identical to that at the beacon transmitter. The possible choices are: *25, 50, 100, 200.*

EDAC Encoding Select *Yes* to enable EDAC (Error Detection and Correction) Encoding, or *No* to disable.

Ch 1 Enable Select *Yes* to enable the beacon modulator to modulate the output signal on channel number 1. Selection of *No* suspends the output. This field MUST be set to *Yes* to transmit DGPS corrections.

Ch 1 Frequency Enter the frequency for channel number 1 to tune the beacon receiver. The

value must be between 283.5 - 325.0 Khz. The resolution is .5 Khz.

Fill Pattern Specify how the beacon modulator should modulate when DGPS corrections are not available. The valid choices are:

- *Space* — Modulate using only 0's.
- *Mark* — Modulate using only 1's.
- *Alternate* — Modulate using a pattern of 0,1,0,1, ... etc.
- *Park* — Do not modulate.

Ch 2 Enable Select *Yes* to enable the beacon modulator to modulate the output signal on channel number 2. Selection of *No* suspends the output. This field MUST be set to *Yes* to transmit DGPS corrections.

Ch 2 Frequency Enter the frequency for channel number 2 to tune the beacon receiver. The value must be between 283.5 - 325.0 KHz. The resolution is .5 Khz.

Reset Modulator Pressing *Enter* will cause the receiver to send a reset command to the beacon modulator.

BEACON ALMANAC ENTRY SCREEN

This menu selection provides the location, frequency, service range, and health information for a network of beacons equipped to transmit DGPS information. The bit rate, modulation mode, synchronization and EDAC setup for the individual beacons is also included in this screen. The beacon almanac information is contained in an RTCM type 7 record, sent from the reference station. An example of the *Beacon Almanac Entry* screen is given below.

```
LEICA 9400R REF  CDU
 Latitude   N 33 48.51080              UTC   15:50:38   03/16/1995
 Longitude W 118 20.99779              Station ID      0
 Ellipsoid Ht      0.00  meters        Frequency Offset  -0.5958 PPM
 Mode Corrections Out
                              Beacon Almanac Entry
 Latitude  Longitude   Range   Freq    Hlth  ID     Bit     Modu  Frame   EDAC
                        (km)   (KHz)                Rate    Mode

 N 33 50   W 118 30    1000   300.5    +     1001   100     MSK   Sync     N
                                       ?            ???     MSK   Sync     N
                                       ?            ???     MSK   Sync     N
                                       ?            ???     MSK   Sync     N
                                       ?            ???     MSK   Sync     N
                                       ?            ???     MSK   Sync     N
                                       ?            ???     MSK   Sync     N
                                       ?            ???     MSK   Sync     N
                                       ?            ???     MSK   Sync     N
                                       ?            ???     MSK   Sync     N

          <ESC>=Exit  <SPACE>=Toggle choice  <ENTER>=Save choice
```

Figure 3-12. Beacon Almanac Entry Screen

Latitude/Longitude The coordinates for the beacon transmitter.

Range The service range of the beacon signal, in kilometers. A range of 0 will delete the line from the beacon almanac.

Freq The frequency, in KHz, of the beacon signal.

Hlth The current health status of the beacon transmitter. A `+' indicates that the transmitter is operating normally, `?' means the status is undefined, `/' means the status is not available and `-' means don't use the information.

ID The identification number of the reference station associated with the beacon transmitter.

Bit Rate The bit rate of the beacon transmitter.

Modu Mode The modulation mode of the beacon transmitter. *MSK* indicates Minimum Shift Keying modulation, *FSK* is for Frequency Shift Keying.

Frame	`*Sync*' indicates that the data is synchronous, `*Async*' means asynchronous.
EDAC	`*N*' indicates that the EDAC Encoding is off, `*Y*' indicates EDAC Encoding is on.

