RTM 61M

Version 1.03

User's Manual

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Introduction 1

The Geomar RTmap61M Data Logging System consists of a data logging program RTmap61M and associated PC computer program RTM61M. The program RTmap61M is designed for various field computers, Windows CE based Allegro CX and DOS based Allegro CE/DOS and Allegro DOS. The RTmap61MP is prepared to handle the different size screen of the Pro4000 field computer. If necessary DOS based RTmap61M can be used with any other IBM compatible computer running an MS DOS operating system and equipped with the necessary number of serial ports. The only disadvantage of using a standard laptop computer will be the small size of the display which is limited for the Allegro field computers.

The program RTM61M is used to process data files recorded under the control of program RTmap61M. It recognizes data file formats created with various versions of RTmap61M automatically. When data acquisition program is used in Allegro CX or other Windows CE based computer the RTM61M version 1.50 or later must be used.

1.1 About the RTM61M

The program RTM61M is a Windows based program for IBM PC compatible computers operating under Windows 95/98/XP/NT(V4.0) and Windows 2000. The program RTM61M is designed to process data collected by a field computer under the control of programs RTmap61M or RTmap61MP. The program can be used to transfer data from the DOS based field computer to PC, to position EM61M sensor based on real time GPS data or by using a postprocessed GPS file. The program allows you also to convert data to Geonics DAT61MK2 format, to convert to ASCII text file format, to position field comments, generate position file for stand-alone GPS positions (GXY), and to correct created XYZ files for a delay (lag) caused by the system time constant.

Main function of this program is to position Geonics EM61M based on the recorded GPS position, the instant heading of the system, the configuration of the system, and several user specified filters. Configuration of the system is described by offsets of the GPS antenna from the center of the EM61M sensor. The program calculates real position of the instrument based on specified GPS antenna offset and direction of the movement. However, it is highly recommended that GPS antenna is placed in the center of the EM61M sensor as this configuration provides the best accuracy. Optionally elevation data can be written to the output file. The program corrects elevation data for the GPS antenna height. The program can process seven different NMEA GPS messages record-

ed by data acquisition software RTmap61M: a pair GGA/GSA, GGA, POS, LLK, LLQ, GLL, and GGK (Trimble and Leica versions). In addition program handles interface of Leica Robotics Total Station TPS1100 and TPS1200.

The RTM61M also allows you to correct the collected GPS positions with post-processed GPS files.

The RTM61M uses data files in RTmap61M format which have extension name P61. These are binary files with a record length of 27 bytes terminated by Line Feed character. These files should not be edited using standard text editors. The program can also process files with extension GXY. The GXY file contains stand-alone GPS positions if the RTmap61M program was used to collect GPS data only. These files are also binary (records are 27 bytes for Windows CE based program and terminated by Line Feed character) and care should be taken if they are viewed with text editors. Files GXY generated by any other Geomar data acquisition program i.e. ML61, NAV61, NAV31, etc. are fully compatible and they can be processed by RTM61M.

One sample RTmap61M data file, 030610A.T61, and one external (postprocessed) GPS file Trext18.txt are included on the program disk. They allow the user to become familiar with running the RTM61M program.

1.2 Contents of RTM61M Distribution Disk

Program RTM61M is supplied on one CD disk. Disk contains following files and directories:

SetupT61M	-	setup program for RTM61M
Documentation	-	directory containing all RTmap61M and RTM61M, and other Geomar manuals in PDF format.
RTmap61M	-	Allegro CX version of data acquisition program
Util	-	only when program is supplied with USB security key (dongle). This directory contains all necessary files that are used USB security key (dongle) functions.

The program can be also supplied on floppy disks if requested.

1.3 RTM61M Software Installation

RTM61M uses a setup program to load files onto your computer. The following section describes the installation process. To install RTM61M: Insert the RTM61M CD disk (or floppy diskette #1) into computer CD (or floppy) disk drive. Exit all Windows applications before installing the program. From the Windows File Manager, select **Run** from the **File** menu. The Run dialog box opens (Figure 1.1).

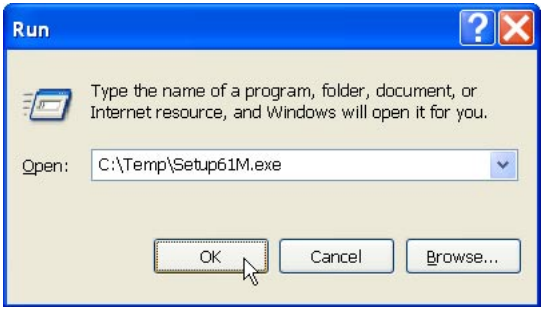


Figure 1.1: Run Dialog window

Browse for the file SETUP61M.EXE in the directory of the diskette. Click **OK** to launch the Setup program. Once the Setup determines your computer configuration the Welcome window opens (Figure 1.2).

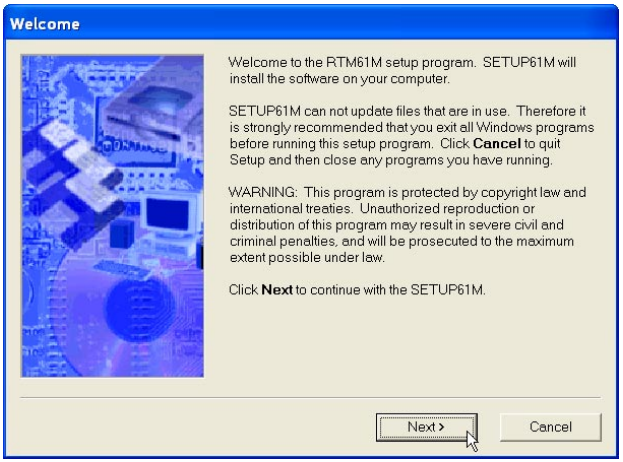


Figure 1.2: Welcome window

Read the text and click the **Next** button. The Serial Number window will be displayed (Figure 1.3).

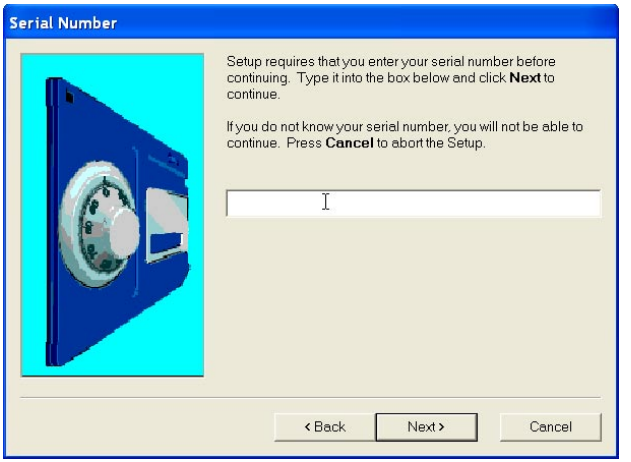


Figure 1.3: Serial Number window

In case the software is supplied with USB security key (dongle) the Serial Number window will be not displayed, otherwise please type the Serial Number into the provided box and press the **Next** button. (If you do not know the Serial Number, you will not be able to continue.) The Installation Directory window opens (Figure 1.4).

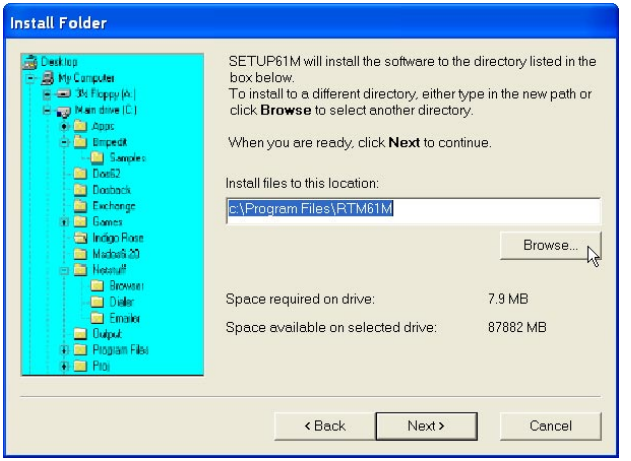


Figure 1.4: Installation Directory window

The default directory is C:\Program Files\RTM61M. Click the **Next** button to install the program to this directory. If you wish to install RTM61M to another directory, click the **Browse** button, and the Select Installation Directory window will open (Figure 1.5).

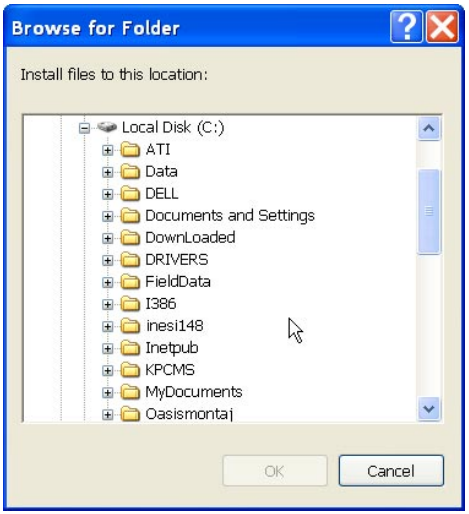


Figure 1.5: Select Installation Directory window

Select a target directory and click **OK**. The Select Installation Directory window closes, and the Installation Directory window opens with the selected directory listed. Click the **Next** button. The Select Short cut Folder window opens (Figure 1.6).

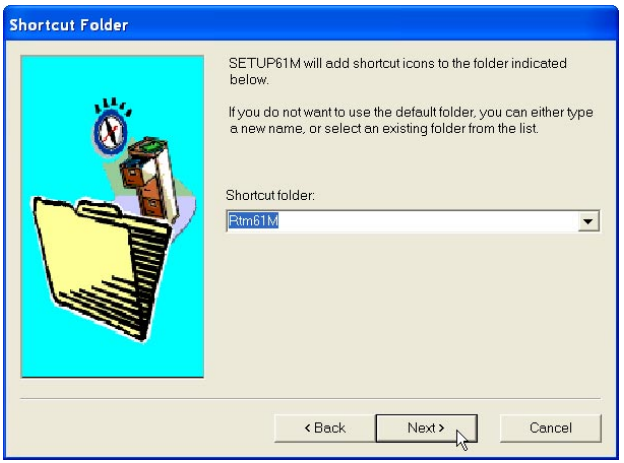


Figure 1.6: Select Shortcut Folder window

The setup program will create a RTM61M menu item in the Program menu accessible by clicking **Start**. If you do not want to use the proposed folder, you can either enter a new name, or select an existing folder from the list. Click **Next** and the Ready to Install window will follow (Figure 1.7).

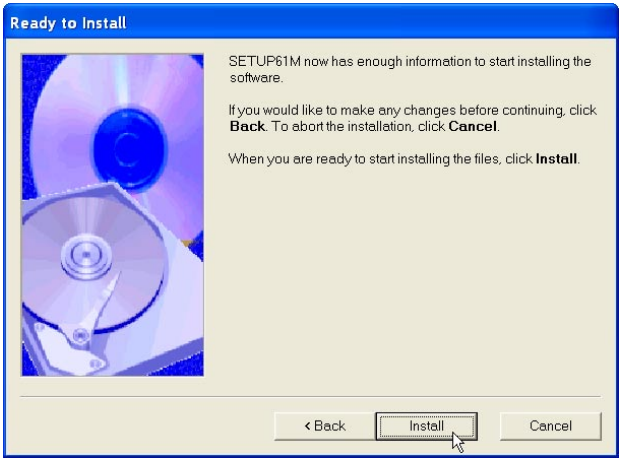


Figure 1.7: Ready to Install window

In case you would like to make any changes before the installation, click **Back**. To abort installation click **Cancel**. If you are ready to start installation, click **Finish**. The installation progress bar will appear (Figure 1.8).

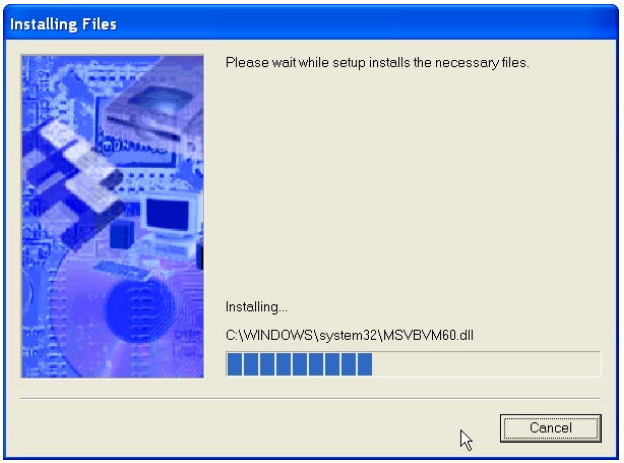


Figure 1.8: Installing Files

The Installing Files window with a progress bar displays the percentage of the installation completed. When finished, the following window will appear (Figure 1.9).

Click **Finish** to end installation. Setup61M creates a RTM61M program group and places **RTM61M** and **Uninstall** icons into it. The setup program creates also a **RTM61M** menu item in the Program menu accessible by clicking **Start**. A reminder to restart the system will be displayed at the end of the setup program. The destination directory that was chosen earlier contains program files and sample data files.

Figure 1.9: Finished window

1.4 Program Overview

Start the RTM61M by double clicking the RTM61M icon in the **Start|Programs** menu, in Windows Explorer, or on the desktop if a shortcut was created. At the start, RTM61M displays the following screen (Figure 1.10):

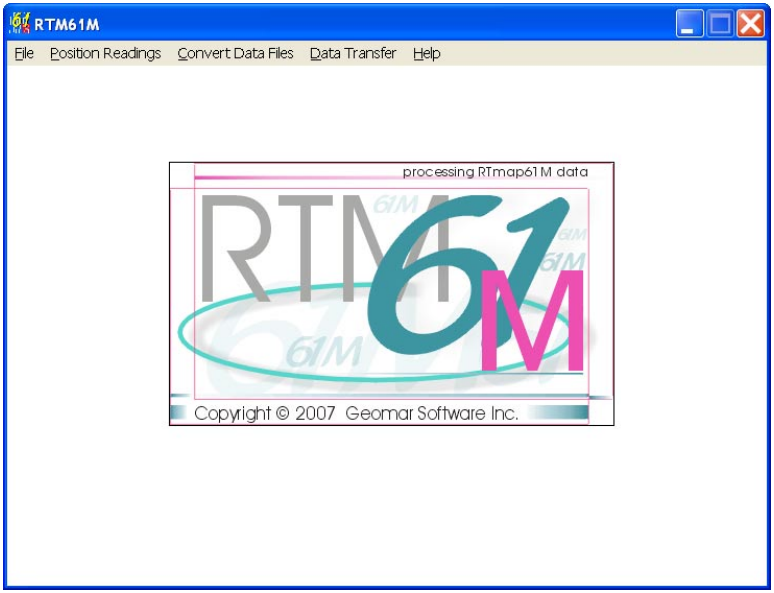


Figure 1.10: RTM61M Main Screen

The RTM61M is a menu driven program. Most of menus items are disabled till a data file is loaded in to the program. A short description of the possible menu options is given below.

File Menu

The File Menu is shown in Figure 1.11. Functions accessible from this menu allow you to load data file, to save data set, to save data set under different file name (Save As), to remove loaded data from the program memory (Close), to edit data parameters, to display two dimensional layout of selected XYZ file, and exit the program.

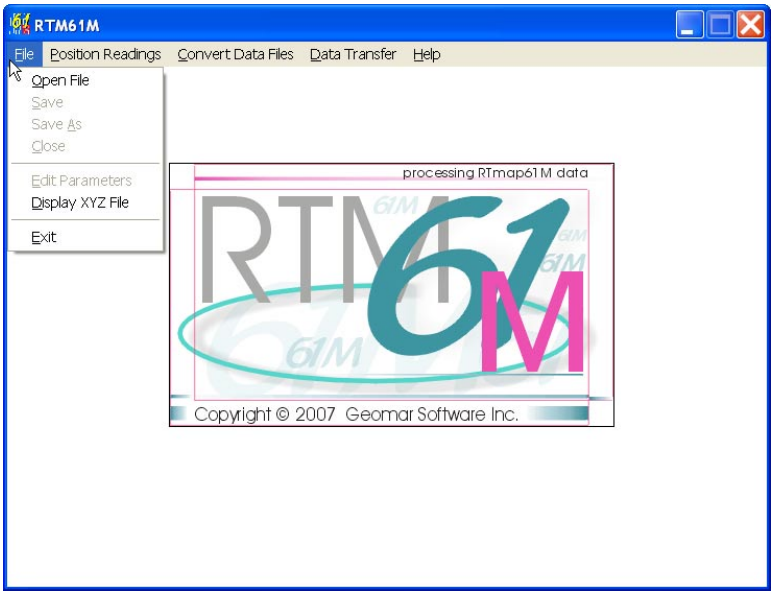


Figure 1.11: RTM61M File menu

When program starts most of items in File menu are disabled. As soon as data file is selected and data is loaded to the program memory the splash graphic disappears and the program displays information related to data file contents, Figure 1.12. At the same time remaining items in the File menu are enabled.

RTM61M does not allow to overwrite original data file. The Save option is enabled only when not original data file (i.e. with edited parameters or previously Saved As) was loaded or after option Save As was used. When original data file is selected the name of the file and date of the creation is displayed at the top of the screen. In case when not original file was loaded then the current file name is displayed, followed by an original date of creation and original file name, for example: "Created on 06/02/2003 as 0602A.T61".

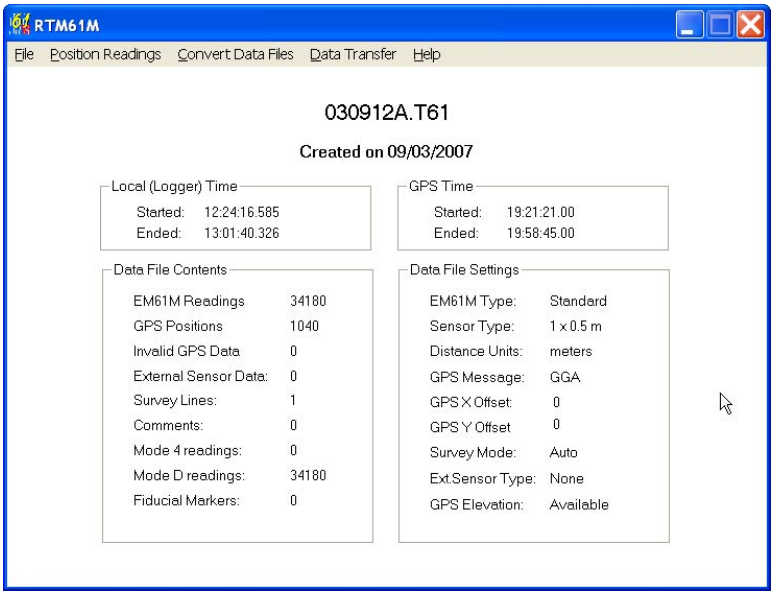


Figure 1.12: RTM61M Main Screen after Loading data file

The information displayed by the RTM61M contains Local and UTC time, number of EM61M data points and GPS positions, specified distance units and GPS antenna offsets, etc. (see Figure 1.12). Four parameters: Sensor Size, Distance Units, GPS X and Y offsets can be adjusted using the Edit Parameters item (see Figure 1.13).

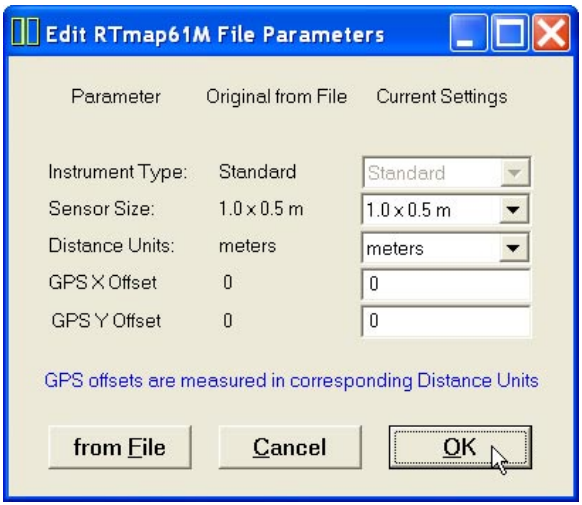


Figure 1.13: Edit Parameters window

The Position Sensors menu represents the main function of the program: positioning of the EM61M sensor based on the system geometry and GPS positioning (Figure 1.14).

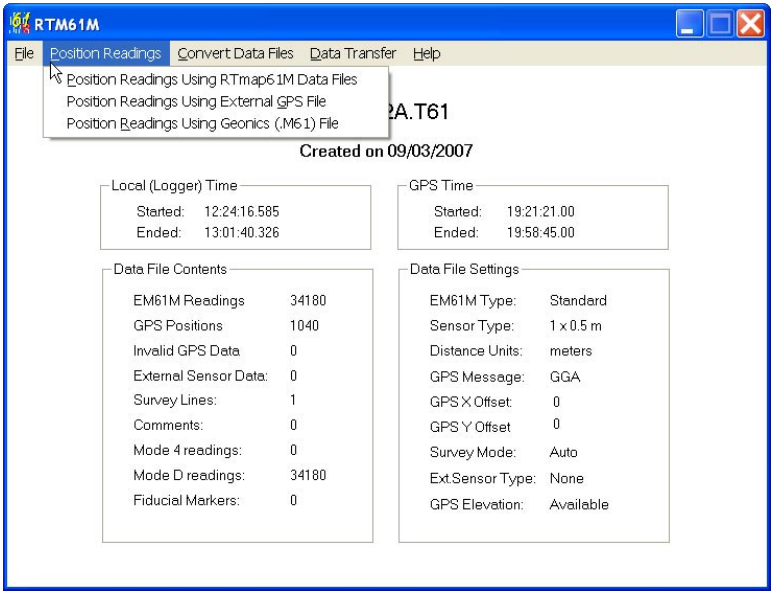


Figure 1.14: RTM61M Position Sensors menu

The first item of the menu, Position Sensors using RTmap61M Data File allows you to position sensors based on Real Time GPS data embedded in RTmap61M file. Using GPS data the program can also place elevation data in the output file.

The second item, Position Sensors using External GPS File is used to replace Real Time GPS data by positions from the post-processed GPS data file. The later requires that the GPS data is collected in the field computer running RTmap61M program as well as in the GPS receiver logger. GPS data can be processed by the GPS manufacturer software and then exported as an ASCII file. This option is especially useful in the following cases:

- when Real Time differentially corrected positioning is not available,
- accuracy of positioning may be further improved by processing data using special GPS software,
- if special or unique coordinate system provided by GPS software is required and it is not available in other employed data processing or mapping software.

The third method allows you to position EM61M stations based on Real Time GPS data which were recorded in RTmap61M data file during the survey and then converted and processed in Geonics program DAT61MK2. The DAT61MK2 has its own GPS Positioning option however it does not support NMEA messages other than GGA, filtering for PDOP Mask, GPS Minimum Interval and GPS Antenna offsets.

Convert Data Files Menu

The Convert Data menu has four functions available. The menu is shown in Figure 1.15.

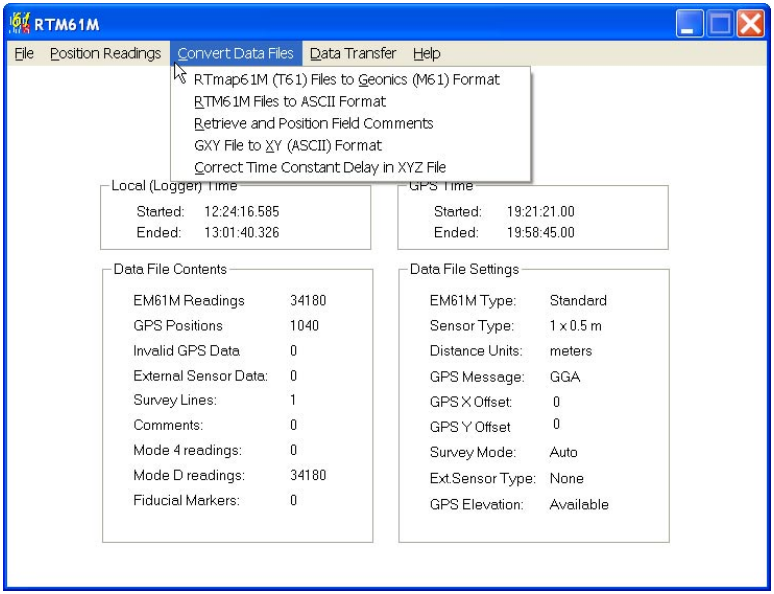


Figure 1.15: RTM61M Convert Data menu

The first item, RTmap61M Files to Geonics M61 Format allows you to convert RTmap61M data files to files that can be loaded and processed by the Geonics DAT61MK2W program.

The second item, RTmap61M Files to ASCII Format allows you to convert data files to ASCII text format. This file can be simply used to examine data in text mode, or it can be easily converted to other formats if required.

In case when the RTmap61M program was used to acquire stand-alone GPS positions (without EM data) the data files have extension name GXY. The third item, GXY File to XY (ASCII) Format can be used to convert binary data file to simple text file with

two to four columns: Easting (Longitude), Northing (Latitude), and optionally Elevation (including correction for GPS antenna height) and Time Stamp of the record. These files can be used in other applications, i.e. in mapping software to denote topographical features as roads, fences, etc.. This option can be also used to convert any RTmap61M data file to a text file containing coordinates and elevation of GPS positions.

The fourth item of the Convert menu, Retrieve and Position Field Comments allows you to filter out and position field comments entered by the operator during the survey.

The last option of the Convert menu, Correct Time Constant Delay in XYZ Files can be used to correct the effect of the system (combined EM61M and GPS receiver) time constant delay in two dimensional XYZ files generated during positioning EM61M data.

Data Transfer Menu

This menu has one item only: Download Allegro CX Files. The menu is shown in Figure 1.16.

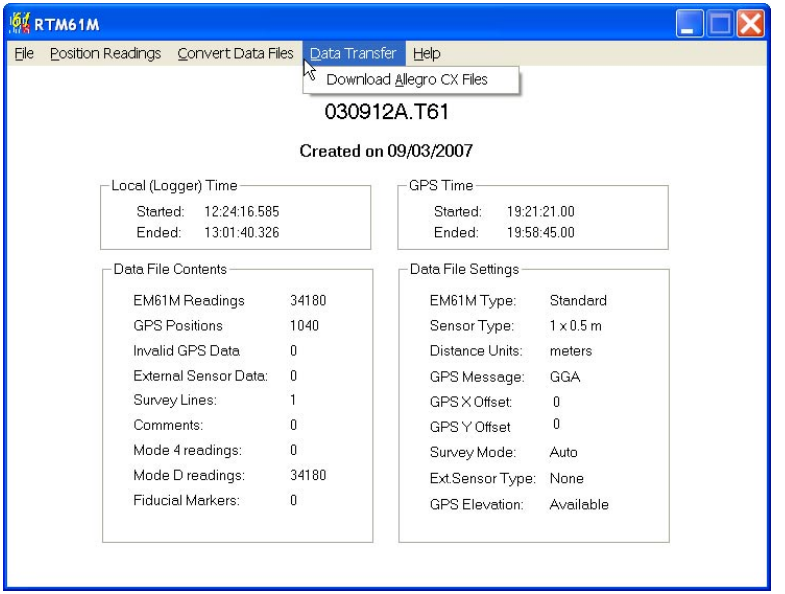


Figure 1.16: RTM61M Data Transfer menu

Transfer of files from Allegro CX (Windows CE.NET based field computer) is handled by the MS ActiveSync program. Therefore the second item of this menu displays information only (Figure 1.17).

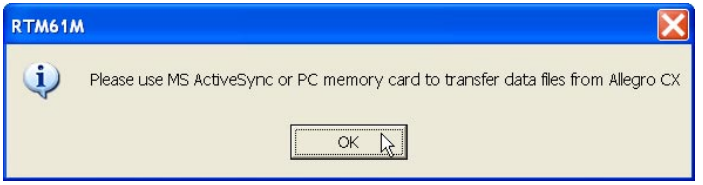


Figure 1.17: Allegro CX data transfer info

Optionally, data files and program files can be transferred between Allegro CX and other computers by using PC memory card. A PCMCIA card slot is located behind the Allegro display (please see Allegro manual). Memory card becomes a Storage Card in Allegro CX. Memory card is the fastest and easiest way of performing data transfer between Allegro and PC computer. In addition to data transfer, memory card can serve as a data back up device during the survey.

Help Menu

Item "About" is the only available option in this menu (Figure 1.18). It displays name

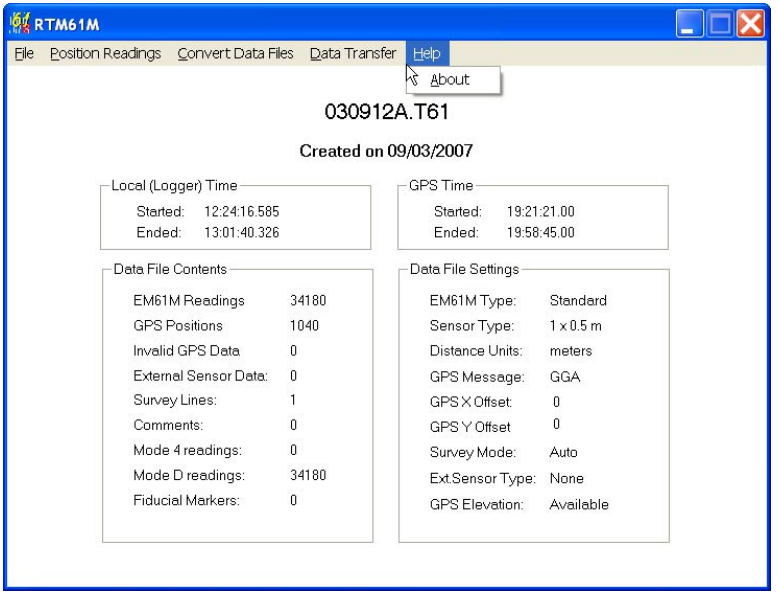


Figure 1.18: RTM61M Help menu

and version of the program, as shown in Figure 1.19. Help function is not available in this version of the RTM61M.

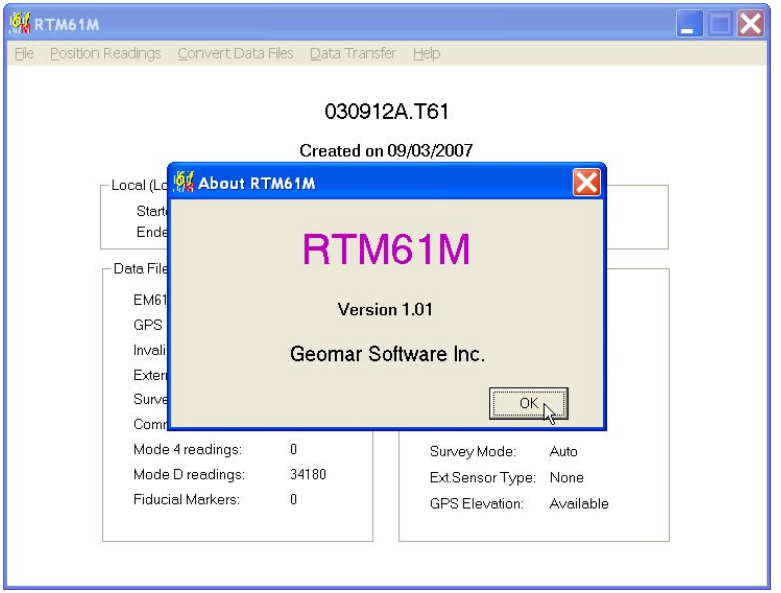


Figure 1.18: About RTM61M window

A detailed description of the function of each menus item is provided in relevant sections of the manual.

File Menu 2

File menu of RTM61M program is shown in Figure 2.1. There are several items associated with the File menu:

- Open File (loads RTmap61M data file to the program memory),
- Save (saves data to the same file, disabled if original data file loaded),
- Save As (saves data to a file with different file name),
- Close (closes current data set),
- Edit Parameters (changes parameters in loaded data set),
- Display XYZ File (displays layout of stations in XYZ file),
- Exit (terminates RTM61M program).

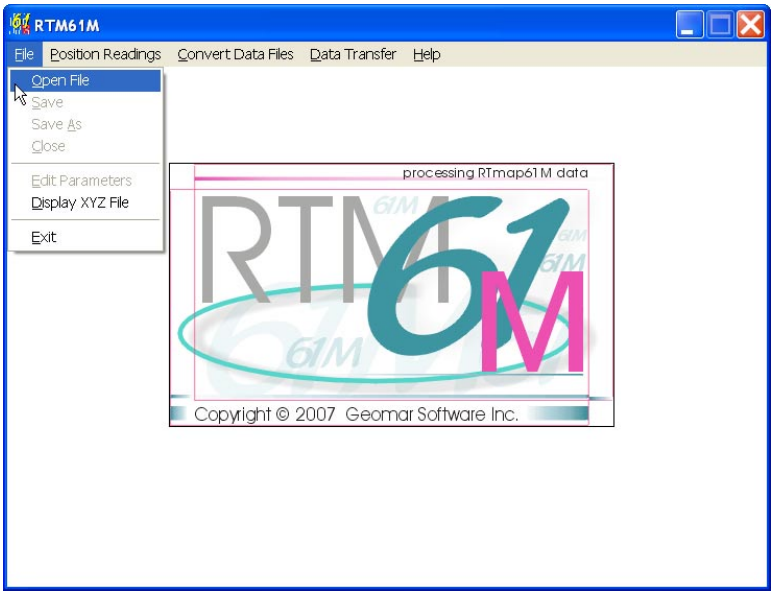


Figure 2.1: RTM61M File menu

When program starts most of items in the File menu are disabled. They are enabled automatically as soon as data file is loaded in to the program memory.

The general rule of the RTM61M software is that the program cannot overwrite original file name. In order to Save file, the original file name must be "Saved As" first. The program tags such file and menu item Save is enabled. At further runnings when the "Saved As" file will be loaded item Save will be enabled automatically.

2.1 Open File

The Open File option allows you to load RTmap61M data file to the program memory. Select **File|Open File** from the main program menu, as shown in Figure 2.1. After the selected menu item is clicked the Select RTmap61M Input File window will be displayed in the centre of the screen, Figure 2.2.

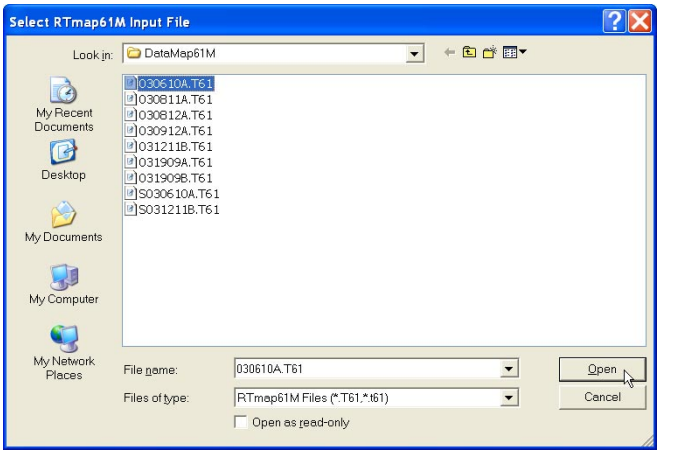


Figure 2.2: Select RTmap61M Input File window

The window lists files with extension name P61. Select a file name and click the **Open** button. The Select RTmap61M File window will close and the progress bar will appear in the center of program's main window indicating percentage of loaded file (Figure 2.3).