GPS CHANNEL STATUS DISPLAY SCREEN

This screen reports individual channel status. There is one line of information for each of the twelve channels. The *F2* function key can be used at any time to activate this display.

```
LEICA 9400R REF  CDU
 Latitude    N 33 48.51684              UTC   22:17:15   11/17/1995
 Longitude W 118 21.00430               Station ID      40
 Ellipsoid Ht     -2.00  meters         Frequency Offset  -1.0129 PPM
 Mode Corrections Out
                          GPS Channel Status Display
  PRN    Status   Sig/No      Corr       Rate       Age    IODE    Azm     Elev
                  (db/Hz)      (m)       (m/s)      (s)            (dg)    (dg)

  25      ++        45       -31.94      0.500      0.6     A4     045      28
  22      ++        50       -14.59      0.199      0.6     83     113      43
  19     SRCH        0                                             231       0

  15      ++        43       -28.86      0.080      0.6     9E     206      23

   4     SRCH        0                                             322       5
  18      ++        40        -4.86      0.116      0.6     A3     288      17
  14      ++        53        -1.93      0.001      0.6     1A     314      75

  29      ++        51       -22.12      0.601      0.6     32     307      45


                          Sats visible 8
                             Sats Used 6
```

Figure 3-13. GPS Channel Status Display Screen

PRN Satellite ID Number

Status Current status of the satellite signal. The possible values are:

+	Satellite signal good.
-	Satellite forced unhealthy.
EPH	A satellite ephemeris is being collected. No current ephemeris information is available yet.
FRAM	The receiver has not yet synchronized with the satellite message.
LOW	The satellite elevation is below the user specified Satellite Elevation Mask. (see *Reference Station Control* screen)
REAQ	The satellite signal has been lost (C/N0 is too low).
SRCH	The satellite signal has not yet been detected.

Status	*(continued)*
	WAIT — Waiting for sufficient measurements to start correction filter. May also indicate waiting for almanac collection to complete.
Sig/No	Carrier signal to noise ratio in dB/Hz (also known as C/N0). A minimum value of 28 dB/Hz is required for tracking. A value of zero is displayed for those satellites that have not yet been acquired by the receiver.
Corr	Differential correction, in meters.
Rate	The rate of change of the differential correction, in meters per second.
Age	The time, in seconds, since the correction was computed.
IODE	Issue Of Data Ephemeris as broadcast by the satellite.
Azm	Azimuth angle of the satellite in degrees from true north.
Elev	Elevation angle of the satellite in degrees above the horizon.
Sats Visible	The total number of satellites visible to the receiver based on the almanac, present position of the antenna, and elevation mask limit.
Sats Used	The number of satellites actually used for correction generation.

SEND RTCM MESSAGE SCREEN

This menu selection enables the user to broadcast a message to the DGPS navigators. The message is entered in this screen and is packaged into a type 16 RTCM record to be broadcast. The type 16 record is transmitted when *Enter* is pressed and the Send RTCM Message field is highlighted.