As soon as data file is selected and data is loaded to the program memory the splash graphic disappears and the program displays information related to data file contents. At the same time remaining items in the File menu (and items in other menus as well) are enabled and the Open File item is disabled.

The RTM61M main window displays the most important parameters of the entered data file (Figure 2.4). At the top of the window the current file name, date of file and optionally original file name (as entered in the field), and start and end times in local time (field computer clock) and UTC time (GPS time in NMEA messages) are displayed. Below, in the left window frame labeled **Data File Contents** a total number of EM61M readings, number of GPS positions recorded, number of invalid GPS positions (with not valid checksum), number of survey lines, comments, and number of used fiducial markers in the field are given. In the right frame labeled **Data File Settings** listed are: the EM61-MK2 Sensor Size, type of used GPS NMEA message, GPS X and Y offsets (in Distance Units), and survey mode.

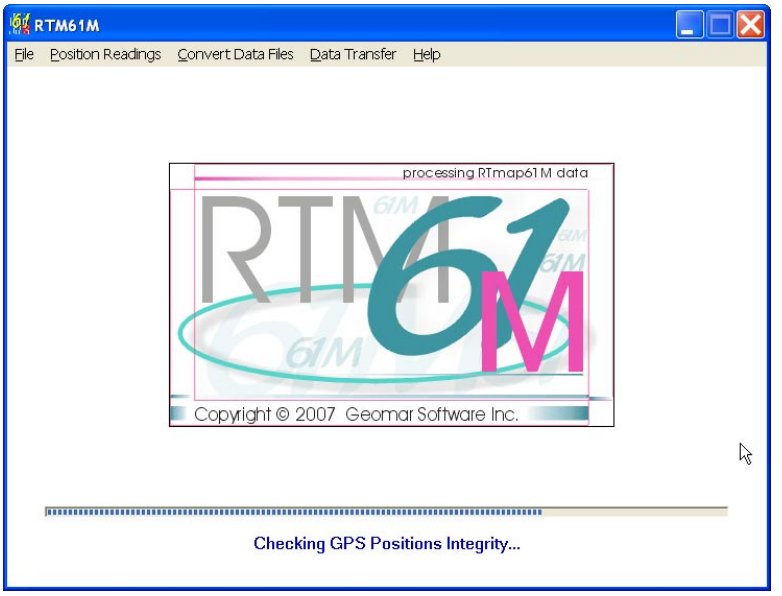


Figure 2.3: Progress bar indicating loading RTmap61M file

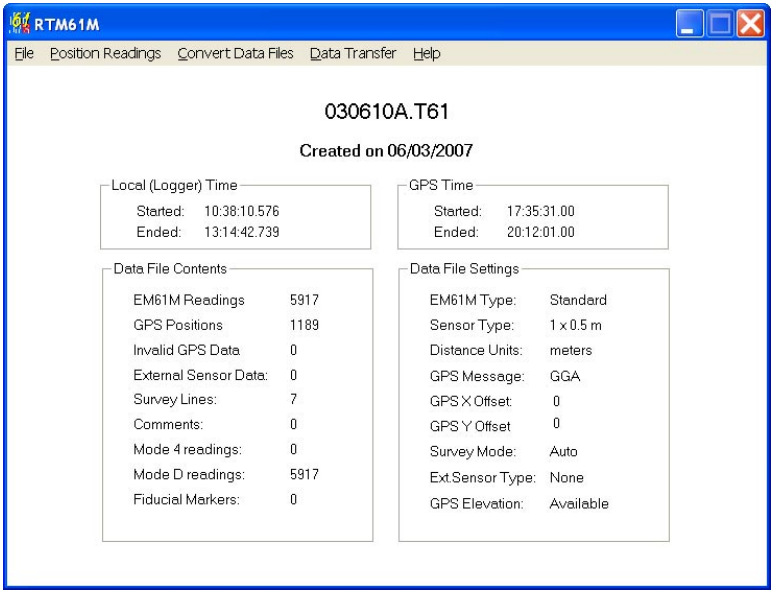


Figure 2.4: RTM61M Main Screen after data file is loaded

When original data file is selected the name of the file and date of the creation is displayed at the top of the screen. In case when not original file was loaded then the current file name is displayed, followed by an original date of creation and original file name, for example: "Created on 06/03/2007 as 030610A", (see Figure 2.5).

At this point loaded data can be used for further data processing.

2.2 Save, Save As, Close

As it was mentioned data can be saved only if the data file was previously Saved As. This assures that the original data file will not be overwritten, i.e. with edited parameters. The File menu item **Save** is enabled only when other than original data file is loaded. The indication that file was previously Saved As is given at the top of the screen, under currently loaded file name label "Created on 06/03/2007 as 030610A" provides information that the original file name was 030610A.T61 (Figure 2.5). Otherwise this label would provide only date of the created file (see Figure 2.6).

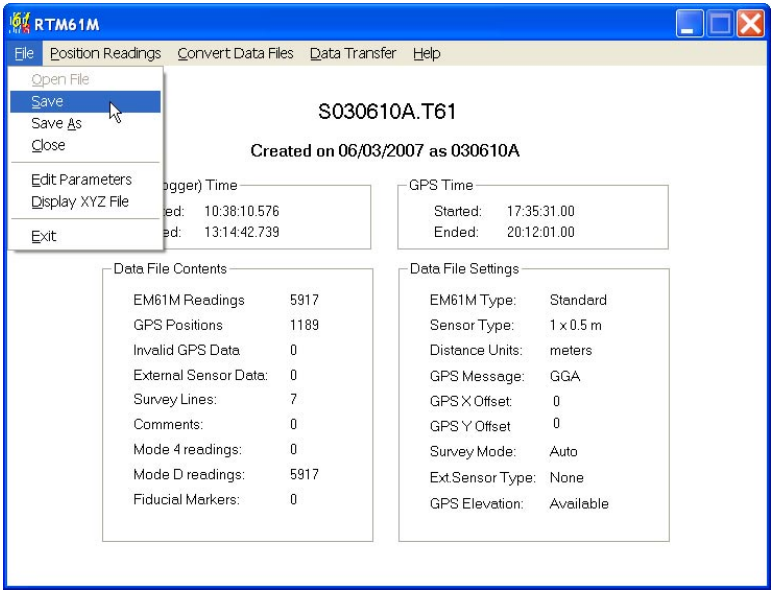


Figure 2.5: RTM61M Main Screen with item Save enabled after not original file was loaded

The File menu item labeled **Save As** allows you to save any data set. Select **File|Save As** from the program main menu (see Figure 2.6). After the selected menu item is clicked,

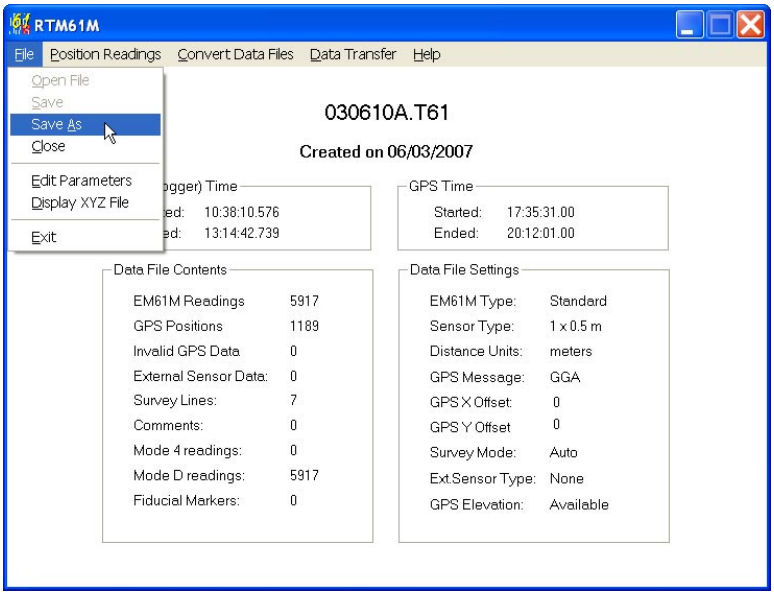


Figure 2.6: RTM61M Screen with loaded original data file, disabled Save option, and selected Save As item

the Save As RTmap61M Input File window will be displayed in the centre of the screen, Figure 2.7.

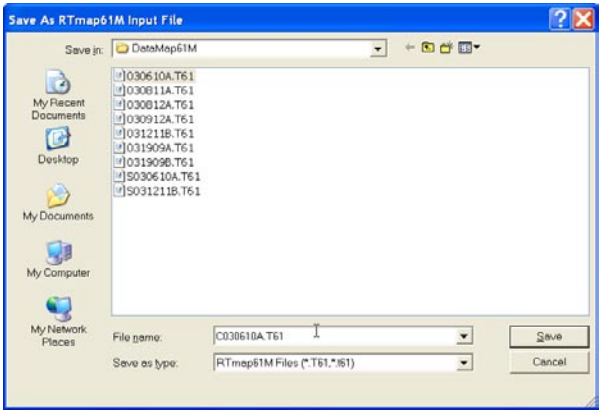


Figure 2.7: Save As RTmap61M Input File window

This option is especially useful when working with data files created in Allegro CX. Windows CE system creates files that are not organized according to time stamp sequence. When such file is loaded, first it is sorted by the program. The option Save As will save data in organized format, and therefore loading previously saved file will be faster (since sorting is not necessary). The program recognizes sorted files automatically.

After the file is saved with Saved As option the Main Screen of RTM61M will be updated, and file name will placed at the top of the screen and the item **Save** in the File menu will be enabled, Figure 2.8 (compare with Figure 2.6).

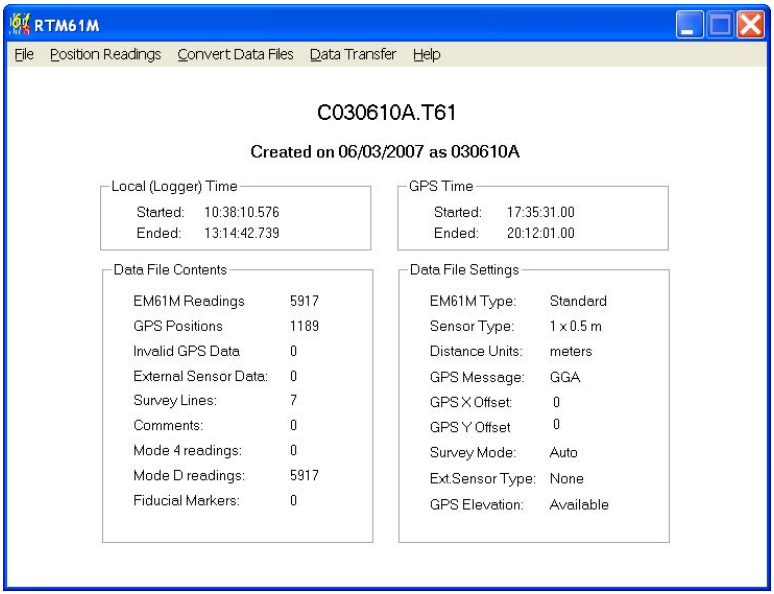


Figure 2.8: RTM61M Main Screen after completed Save As option

Clicking on the **Close** item in File menu will remove data set from the program memory, the Main Screen will display splash graphic and the menu item Open File will be enabled. This action allows you to load another RTmap61M data file.

2.3 Edit Parameters

Four parameters entered during the field work can be modified during data processing. Click on the **Edit Parameters** item in the File menu and the Edit RTmap61M File Parameters window will appear (Figure 2.9). The Edit Parameters window is also available in Position Readings options.

The window displays parameters that the user can edit. These are: EM61-MK2 Sensor Size, Distance Units, and GPS X and Y offsets. If all parameters were correctly specified in the field then clicking on **OK** or **Cancel** button will accept these entries. In case some of the parameters require modification they can be entered in appropriate text boxes located under label Current Settings. Sensor Size and Distance Units can be selected from combo list boxes, while GPS X and GPS Y offsets must be entered in appropriate

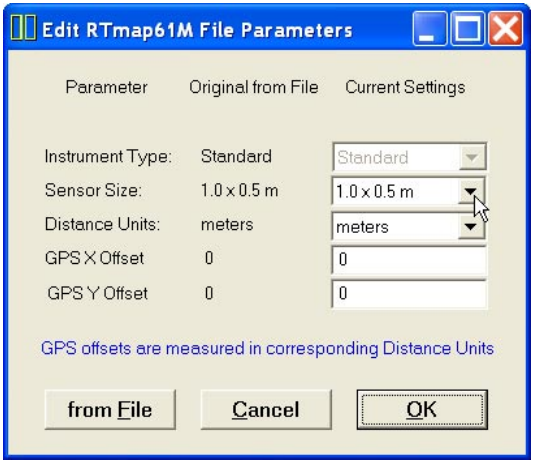


Figure 2.9: Edit RTmap61M File Parameters window

text boxes. Example of RTmap61M File Info window with modified parameters is shown in Figure 2.10.

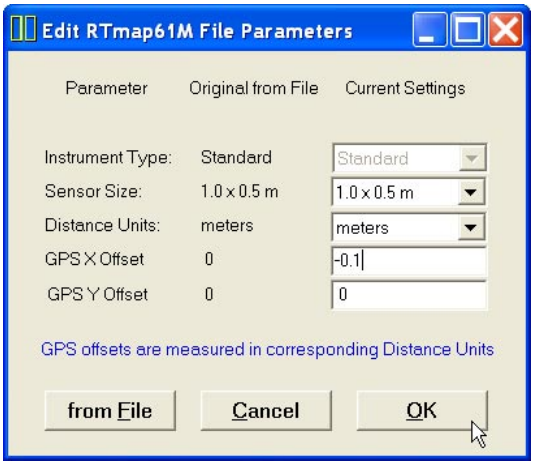


Figure 2.10: Modified parameters in Edit Parameters window

Clicking on the **OK** button will accept any changes, clicking on the **Cancel** button will cause the program to use initial parameters (state when window was displayed), while clicking on the button **from File** will change parameters to original values (listed in fields under label Original from File). After the buttons **OK**, **Cancel** or **from File** are clicked the Edit RTmap61M File Parameter will disappear.

Any updates in this window are valid only for duration of the program. The data file will remain the same unless it **Saved** or **Saved As** in File menu.

2.4 Display XYZ File

The Display XYZ File option allows you to display two dimensional layout of stations in a selected XYZ file. Select **File|Display XYZ File** from the main program menu, as shown in Figure 2.1. The Select XYZ to Open window will appear.

The window lists files with extension name XYZ. Select a file name and click the **Open** button. The Select XYZ to Open window will close, the file will be loaded and two dimensional image will be displayed (Figure 2.11).

The image displayed in the Plot XYZ window shows the spatial layout of stations to scale, based on the station coordinates as written in the selected XYZ file.

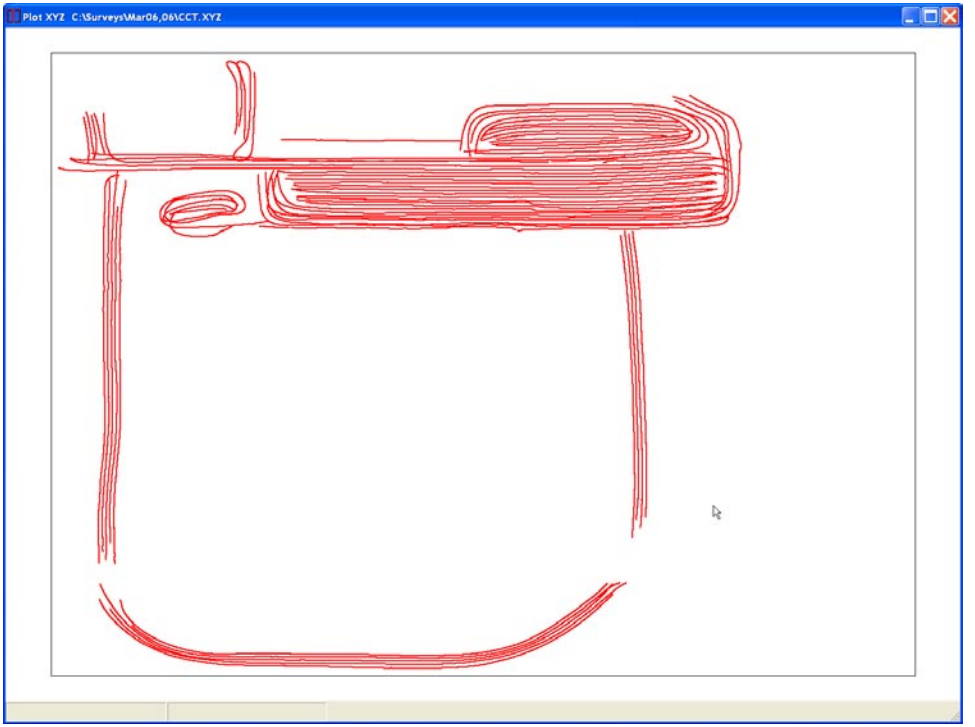


Figure 2.11: Two dimensional layout of stations in XYZ File

Position Readings 3

Positioning of the Geonics EM61M is the main function of the RTM61M. Location of the electromagnetic sensor is calculated based on the recorded GPS position, instant heading of the system, and the system geometry which is described by the location of GPS antenna.

There are three methods of positioning sensors in RTM61MMK2: Position Sensors using RTmap61M Data File, Position Sensors using External GPS File, and Position Sensors using Geonics (M61) File. The first method allows you to position sensors based on Real Time GPS data embedded in RTmap61M file while in the second technique Real Time GPS data are replaced by GPS positions from the postprocessed GPS data file. The second method requires that the GPS data is collected in the field computer running RTmap61M program as well as in the GPS receiver logger. This option is especially useful in following cases:

- when real time differential data correction is not available,
- accuracy of positioning may be further improved by processing data using special GPS software,
- if a special or unique coordinate system provided by GPS software is required and it is not available in other employed data processing or mapping software.

The third method allows you to position EM61M stations based on Real Time GPS data which were recorded in RTmap61M data file during the survey and then converted and processed in Geonics program DAT61MK2. The DAT61MK2 has its own GPS Positioning option however it does not support NMEA messages other than GGA, filtering for PDOP Mask, GPS Minimum Interval and GPS Antenna offsets.

Description of functions involved in positioning the EM61M is preceded by a short description of the system geometry.

3.1 The RTmap61M System Geometry

The GPS antenna can be placed anywhere in relation to the instrument center. However to achieve the highest possible accuracy of the calculated positions the GPS antenna must be placed as close to the center of the system as possible. The best and optimal placement of the GPS antenna is located above the center of the EM61M sensor.

When a survey is positioned by GPS system and GPS antenna can not be placed in the center point of the instrument the program allows to specify the GPS antenna offset from the EM61M sensor center. Two parameters, GPS X Offset and GPS Y Offset

describe location of GPS antenna. This location is represented by the distance which is measured from the center of the EM61M antenna to the center of the GPS antenna, while facing direction of the movement, see Figure 3.1.

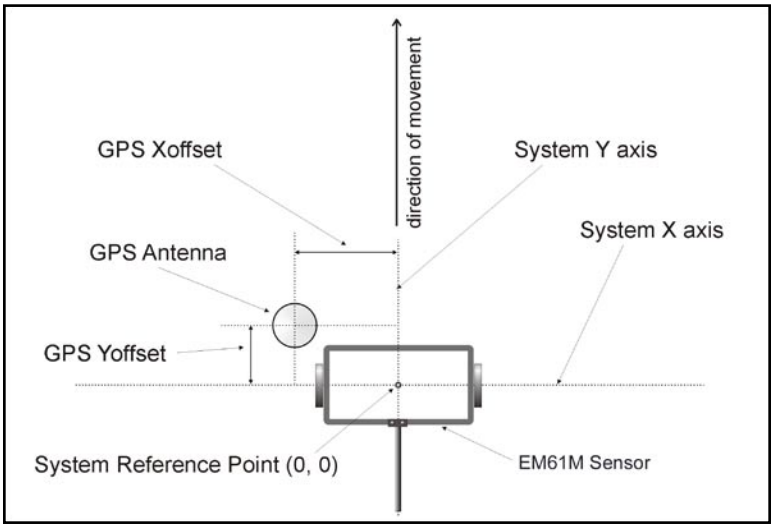


Figure 3.1: The EM61M and GPS antenna geometry

The procedure of specifying X and Y offsets in relation to the direction of the system movement is very important and should be maintained during data collection for the entire data file. Therefore, the operator can not walk few steps or drive backwards without changing data file name. If it is necessary data logging must be paused for the time of such movement since positioning of the sensor based on GPS is based on this assumption.

This option is provided mainly for situations where the operator pushes or tows the EM61M, and GPS antenna (placed in backpack) is located above his shoulder. In this case distance between GPS antenna and the instrument (GPS X Offset) is small, and GPS Y Offset will be usually larger and its sign will depend on pushing or towing. This situation corresponds to the system geometry presented in Figure 3.1. Another case that offsets have to be used is when longer cable from GPS receiver to GPS antenna is unavailable.

The offset in Y direction (GPS Y Offset) can be used if the instrument is towed as long as the GPS antenna is located on the same trailer as the EM61M sensor (Figure 3.2). As it was mentioned earlier, the best placement of the GPS antenna is located above the center of the EM61M sensor. In case where the GPS antenna is located in front of the electromagnetic sensor the GPS Y Offset is positive, and if the GPS antenna is located behind the instrument the GPS Y Offset is negative.

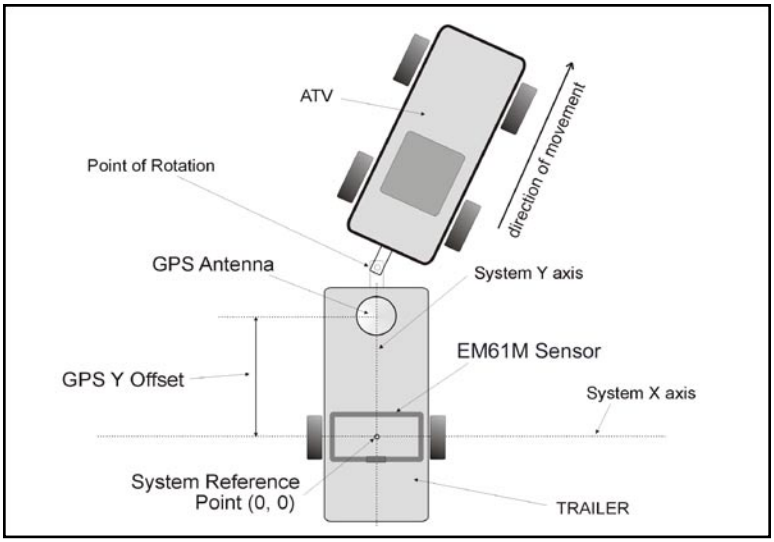


Figure 3.2: Geometry of the EM61M sensor and GPS antenna during towing

If GPS antenna is located i.e. on ATV and the EM61M is placed on the trailer (there is a point of rotation between them) then the program RTM61M may provide not accurate results. In such case use program GPS-XYZ, PathMaker or similar software, to calculate lay back of the instrument.

In the case where a wrong value was entered in the field, GPS X Offset and GPS Y Offset parameters can be corrected later during data processing in the program RTM61M.

In general, when GPS antenna is located off the center of the system positions of the instrument will be calculated based on the GPS antenna position and instant heading. In order to achieve higher quality of data positioning the survey should be carried out along relatively smooth pathways, especially if GPS antenna is located further from the center of the instrument.

When the direction of the survey line is changed it is advised to pause recording of data for the duration of U-turn. Toggling between Stand By mode (pause) and Log mode is relatively easy in the most difficult field conditions, it is done by one key stroke (Pause and Start keys), and it can save time during data processing.

Similar approach applies to situations when the system is stopped. In this case if readings are not paused, the random distribution of small GPS errors will likely result in unreliable locations of calculated sensor positions. If the offset of GPS antenna is used it may appear that the instrument is rotating since GPS errors occur in many directions. Paus-

ing readings while the system is stopped will save time during data processing and will result in better data presentation.

3.2 Positioning Readings Using RTmap61M Data File

After a data file is loaded the RTM61M main window displays the most important parameters of the entered data file (Figure 3.3). At the top of the window the current file name, date of file and optionally original file name (as entered in the field), and start and end times in local time (field computer clock) and UTC time (GPS time in NMEA messages) are displayed. Below, in the left window frame labeled **Data File Contents** a total number of EM61M readings, number of GPS positions recorded, number of invalid GPS positions (with not valid checksum), number of survey lines, comments, number of readings in mode 4 and D, and number of used fiducial markers in the field are given. In the right frame labeled **Data File Settings** listed are: type of the instrument, Sensor Size, type of used GPS NMEA message, GPS X and Y offsets (in Distance Units), and survey mode.

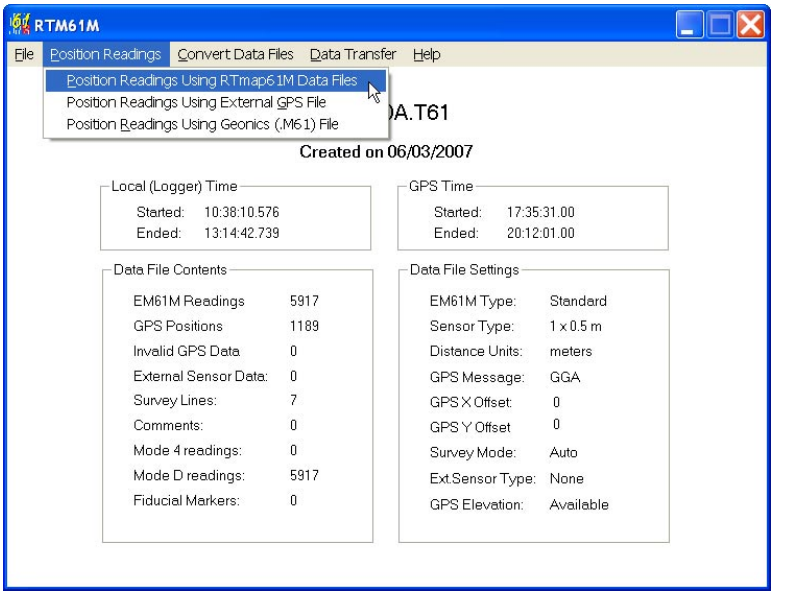


Figure 3.3: Position Readings menu

The Position Readings Using RTmap61M Data option allows you to position EM61M stations based on Real Time GPS data which were recorded in RTmap61M data file during the survey. Select **Position Sensors|Position Readings Using RTmap61M Data Files** from the main program menu, as shown in Figure 3.3.

After the selected menu item is clicked the Position EM61M Readings Using RTmap61M Data File window will be displayed in the centre of the screen, Figure 3.4.

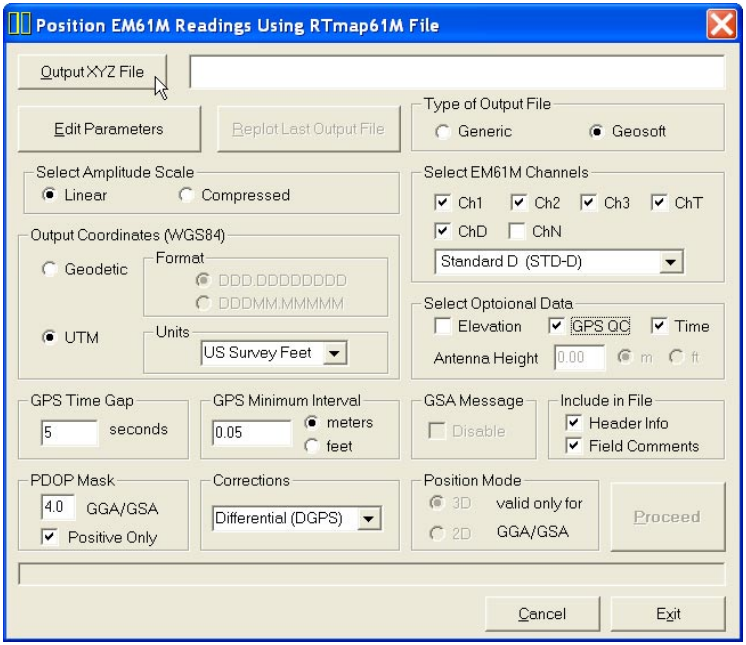


Figure 3.4: Position EM61M Readings Using RTmap61M Data File window

Parameters in Positioning Readings Using RTmap61M Data File Window

Several parameters which affect the contents and format of the created output (XYZ) file must be specified. These are the XYZ output file name, parameters describing contents and format of the created file and parameters related to electromagnetic as well as to GPS data.

Edit Parameters

The RTM61M main window (Figure 3.3) displays the most important parameters of the entered data file. In case some parameters were wrongly entered in the field it is possible to change them using Edit Parameters option (the same option is available in the File menu of the RTM61M main screen). Click on the **Edit Parameters** button and Edit RTmap61M File Parameters window will appear (Figure 3.5).

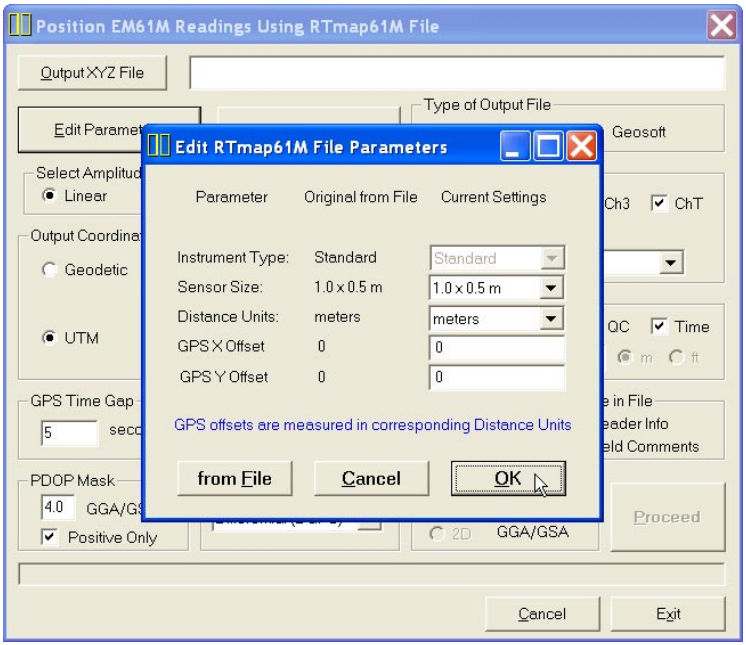


Figure 3.5: Edit RTmap61M File Parameters window

The window displays parameters that the user can edit. These are: the EM61M type, Sensor Size, Distance Units and GPS X and Y offsets. If all parameters were correctly specified in the field then clicking on **OK** or **Cancel** button will accept these entries. In case some of the parameters require modification they can be entered in appropriate text boxes located under label Current Settings. EM61M Type, Sensor Size and Distance Units parameters can be selected from combo list boxes, while GPS X and GPS Y offsets must be entered in appropriate text boxes. Example of RTmap61M File Info window with modified parameters is shown in Figure 3.6.

Clicking on the **OK** button will accept any changes in parameters, clicking on the **Cancel** button will cause the program to use initial parameters (state when window was displayed), while clicking on the button **from File** will change parameters to original values (listed in fields under label Original from File). After the buttons **OK**, **Cancel** or **from File** are clicked the Edit RTmap61M File Parameter will disappear.

Any updates in this window are valid only for duration of the program. The data file will remain the same unless it **Saved** or **Saved As** in File menu.

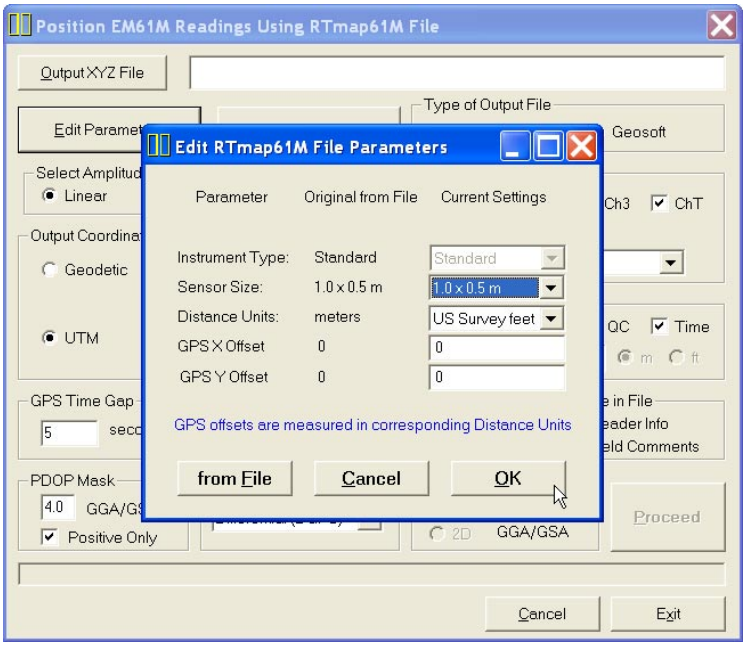


Figure 3.6: Modified parameters in Edit Parameters window

Output File

Click on the **Output XYZ File** button. The Select Output File window is displayed (Figure 3.7).

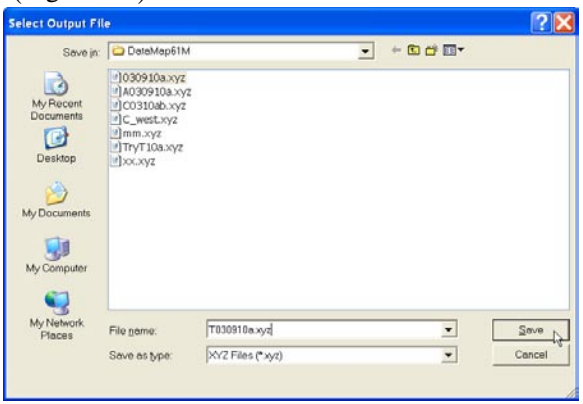


Figure 3.7: Select Output File window

Select a file name and click the **Save** button. The Select XYZ File window will close and the selected file name will be displayed beside the **Output XYZ File** button in the Position EM61M Readings Using RTmap61M File window.

When Output file is specified the **Proceed** button in the Position EM61M Readings Using RTmap61M File becomes active (Figure 3.8).

Select EM61M Channels

To select a data type (component and dipole mode) click on desired check buttons labeled **Ch1**, **Ch2**, **Ch3**, **Ch4** or **ChT**, **ChD**, and **ChN**. Data is always placed in the created XYZ file in the following order: X coordinate (Easting or Longitude), Y coordinate (Northing or Latitude), and Ch1, Ch2 through ChD. This data may be followed by a column containing Time Stamp (this optional parameter is located in a section Select Amplitude Scale).
If during data collection more than one instrument mode was used then select Instrument Mode to be used during the creation of XYZ file in the combo list box located below selection of EM61M channels. Change of the EM61M mode may change selection of available channels.
If parameter **Header Info** in Include in File section is checked a line listing all parameters in the file will be placed as a header for each created XYZ file.

Select Amplitude Scale

Readings can be written in the output file in Linear (original) scale, or Compressed, as the signed square root of each value. Check the appropriate radio button in the Select Amplitude Scale section.