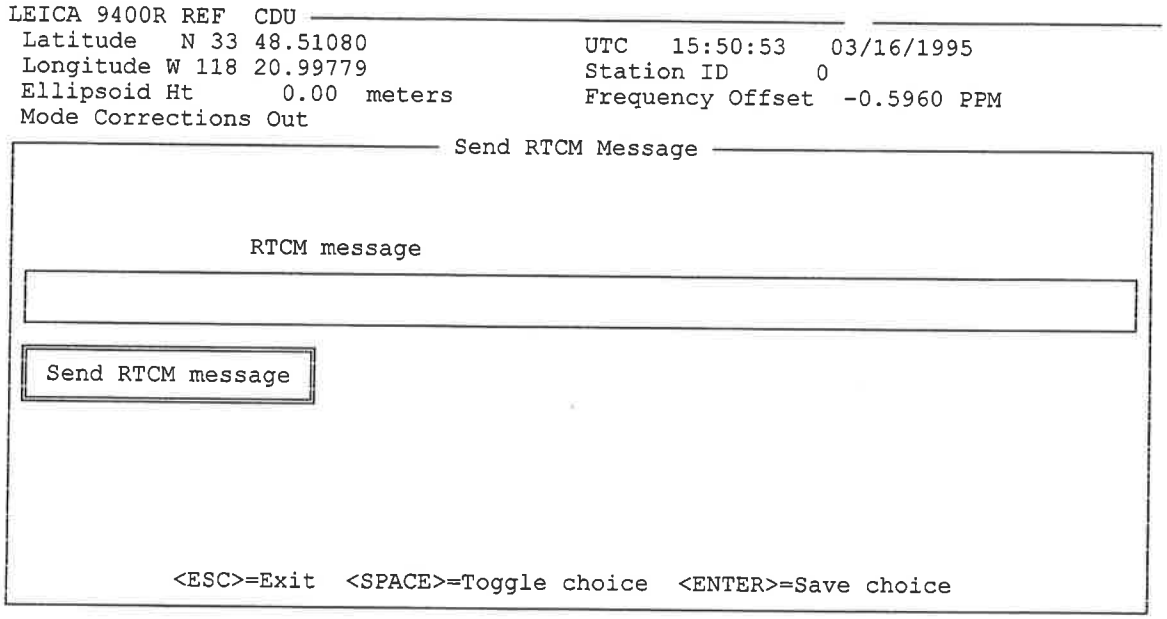

Figure 3-14. Send RTCM Message Screen

SATELLITE HEALTH SCREEN

The satellites are classified by the GPS system as either healthy or unhealthy. The basis for the classifications are the comprehensiveness of the almanac and accuracy of the ephemeris. The classifications are broadcast by the satellites themselves in their navigation messages. The classification appears in the *Satellite Health* screen as + (healthy) or - (unhealthy).

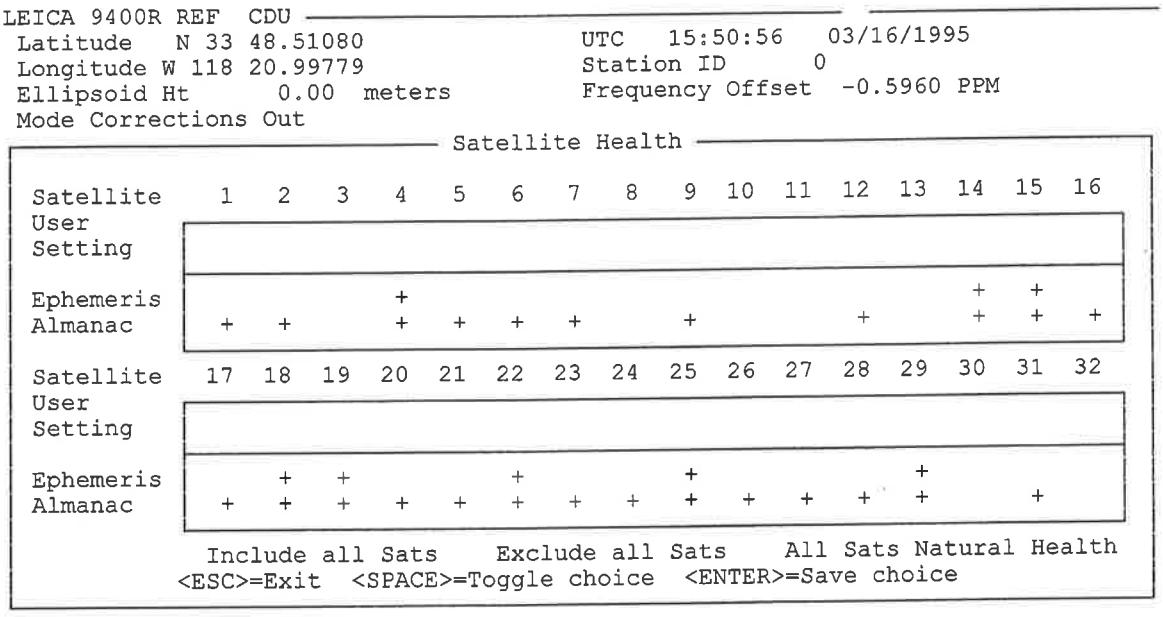

Figure 3-15. Satellite Health Screen

Satellite User Setting — You can 'force' a reported unhealthy satellite to be tracked or you can 'force' a reported healthy satellite to be excluded from tracking. You include, exclude, or allow the reported status to determine satellite use by toggling the *Space Bar*. The possible choices are:

- *EX* — Exclude the satellite from tracking.
- *IN* — Include the satellite for tracking.
- *Blank* — Let the reported status determine inclusion.