Select Optional Data

Three optional data can be written in the output file. These are Elevation, GPS QC parameters (Quality Indicator, PDOP or equivalent, number of satellites), and Time Stamp for each reading. To select optional data click on the check box next to the corresponding name.
If the check box labeled **Elevation** is clicked (checked) then a text box labeled **Antenna Height** and two radio buttons labeled **m** and **ft** become active. The text box labeled Antenna Height allows you to enter correction for Elevation data. The Antenna Height corresponds to the distance between ground surface and GPS antenna. If Antenna Height is set to zero then elevations for the GPS antenna (not the ground surface) are written to the output file. Two radio buttons labeled **m** (meters) and **ft** (feet) allows you to specify units for elevation data placed in the output file. It is assumed that Antenna Height parameter is entered in units specified by these radio buttons.
Elevation values base on the recorded GPS data. Therefore Elevations will not be written to the file if the NMEA message GLL was used during the survey. Message GLL does not contain elevation data. Data is always placed in the created XYZ file in the following order: X coordinate (Easting or Longitude), Y

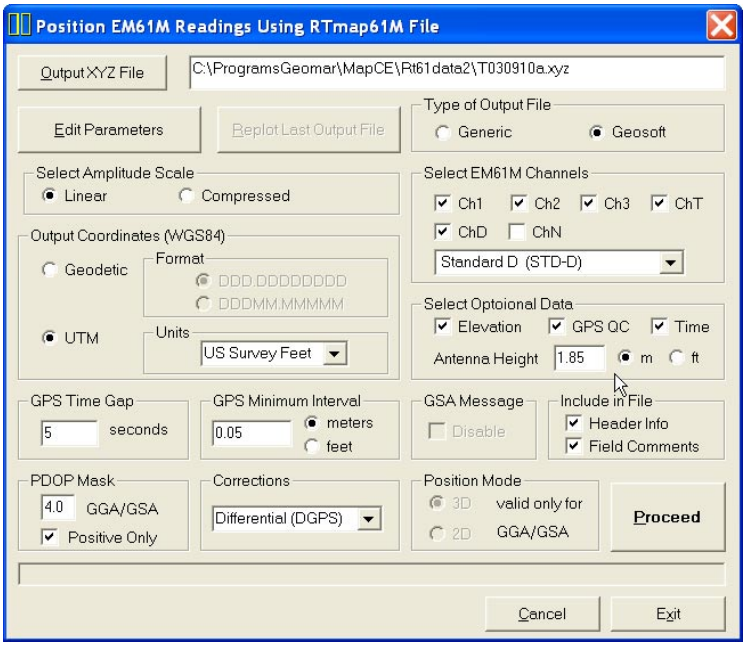


Figure 3.8: Position EM61M Readings Using RTmap61M Data File window

coordinate (Northing or Latitude), EM61M channels (as selected), Elevation, three GPS QC parameters (Quality Indicator, PDOP or equivalent, Number of Satellites), and Time Stamp.
If parameter Header Info in Include in File section is checked a line listing all parameters in the file will be placed as a header for each created XYZ file.

Type of Output File

Check the option appropriate for the contouring software used. The Generic option will create a four or more column file without any text strings. This file can be used as an input file for many contouring packages (including Surfer). Geosoft format will cause the program to write LINE # at the beginning of each survey line.

Include in File

This section contains two check boxes labeled **Header Info** and **Field Comments**. When Header Info box is checked the file will contain a header listing type of coordinates and names of data contained in each column of created XYZ file. Checking box labeled Field Comments will cause the program to

write text of all field comment (entered by the operator during the survey) in to the created file.

Output Coordinates

Positions can be written in the output file as geodetic (geographical) coordinates (Latitude/Longitude) or they can be converted to UTM coordinates. The program uses the WGS1984 datum. To select coordinates click **Geodetic** or **UTM** radio buttons (Figure 3.9).

Geodetic coordinates, Latitude and Longitude are given in degrees. They can be written in two formats DD.DDDDDDDD or DDMM.MMMMM (native format found in NMEA GPS messages). To select which format click the appropriate radio button in Format section located at the radio button labeled Geodetic. This section is active only when radio button Geodetic is selected (Figure 3.9).

UTM coordinates can be generated in meters, feet, or US Survey feet. To select units for UTM coordinates select proper parameter from the combo box located in the Units section located at the UTM radio button (Figure 3.9). This combo box is active only when radio button labeled UTM is selected.

GPS Time Gap

Differentially corrected GPS data often has gaps, due to differences in the constellation of satellites visible to two (fixed and moving receivers), lack of beacon signal, surveying near trees, buildings, and other elevated obstructions. These gaps are filled by RTM61M with the assumption that the GPS receiver speed is essentially constant and that it moves along a straight line during the gaps.

The **GPS Time Gap** parameter specifies the maximum time during which the EM61M data will be linearly interpolated between two GPS positions. Enter this parameter (in seconds) in the edit box labeled **seconds** in the GPS Time Gap section (Figure 3.9). In most cases a value 2 to 3 times larger than the GPS data acquisition frequency is adequate, however the user has to determine this value based on the survey specific conditions and requirements. To ignore effect of this parameter enter a large number of seconds (i.e. 300 or more) as GPS Time Gap parameter.

GPS Minimum Interval

The **GPS Minimum Interval** parameter specifies the minimal distance between two GPS stations that will be used in interpolation. If this distance is smaller

than the specified GPS Minimum Interval, then all EM61M readings located between these two stations will be ignored. This parameter is useful in cases when the operator stops for a moment and data are collected in one point. Limited accuracy of GPS positioning will create randomly distributed positions in area adjacent to the stationary location of the system. If RTM61M will calculate positions of sensor in case offset values (GPS X and/or GPS Y Offsets) are different than zero, positions of the EM61M will have quite large variations associated with apparent change of direction of the survey line caused by randomly close spaced GPS positions. In most cases a value 2 or 3 times smaller than average distance between two GPS stations is adequate, however the user has to determine right value for this parameter which will depend on survey conditions and first of all accuracy of the employed GPS receiver. To ignore the effect of this parameter and to use all stations during creating XYZ file (i.e. during testing when GPS antenna is stationary) set this parameter to zero.

Enter the GPS Minimum Interval in the edit box and check one of the two radio buttons labeled **meters** and **feet** (indicating distance unit) in the GPS Minimum Interval section (Figure 3.9).

GSA Message

This parameter is used to disable GSA message. This is to be used only if the operator has specified in the data acquisition program (RTmap61M) that the GPS Message will be pair GGA/GSA and for any reason message GSA was not recorded. In such case the RTM61M will search for GPS quality information contained in not recorded GSA statement and it would conclude that GPS readings are invalid. Disabling GSA message in this situation causes that the program will use only information available from GGA message.

PDOP Mask

The PDOP Mask is used to filter quality of GPS positions. The index called PDOP (Position Dilution of Precision) measures the strength of satellite coverage for a given area. PDOP is affected by the number of satellites visible and their relative positions in the sky. The smaller the number of PDOP the stronger the satellite coverage is. When there are more than 5 satellites widely spaced visible, the PDOP is 4 or less. However, when there are less satellites visible, or they are unevenly spaced in the sky, PDOP values can be 6 or higher. In most cases, the PDOP in open sky is less than 3, and most accuracies given for many GPS systems are given for this norm. The index called GDOP covers time accuracy in addition, while the index HDOP is related only to horizontal position fix

(it is used when message GGA was selected). Refer to GPS documentation and literature for more information related to error sources of GPS positioning.

The section PDOP Mask may differ depending on GPS NMEA message used. It is related to PDOP parameter if GGA/GSA, POS, or GGK was employed during the survey, to HDOP if GGA was used, to GDOP if LLK was used during the survey, and it is invalid if GLL or LLQ message was used.

Enter the PDOP (HDOP or GDOP) value in the edit box in the PDOP Mask section, Figure 3.9. All positions (as well as EM61M readings) associated with GPS data of higher than specified value of this index will be ignored.

Corrections

Select type of differentially corrected position data to be used during the creation of XYZ file in the combo list box labeled Corrections. Four types of GPS corrections are given: **Raw (GPS)**, **Differential (DGPS)**, **Differential (RTK 3)**, **Differential (RTK 4)**, and **Differential (RTK 5)**. Last three types of RTK (real time kinematic) corrections are available only in high end of GPS receivers and differently named depending on manufacturer, however in NMEA specifications they indicate Quality Parameter 3, 4, and 5. When **Raw** is selected, both differentially corrected and raw GPS data are used to calculate positions of EM61M stations.

Position Mode

This option is valid only if the pair GGA/GSA messages were used during data collection. If radio button labeled 3D is checked then GPS data in mode 3D are used, while when radio button 2D is checked then program uses 2D as well as 3D mode of GPS data.

It should be noted that if any NMEA message indicates that GPS position (fix) is invalid this data is ignored by the RTM61M.

Creating XYZ Files With Positioned Readings

When all parameter are set and output file name is specified, the **Proceed** button is activated in the Position Readings Using RTmap61M File window. After you click the **Proceed** button, the program begins to filter loaded data, calculates EM61M stations

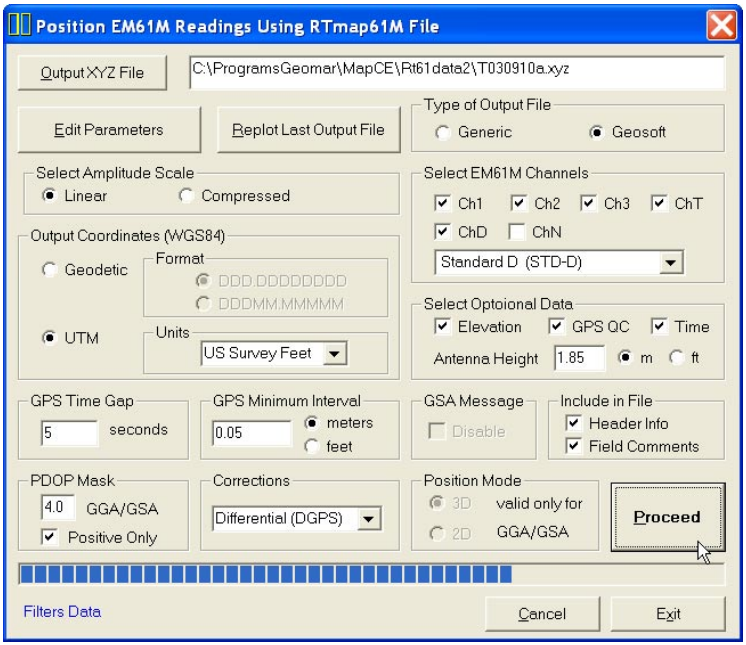


Figure 3.9: Position EM61M Readings Using RTmap61M File window during creating XYZ file

positions based on the recorded GPS readings, instant heading, and other specified parameters, and writes results to the XYZ output file. A progress bar at the bottom of the screen shows the percentage of the file processed (Figure 3.9).

The speed of this operation depends on the size of the input file. After the output XYZ file is created a two dimensional layout of the survey is displayed (Figure 3.10).

The image displayed in the Plot XYZ window shows the spatial layout of stations to scale, based on the station coordinates as written to the created file. The display has fixed colours. GPS positions are marked by larger grey dots while the EM61M stations are plotted by smaller red dots. This plot window can be closed by clicking on **Close** button (located in the top right corner of the window).

After the Plot XYZ window is closed a button **Replot Last Output File** becomes active and the layout of data can be examined again. However, at this time original GPS

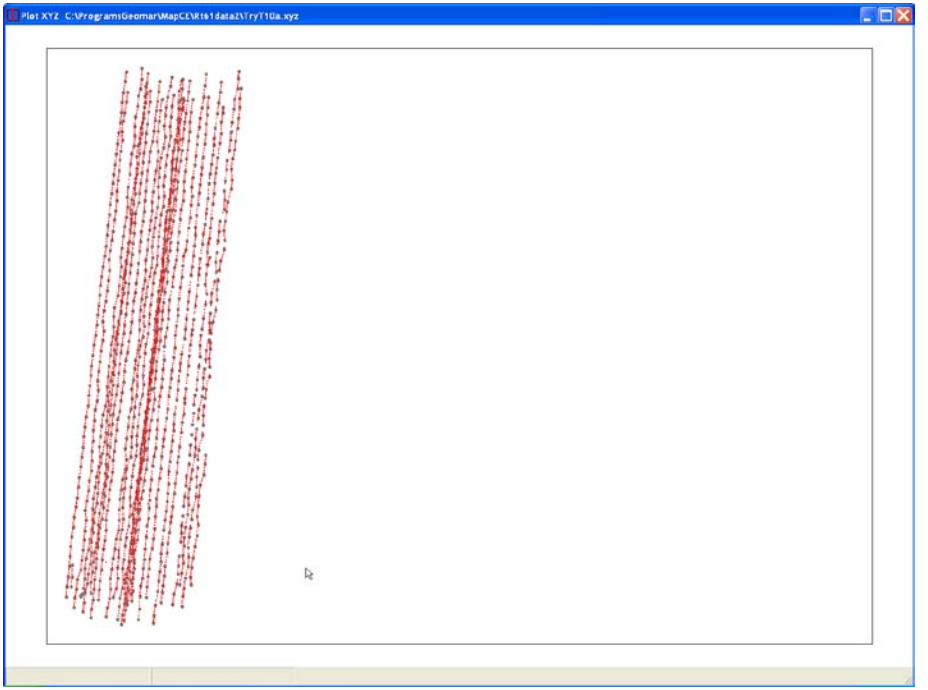


Figure 3.10: Two dimensional layout of stations taken with the Geonics EM61M. The GPS X and Y offsets were set to zero (GPS antenna was located above the center of the EM61M sensor).

positions will not be displayed and only instrument positions will be represented by red dots on the screen. Files created by this portion of the program can be also viewed at any time using the **File|View XYZ File** menu.

After the file is created and its layout is examined it is possible (if required) to recreate XYZ file with changed system geometry parameters. To do this, click **Edit Parameters** button, the Edit RTmap61M File Parameters window will appear again. After changes are done, click the **Proceed** button to repeat procedure of creating XYZ file. See example in Figure 3.11 where GPS antenna location was changed as compared to case shown in Figure 3.10.

If the input file does not contain sufficient GPS information, or parameters are not correctly selected, the program will display a warning message (Figure 3.12), and the program will pause operation till the **OK** button is clicked in the warning window.

Figure 3.11: Two dimensional layout of stations taken with the EM61M. The GPS antenna location: GPS X Offset = 0.25 m and GPS Y Offset = 0.05 m (the first W line was surveyed in N direction).

This message may indicate lack of GPS data in the file, however in most cases it reflects lack of GSA messages when GGA/GSA was selected in the data acquisition program (check Disable GSA Message), raw positions only when Differential button is checked, too small value specified in GPS Time Gap section, not existing EM61M channels specified in Select Data section, etc..

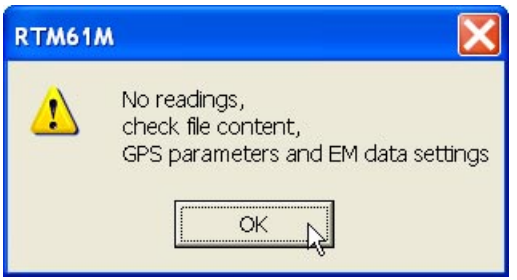


Figure 3.12: Warning window

3.3 Positioning Readings Using External GPS File

After a data file is loaded the RTM61M main window displays the most important parameters of the entered data file (Figure 3.13). At the top of the window the current file name, date of file and optionally original file name (as entered in the field), and start and end times in local time (field computer clock) and UTC time (GPS time in NMEA messages) are displayed. Below, in the left window frame labeled **Data File Contents** a total number of EM61M readings, number of GPS positions recorded, number of invalid GPS positions (with not valid checksum), number of survey lines, comments, number of readings in the instrument mode 4 and D, and number of used fiducial markers in the field are given. In the right frame labeled **Data File Settings** listed are: name of the instrument (fixed), Sensor Size, type of used GPS NMEA message, GPS X and Y offsets (in Distance Units), and survey mode.

The Position Sensors Using External GPS File item of the Position Sensors menu allows you to position EM61M stations based on separately logged GPS positions which were postprocessed by a GPS software and then exported to ASCII format file. It is assumed that GPS positions were concurrently recorded by RTmap61M program during the survey. Select **Position Sensors|Position Readings Using External GPS File** from the main program menu, as shown in Figure 3.13.

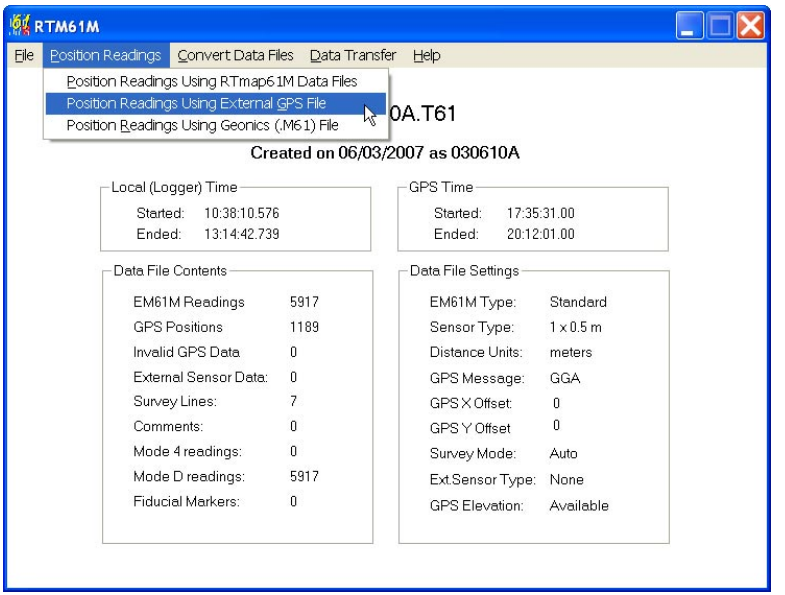


Figure 3.13: Position Readings menu

After the selected menu item is clicked the Position EM61M Readings Using External GPS File window will be displayed in the centre of the screen, Figure 3.14.

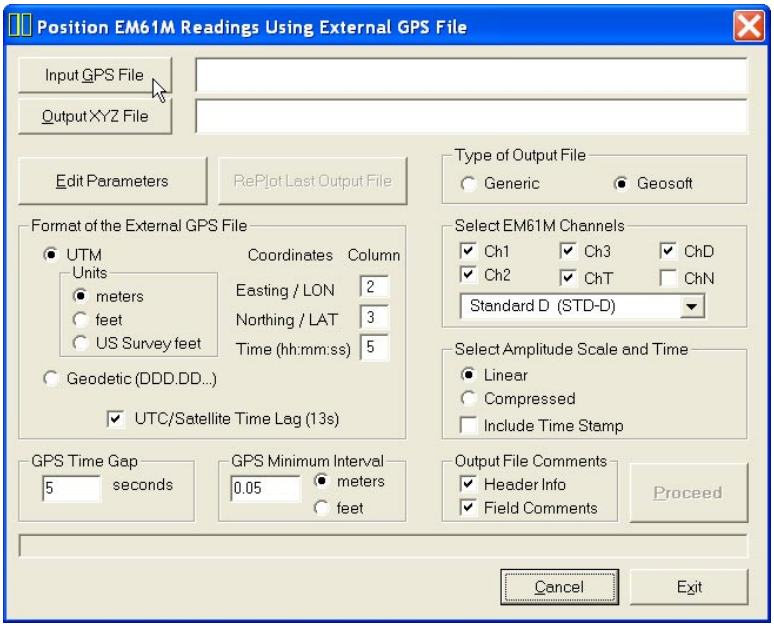


Figure 3.14: Position EM61M Readings Using External GPS File window

Parameters in Positioning Readings Using External GPS File Window

Several parameters which affect the contents and format of the created output (XYZ) file must be specified. These are GPS and XYZ file names, parameters describing contents of the created file and parameters related to GPS as well as to electromagnetic data.

Edit Parameters

The RTM61M main window (Figure 3.13) displays the most important parameters of the entered data file. In case some parameters were wrongly entered in the field it is possible to change them using Edit Parameters option (the same option is available in the File menu of the RTM61M main screen). Click on the **Edit Parameters** button and Edit RTmap61M File Parameters window will appear (Figure 3.15).

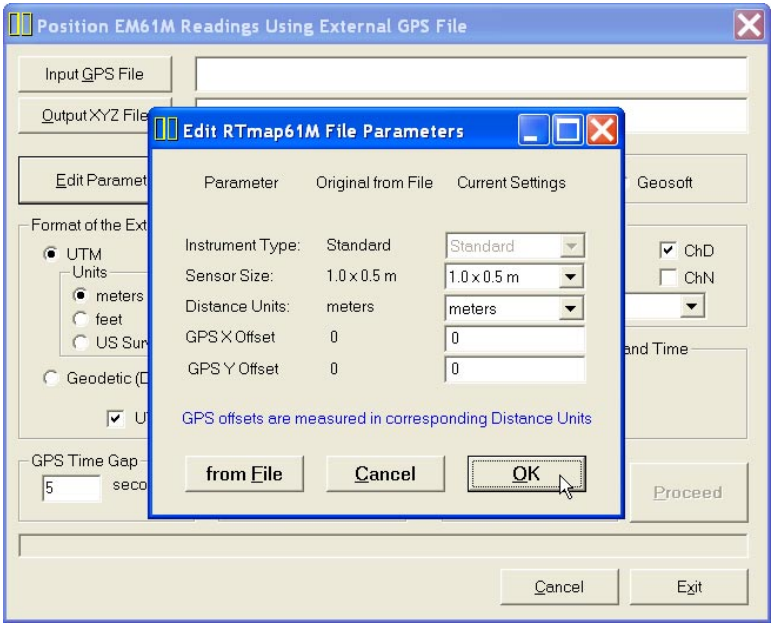


Figure 3.15: Edit RTmap61M File Parameters window

The window displays parameters that the user can edit. These are: the EM61M Sensor Size, Distance Units and GPS X and Y offsets. If all parameters were correctly specified in the field then clicking on **OK** or **Cancel** button will accept these entries. In case some of the parameters require modification they can be entered in appropriate text boxes located under label Current Settings. The Instrument Sensor Size, and Distance Units parameters can be selected from combo list boxes, while GPS X and GPS Y offsets must be entered in appropriate text boxes. Example of RTmap61M File Info window with modified parameters is shown in Figure 3.16.

Clicking on the **OK** button will accept any changes in parameters, clicking on the **Cancel** button will cause the program to use initial parameters (state when window was displayed), while clicking on the button **from File** will change parameters to original values (listed in fields under label Original from File). After the buttons **OK**, **Cancel** or **from File** are clicked the Edit RTmap61M File Parameter will disappear.

Any updates in this window are valid only for duration of the program. The data file will remain the same unless it **Saved** or **Saved As** in File menu.

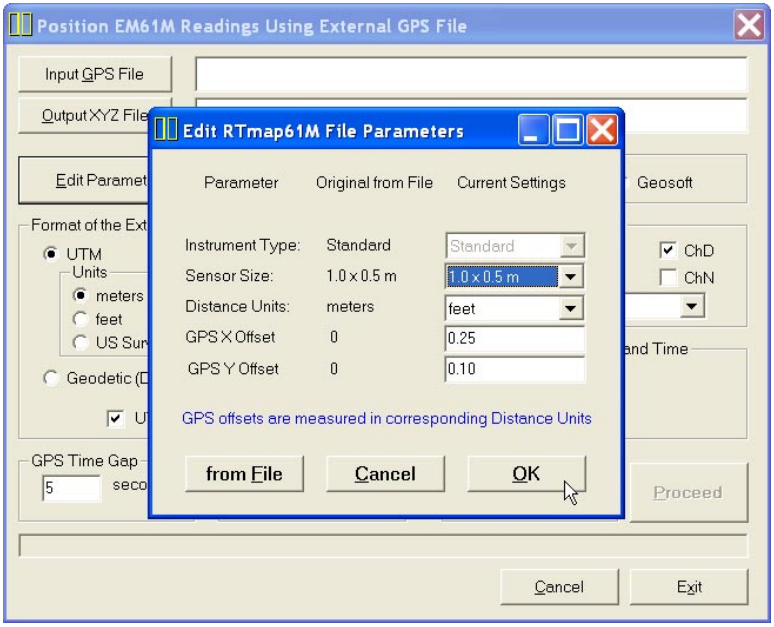


Figure 3.16: Modified parameters in Edit Parameters window

Input GPS File

Click on the **Input GPS File** button. The Select External GPS ASCII File window is displayed (Figure 3.17).

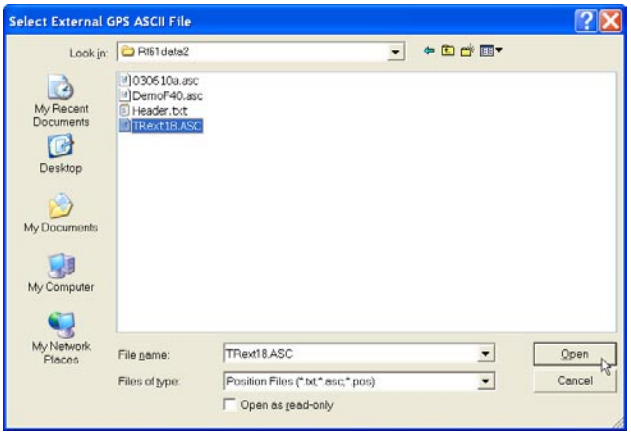


Figure 3.17: Select External GPS File window

Select a file name and click the **Open** button. The Select External GPS ASCII File window will close and the selected file name will be displayed beside the

Input GPS File button in the Position Sensors Using External GPS File window. The external GPS file must be in ASCII (text) format with column delimiters set to comma or spaces. Several examples of the external GPS files are given in Appendix B.

Output File

Click on the **Output XYZ File** button. The Select Output File window is displayed (Figure 3.18).

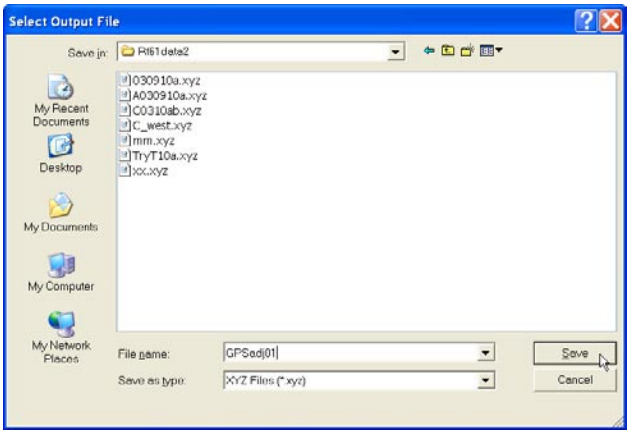


Figure 3.18: Select Output File window

Select a file name and click the **Save** button. The Select XYZ File window will close and the selected file name will be displayed beside the **Output XYZ File** button in the Position Sensors Using External GPS File window.

When all three, Input RTmap61M, Input GPS and Output files are specified the **Proceed** button in the Position EM61M Readings Using External GPS File becomes active (Figure 3.19).

Select EM61M Channels

To select a data type (component and dipole mode) click on desired check buttons labeled **Ch1**, **Ch2**, **Ch3**, **Ch4** or **ChT**, **ChD**, and **ChN**. Data is always placed in the created XYZ file in the following order: X coordinate (Easting or Longitude), Y coordinate (Northing or Latitude), and Ch1, Ch2 through ChD. This data may be followed by a column containing Time Stamp (this optional parameter is located in a section Select Amplitude Scale).
If during data collection more than one instrument mode was used then select Instrument Mode to be used during the creation of XYZ file in the combo list

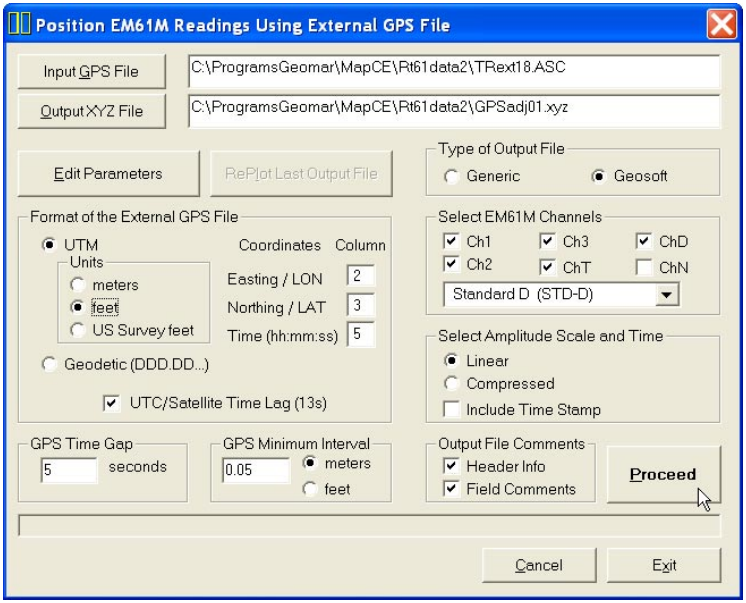


Figure 3.19: Position EM61M Readings Using External GPS File window

box located below selection of EM61M channels. Change of the EM61M mode may change selection of available channels.

If parameter Header Info in Include in File section is checked a line listing all parameters in the file will be placed as a header of the created XYZ file.

Select Amplitude Scale

Readings can be written in the output file in Linear (original) scale, or Compressed, as the signed square root of each value. Check the appropriate radio button in the Select Amplitude Scale section.

Type of Output File

Check the option appropriate for the contouring software used. The Generic option will create a three or more column file without any text strings. This file can be used as an input file for many contouring packages (including Surfer). Geosoft format will cause the program to write a message LINE # at the beginning of each survey line.

Include in File

This section contains two check boxes labeled **Header Info** and **Field Comments**. When Header Info box is checked the file will contain a header listing type of coordinates and names of channels contained in each column of created XYZ file. Checking box labeled Field Comments will cause the program to write text of all field comment (entered by the operator during the survey) in to the created file.

GPS Time Gap

Differentially corrected GPS data often has gaps, due to differences in the constellation of satellites visible to two (fixed and moving receivers), lack of beacon signal, surveying near trees, buildings, and other elevated obstructions. These gaps are filled by RTM61M with the assumption that the GPS receiver speed is essentially constant and that it moves along a straight line during the gaps.

The **GPS Time Gap** parameter specifies the maximum time during which the EM61M data will be linearly interpolated between two GPS positions. Enter this parameter (in seconds) in the edit box labeled **seconds** in the GPS Time Gap section (Figure 3.19). In most cases a value 2 to 3 times larger than the GPS data acquisition frequency is adequate, however the user has to determine this value based on the survey specific conditions and requirements. To ignore effect of this parameter enter a large number of seconds (i.e. 300 or more) as GPS Time Gap parameter.

GPS Minimum Interval

The **GPS Minimum Interval** parameter specifies the minimal distance between two GPS stations that will be used in interpolation. If this distance is smaller than the specified GPS Minimum Interval, then all EM61M readings located between these two stations will be ignored. This parameter is useful in cases when the operator stops for a moment and data are collected in one point. Limited accuracy of GPS positioning will create randomly distributed positions in area adjacent to the stationary location of the system. If RTM61M will calculate positions of sensor in case offset values (GPS X and/or GPS Y Offsets) are different than zero, positions of the EM61M will have quite large variations associated with apparent change of direction of the survey line caused by randomly close spaced GPS positions. In most cases a value 2 or 3 times smaller than average distance between two GPS stations is adequate, however the user has to deter-

mine right value for this parameter which will depend on survey conditions and first of all accuracy of the employed GPS receiver. To ignore the effect of this parameter and to use all stations during creating XYZ file (i.e. during testing when GPS antenna is stationary) set this parameter to zero.

Enter the GPS Minimum Interval in the edit box and check one of the two radio buttons labeled **meters** and **feet** (indicating distance unit) in the GPS Minimum Interval section (Figure 3.19).

Format of the External GPS File

This section describes contents of the External GPS File. It is assumed that the file is in ASCII (text) format, and columns are delimited by comma or spaces. Parameters that have to be specified include: type of coordinates (UTM or Geodetic), identifying numbers of columns corresponding to each coordinate and time, and indicating time of GPS data (UTC or satellite time). These parameters are necessary for RTM61M to correctly calculate positions of each sensor.

Post-processed GPS files in ASCII (text) format include UTM or Geodetic (Latitude/Longitude) coordinates. To select coordinates click **Geodetic** or **UTM** radio buttons (Figure 3.20). Geodetic coordinates, Latitude and Longitude are given in degrees. The program assumes format DDD.DDDDDDDD. Format DDMM.MMMMM (native format found in NMEA GPS messages) is not supported by this option of RTM61M. UTM coordinates can be generated in meters or feet. To select units for UTM coordinates click one of the radio buttons located in the Units section located at the UTM radio button (Figure 3.20). These radio buttons are active only when the radio button labeled UTM is selected.

Specify columns where each coordinate and time in text boxes labeled **Column**. Valid format of the time is hh:mm:ss.

Check box labeled UTC/Satellite Time Lag (13s) has to be checked if your GPS software is using Satellite Time to time stamp positions. NMEA messages, and therefore RTmap61M data file contains UTC time as a time of GPS reading. In most cases, if GPS logger is used to save data Satellite Time is used. Please refer to your GPS software manual. Currently difference between UTC and Satellite clocks is 13 seconds.

When all parameter are set and input and output file names are specified, the **Proceed** button is activated in the Position Sensors Using External GPS File window. After you click the **Proceed** button, the program begins to read input files, replaces GPS positions by positions given in GPS file, calculates EM61M stations positions based on the recorded GPS readings, instant heading, and other specified parameters, and writes results to the XYZ output file (or files depending on the Output Data setting). A progress bar at the bottom of the screen shows the percentage read (Figure 3.20).

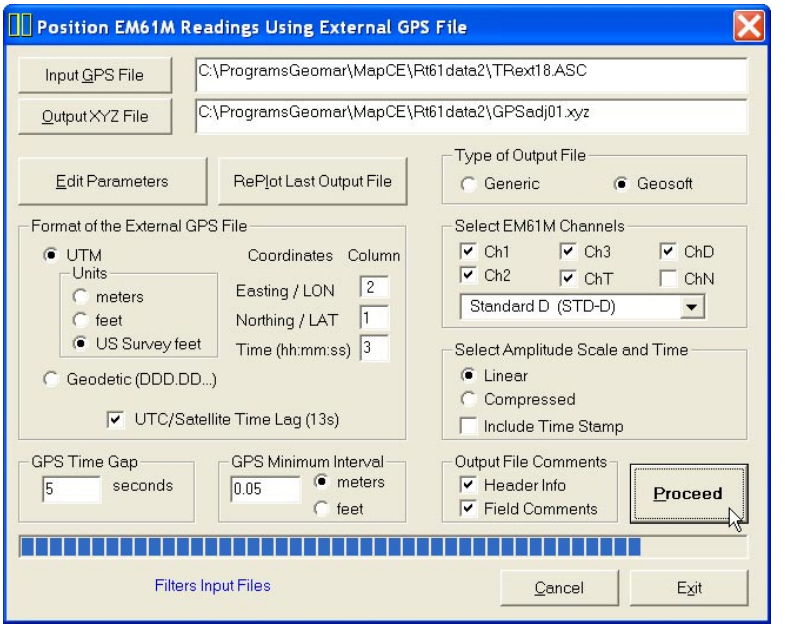


Figure 3.20: Position Sensors Using External GPS File window during creating XYZ file

The speed of this operation depends on the size of input files. After the output XYZ file is created a two dimensional layout of the survey is displayed (Figure 3.21).

The image displayed in the Plot XYZ window shows the spatial layout of stations to scale, based on the station coordinates as written to the created file. The display has fixed colours. GPS positions are marked by larger grey dots while the EM61M stations are plotted by smaller red dots. This plot window can be closed by clicking on **Close** button (located in the top right corner of the window).