Ephemeris — This field shows the satellite health status as given in the ephemeris.

Almanac — This field shows the satellite health status as given in the almanac.

PC SETUP SCREEN

This menu selection provides fields to define the physical interface between the PC CDU and the receiver. The baud rates for the ports used to communicate with the CDU, the screen monitor type, and the port configuration are defined here.

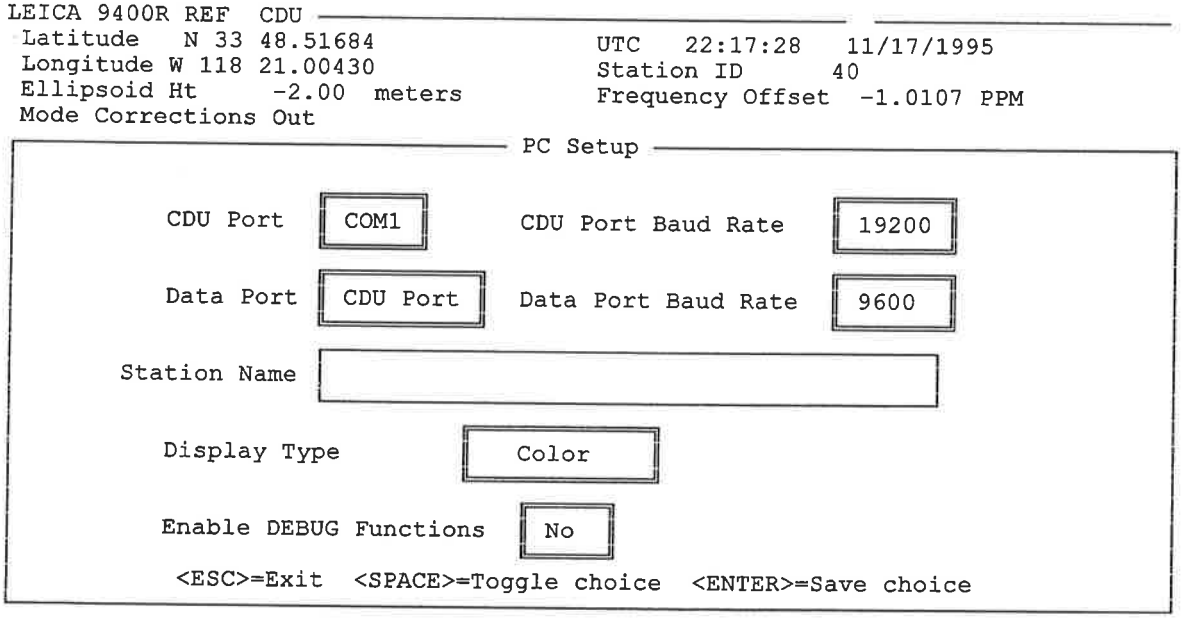

Figure 3-16. PC Setup Screen

NOTE

Make sure that the baud rates you choose on this screen are the same as the baud rates previously selected on the Receiver Port Configuration screen, otherwise there will not be any communication between the PC and the receiver. The factory default baud rate for all receiver ports is 9600.

CDU Port — Specify to which PC port the receiver Control Port is connected. The possible choices are: *COM1* or *COM2*.

CDU Port Baud Rate — Baud rate for the PC - Control Port interface. Verify configuration of the system prior to modifying this field. The possible choices are: *1200, 2400, 4800, 9600, 19200, 38400.*

Data Port — Specify to which PC port the receiver Raw Data Port is connected. The possible choices are: *COM1* or *COM2*.

Data Port Baud Rate — Baud rate for the PC - Raw Data Port interface. Verify configuration of the system prior to modifying this field. The possible choices are: *1200, 2400, 4800, 9600, 19200, 38400.*