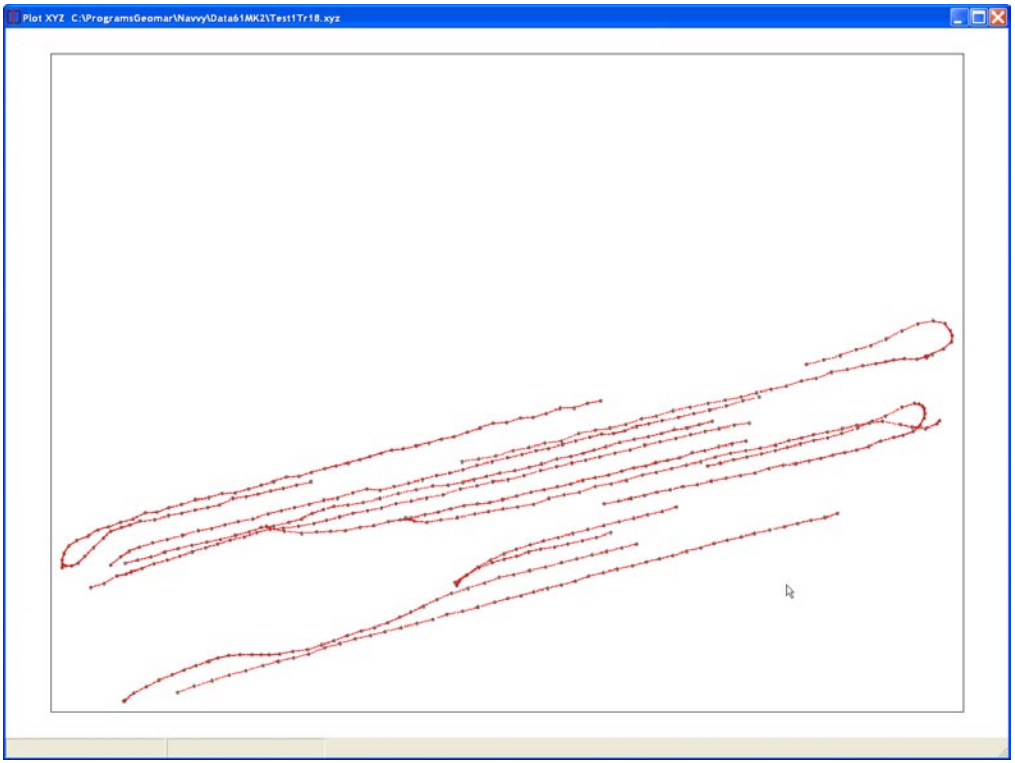


Figure 3.21: Two dimensional layout of stations taken with the Geonics EM61M and GPS. The GPS antenna was located above the center of the EM61M sensor (GPS X and Y offsets are set to zero).

After the Plot XYZ window is closed a button **Replot Last Output File** becomes active and the layout of data can be examined again. However, at this time original GPS positions will not be displayed and all instruments will be represented by the same colour on the screen. Files created by this portion of the program can be also viewed at any time using the **File|View XYZ File** menu.

After the file is created and its layout is examined it is possible (if required) to recreate XYZ file with changed system geometry parameters. To do this, click **Edit Parameters** button, the Edit RTmap61M File Parameters window will appear again. After changes are done, click the **Proceed** button to repeat procedure of creating XYZ file. See example in Figure 3.22 where GPS antenna location was changed as compared to case shown in Figure 3.21.

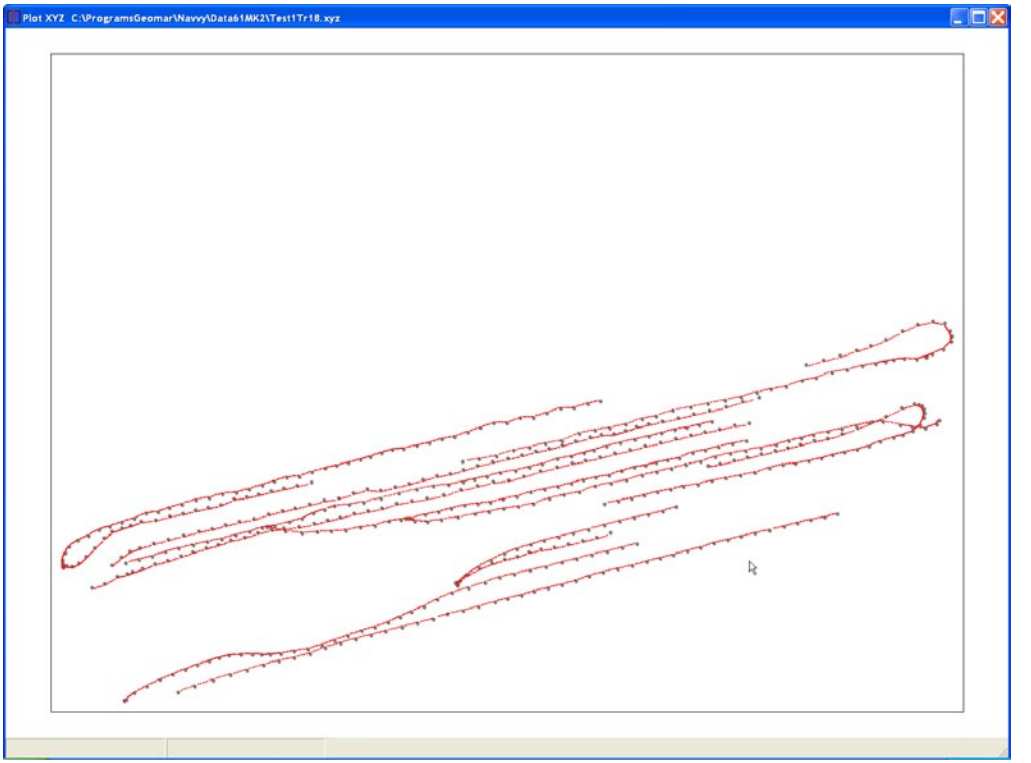


Figure 3.22: Two dimensional layout of stations taken with the Geonics EM61M and GPS. The GPS antenna was located off the center of the EM61 sensor (GPS X offset = 1.0 m and GPS Y offset =0).

If the input file does not contain sufficient GPS information, contains different time range, or parameters are not correctly selected, the program will display a warning message.

3.4 Positioning Readings Using Files in Geonics (M61) Format

The Position Readings Using Geonics (M61) File option allows you to position EM61M stations based on Real Time GPS data which were recorded in RTmap61M data file during the survey and then converted and processed in Geonics program DAT61MK2. The most common processing of data in DAT61MK2 may include shifting EM61M readings, removing offsets, deleting unwanted readings and survey lines. This program is also very useful for plotting data in profile view. The DAT61MK2 has its own GPS Positioning option however it does not support NMEA messages other than GGA, filter for PDOP Mask, GPS Minimum Interval and GPS Antenna offsets.

This option allows to use data processed in DAT61MK2 with all benefits provided by the RTM61M. However one condition must be met: while processing and editing data file in DAT61MK2 order of survey lines can not be changed. In other words, any number of readings can be removed but remaining readings must be placed in the file in order they were recorded. At the same time adding data from other files is not allowed.

Select **Position Sensors|Position Readings Using Geonics (M61) Files** from the main program menu, as shown in Figure 3.23.

Figure 3.23: RTM61M Position Readings menu

After the selected menu item is clicked the Position EM61M Readings Using Geonics (M61) File window will be displayed in the centre of the screen, Figure 3.24.

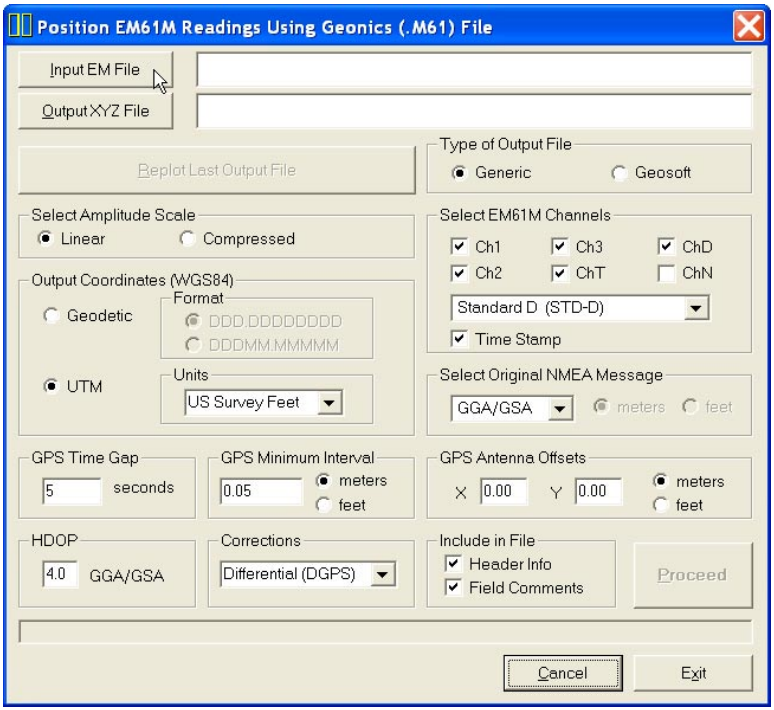


Figure 3.24: Position EM61M Readings Using Geonics (M61) File menu

Parameters in Positioning Readings Using Geonics (M61) File window

Several parameters which affect the contents and format of the created output (XYZ) file must be specified. These are the DAT61MK2, and XYZ file names, parameters describing contents of the created file and parameters related to electromagnetic as well as to GPS data.

Input EM File

Click on **Input EM File** button. The Select Geonics DAT61MK2 Input File window is displayed (Figure 3.25).

The window lists files with extension name M61. Select a file name and click the **Open** button. The Select Geonics DAT61MK2 Input File window will close and the selected file name will be displayed beside the **Input EM File** button.

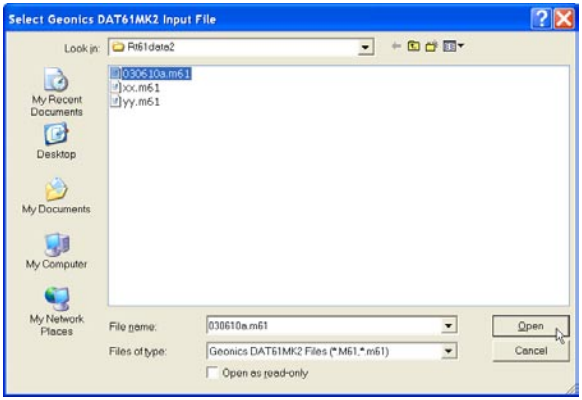


Figure 3.25: Select M61 File window

Output File

Click on the **Output XYZ File** button. The Select Output File window is displayed (Figure 3.26).

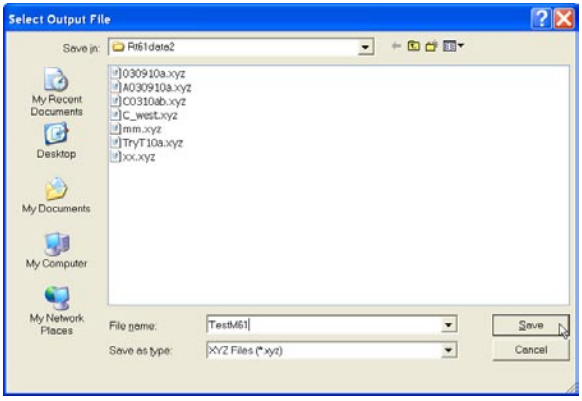


Figure 3.26: Select Output File window

Select a file name and click the **Save** button. The Select XYZ File window will close and the selected file name will be displayed beside the **Output XYZ File** button in the Position EM61M Readings Using Geonics (M61) File window. When both, Input and Output files are specified the **Proceed** button in the Position EM61M Readings Using Geonics (M61) File becomes active (Figure 3.27).

Select EM61M Channels

To select a data type click on desired check buttons labeled **Ch1**, **Ch2**, **Ch3**, **Ch4** or **ChT**, **ChD**, and **ChN**. Data is always placed in the created XYZ file in the fol-

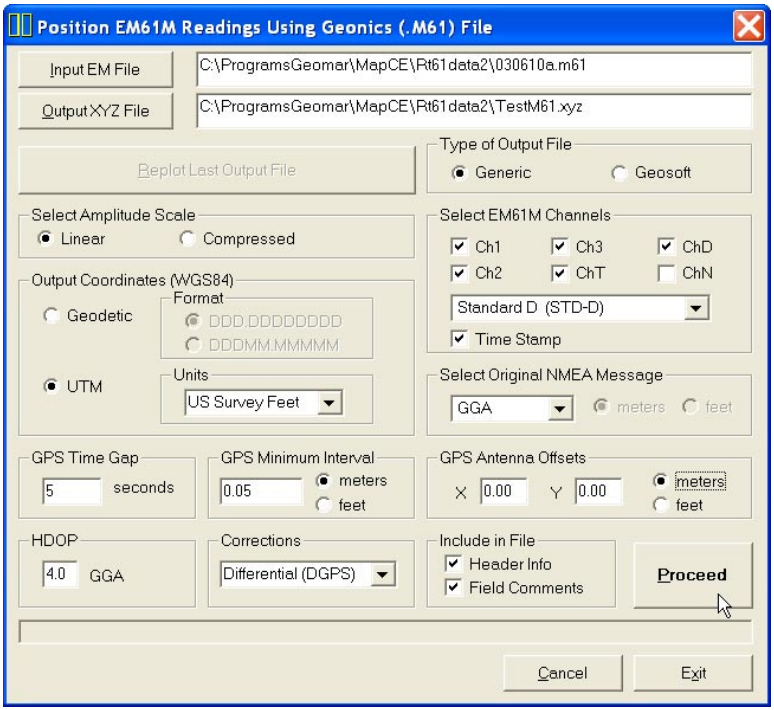


Figure 3.27: Position EM61M Readings Using Geonics (M61) File window

lowing order: X coordinate (Easting or Longitude), Y coordinate (Northing or Latitude), and Ch1, Ch2 through ChD and ChN. This data may be followed by one column containing Time Stamp (see check box in the same section).
If during data collection more than one instrument mode was used then select Instrument Mode to be used during the creation of XYZ file in the combo list box located below selection of EM61M channels. Change of the EM61M mode may change selection of available channels.
If parameter **Header Info** in Include in File section is checked a line listing all parameters in the file will be placed as a header for each created XYZ file.

Select Amplitude Scale

Readings can be written in the output file in Linear (original) scale, or Compressed, as the signed square root of each value. Check the appropriate radio button in the Select Amplitude Scale section.

Select Original NMEA Message

Specify name of NMEA GPS message that was used during data collection. Geonics format does not include type of NMEA message and RTM61M uses this parameter to properly process GPS data.
If a message that contains position in other than Geodetic coordinates (LLK, LLQ, and Leica TPS) is indicated then two radio buttons labeled **meters** and **feet** are enabled. Please specify proper distance units.

GPS Antenna Offsets

Specify values of X and Y GPS Antenna offsets and units. Geonics format does not include these parameters, therefore RTM61M uses values that are indicated in this section of the window.

Type of Output File

Check the option appropriate for the contouring software used. The Generic option will create a three or more column file without any text strings. This file can be used as an input file for many contouring packages (including Surfer). Geosoft format will cause the program to write LINE # at the beginning of each survey line.

Include in File

This section contains two check boxes labeled **Header Info** and **Field Comments**. When Header Info box is checked the file will contain a header listing type of coordinates and names of data contained in each column of created XYZ file. Checking box labeled Field Comments will cause the program to write text of all field comment (entered by the operator during the survey) in to the created file.

Output Coordinates

Positions can be written in the output file as geodetic (geographical) coordinates (Latitude/Longitude) or they can be converted to UTM coordinates. The program uses the WGS1984 datum. To select coordinates click **Geodetic** or **UTM** radio buttons (Figure 3.27).

Geodetic coordinates, Latitude and Longitude are given in degrees. They can be written in two formats DD.DDDDDDDD or DDMM.MMMMM (native format found in NMEA GPS messages). To select which format click the appropriate radio button in Format section located at the radio button labeled Geodetic. This section is active only when radio button Geodetic is selected (Figure 3.27).

UTM coordinates can be generated in meters or feet. To select units for UTM coordinates click on a combo box placed in the Units section located at the UTM radio button (Figure 3.27) and select proper units: Meters, Feet, or US Survey Feet. This combo box is active only when radio button labeled UTM is selected.

GPS Time Gap

Differentially corrected GPS data often has gaps, due to differences in the constellation of satellites visible to two (fixed and moving receivers), lack of beacon signal, surveying near trees, buildings, and other elevated obstructions. These gaps are filled by RTM61M with the assumption that the GPS receiver speed is essentially constant and that it moves along a straight line during the gaps.

The **GPS Time Gap** parameter specifies the maximum time during which the EM61M data will be linearly interpolated between two GPS positions. Enter this parameter (in seconds) in the edit box labeled **seconds** in the GPS Time Gap section (Figure 3.27). In most cases a value 2 to 3 times larger than the GPS data acquisition frequency is adequate, however the user has to determine this value based on the survey specific conditions and requirements. To ignore effect of this parameter enter a large number of seconds (i.e. 300 or more) as GPS Time Gap parameter.

GPS Minimum Interval

The **GPS Minimum Interval** parameter specifies the minimal distance between two GPS stations that will be used in interpolation. If this distance is smaller than the specified GPS Minimum Interval, then all EM61M readings located between these two stations will be ignored. This parameter is useful in cases when the operator stops for a moment and data are collected in one point. Limited accuracy of GPS positioning will create randomly distributed positions in area adjacent to the stationary location of the system. If RTM61M will calculate positions of sensor in case offset values (GPS X and/or GPS Y Offsets) are different than zero, positions of the EM61M will have quite large variations associated with apparent change of direction of the survey line caused by randomly close spaced GPS positions. In most cases a value 2 or 3 times smaller than average distance between two GPS stations is adequate, however the user has to determine right value for this parameter which will depend on survey conditions and first of all accuracy of the employed GPS receiver. To ignore the effect of this parameter and to use all stations during creating XYZ file (i.e. during testing when GPS antenna is stationary) set this parameter to zero.

Enter the GPS Minimum Interval in the edit box and check one of the two radio buttons labeled **meters** and **feet** (indicating distance unit) in the GPS Minimum Interval section (Figure 3.27).

PDOP Mask

The PDOP Mask is used to filter quality of GPS positions. The index called PDOP (Position Dilution of Precision) measures the strength of satellite coverage for a given area. PDOP is affected by the number of satellites visible and their relative positions in the sky. The smaller the number of PDOP the stronger the satellite coverage is. When there are more than 5 satellites widely spaced visible, the PDOP is 4 or less. However, when there are less satellites visible, or they are unevenly spaced in the sky, PDOP values can be 6 or higher. In most cases, the PDOP in open sky is less than 3, and most accuracies given for many GPS systems are given for this norm. The index called GDOP covers time accuracy in addition, while the index HDOP is related only to horizontal position fix (it is used when message GGA was selected). Refer to GPS documentation and literature for more information related to error sources of GPS positioning.

The section PDOP Mask may differ depending on GPS NMEA message used. It is related to PDOP parameter if GGA/GSA, POS, or GGK was employed during the survey, to HDOP if GGA was used, to GDOP if LLK was used during the survey, and it is invalid if GLL or LLQ message was used.

Enter the PDOP (HDOP or GDOP) value in the edit box in the PDOP Mask section, Figure 3.27. All positions (as well as EM61M readings) associated with GPS data of higher than specified value of this index will be ignored.

Corrections

Select type of differentially corrected position data to be used during the creation of XYZ file in the combo list box labeled Corrections. Four types of GPS corrections are given: **Raw (GPS)**, **Differential (DGPS)**, **Differential (RTK 3)**, **Differential (RTK 4)**, and **Differential (RTK 5)**. Last three types of RTK (real time kinematic) corrections are available only in high end of GPS receivers and differently named depending on manufacturer, however in NMEA specifications they indicate Quality Parameter 3, 4, and 5. When **Raw** is selected, both differentially corrected and raw GPS data are used to calculate positions of EM61M stations.

It should be noted that if any NMEA message indicates that GPS position (fix) is invalid this data is ignored by the RTM61M.

When all parameter are set and input and output file names are specified, the **Proceed** button is activated in the Position Readings Using Geonics (M61) File window. After you click the **Proceed** button, the program begins to read the input file, calculates EM61M stations positions based on the recorded GPS readings, instant heading, and other specified parameters, and writes results to the XYZ output file. A progress bar at the bottom of the screen shows the percentage of the file processed (Figure 3.28).

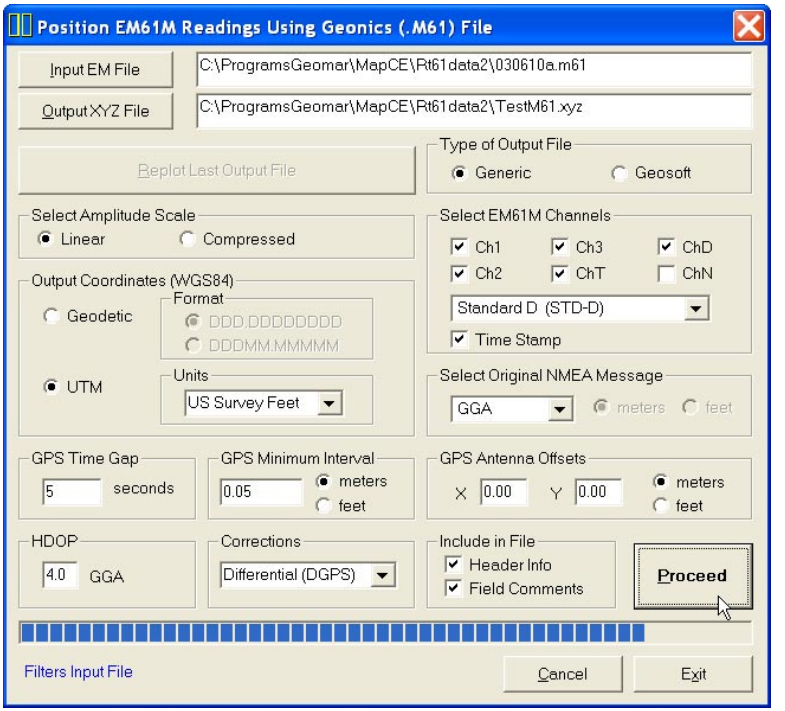


Figure 3.28: Position EM61M Readings Using Geonics (M61) File window during creating XYZ file

The speed of this operation depends on the size of the input file. After the output XYZ file is created a two dimensional layout of the survey is displayed (Figure 3.29).

The image displayed in the Plot XYZ window shows the spatial layout of stations to scale, based on the station coordinates as written to the created file. The display has fixed colours. GPS positions are marked by larger grey dots while the EM61M stations are plotted by smaller red dots. This plot window can be closed by clicking on **Close** button (located in the top right corner of the window).

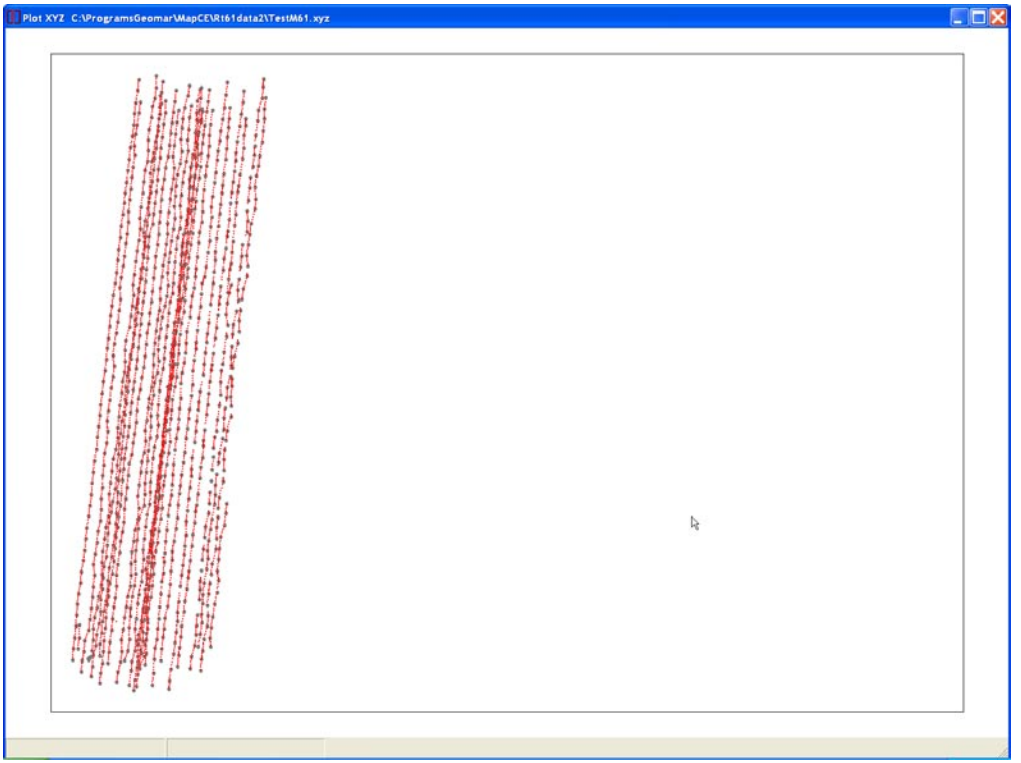


Figure 3.29: Two dimensional layout of stations taken with the Geonics EM61M. The GPS X and Y offsets were set to zero (GPS antenna was located above the center of the EM61M sensor).

After the Plot XYZ window is closed a button **Replot Last Output File** becomes active and the layout of data can be examined again. However, at this time original GPS positions will not be displayed and only instrument positions will be represented by red dots on the screen. Files created by this portion of the program can be also viewed at any time using the **File|View XYZ File** menu.

After the file is created and its layout is examined it is possible (if required) to recreate XYZ file with changed system geometry parameters run this option again. After changes are done, click the **Proceed** button to repeat procedure of creating XYZ file. See example in Figure 3.30 where GPS antenna location was changed as compared to case shown in Figure 3.29.

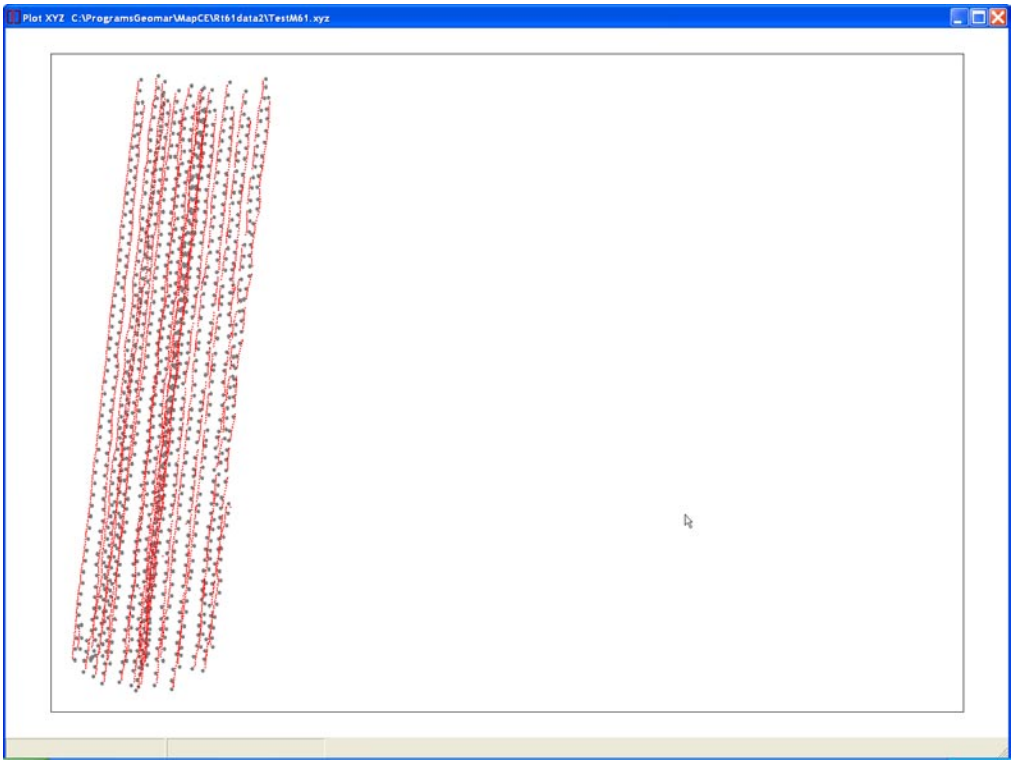


Figure 3.30: Two dimensional layout of stations taken with the Geonics EM61M. The GPS X and Y offsets: GPS X Offset = 0.15 m and GPS Y Offset = 0.0

Convert Data Files 4

Convert menu of RTM61M program allows you to convert the RTmap61M binary file to other formats. There are five items associated with the Convert menu (Figure 4.1):

- convert RTmap61M file to Geonics DAT61MK2 (.T61) format,
- convert RTmap61M file to general format ASCII file,
- retrieve and position field comments from RTmap61M,
- convert GXY file to ASCII file containing positions,
- correct system time constant delay in XYZ files.

Figure 4.1: Convert Data Files menu

Files converted to Geonics M61 format can be further processed by the Geonics DAT61MK2 program, while files converted to general ASCII format can be easily reformatted and used by other software. While retrieving comments from RTmap61M file, the program retrieves text of the comment and their position based on neighbouring GPS records. When converting GXY files (containing only GPS positions and field comments) the program generates simple XY type of file (coordinates in two columns with optional parameters). Correct Time Constant Delay item provides correction for specified time constant delay of the system (EM instrument specific time constant combined with GPS latency). Any XYZ file containing sequential time stamp column can be corrected while using this option.

It should be noted that three first items of Convert Files menu are disabled. They are enabled automatically after the RTmap61M data file is loaded in File menu (Figure 4.2).

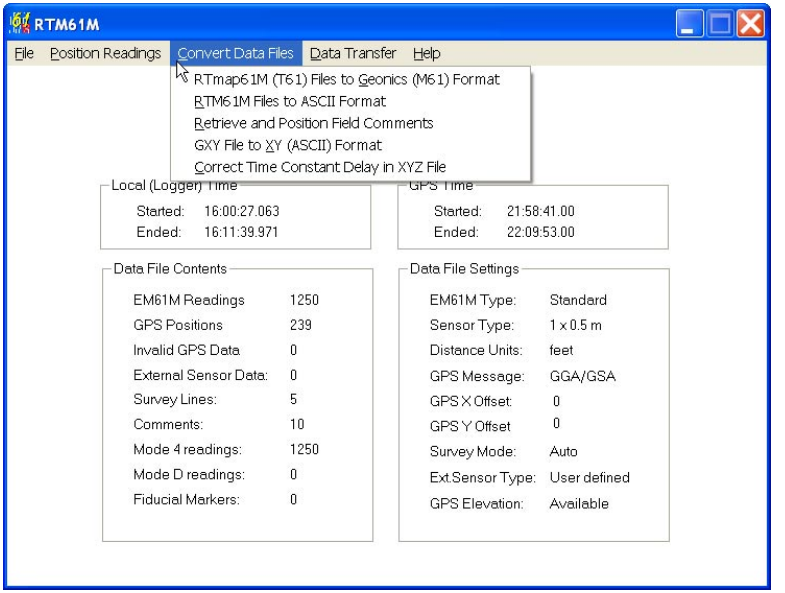


Figure 4.2: Convert Data Files menu after RTmap61M file is loaded to the program

Selected examples of file formats created by RTM61M are given in Appendix B of this manual.

4.1 Convert RTmap61M Data to Geonics DAT61MK2 (M61) Format

The Convert RTmap61M to Geonics M61 Format option allows you to convert RTmap61M files to Geonics DAT61MK2 format. Select **Convert|RTmap61M to Geonics M61 Format** from the main program menu, as shown in Figure 4.2.

After the selected menu item is clicked the Convert RTmap61M Files (T61) to Geonics M61 Format window will be displayed in the centre of the screen, Figure 4.3.

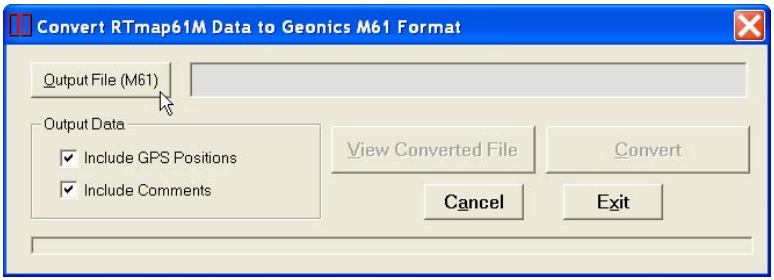


Figure 4.3: Convert RTmap61M Files to Geonics M61 Format

Parameters in Convert RTmap61M Data to Geonics M61 Format Window

Several parameters which affect the contents and format of the created output (M61) file must be specified. The first is Output File name. Output Data parameters if checked cause the program to write GPS positions, Comments entered in the field. Time Stamp for each reading is included automatically.

Output File (M61)

Click on the **Output File (M61)** button. The Select Output File window is displayed (Figure 4.4).

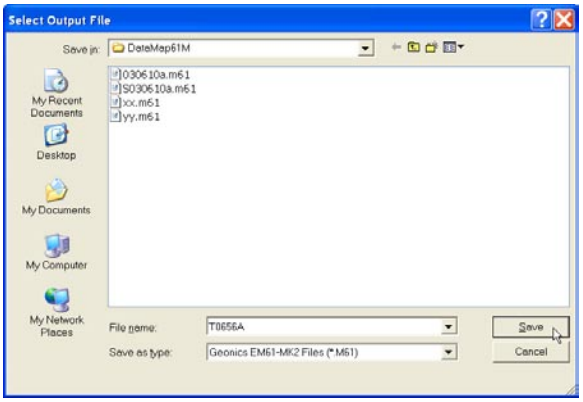


Figure 4.4: Select Output File window

Select a file name and click the **Save** button. The Select Output File window will close and the selected file name will be displayed beside the **Output File (M61)** button in the Convert RTmap61M to Geonics M61 Format window.

When Output file is specified the **Convert** button in the Convert RTmap61M to Geonics M61 Format window becomes active.

Output Data

RTM61M can generate a file with EM61M data as recorded by RTmap61M data acquisition program. The file may also contain GPS positions and Comments. Check appropriate check boxes in section labeled Data Output. GPS positions are properly written in Geonics DAT61MK2 format regardless which GPS message was used during the survey.

Converting RTmap61M Data to Geonics DAT61MK2 (M61) Format

When all parameters are set and input and output file names are specified, the **Convert** button is activated in the Convert RTmap61M File to Geonics M61 Format window. After you click the **Convert** button, the program begins to read the input file, converts data to DAT61MK2 format and writes results to the output file. A progress bar at the bottom of the screen shows the percentage of the file read (Figure 4.5).

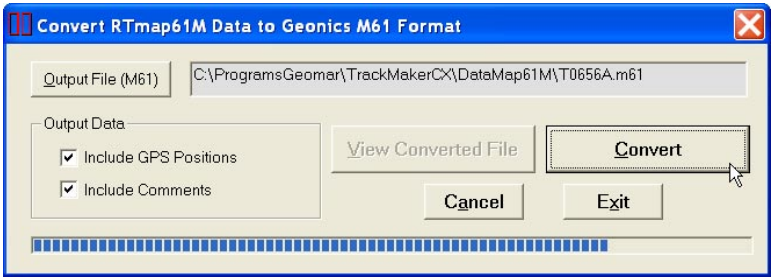


Figure 4.5: Convert RTmap61M Files (T61) to Geonics M61 Format window during data processing

The speed of this operation depends on the size of the input file. After the output (M61) file is created the **View Converted File** button becomes active. Clicking on this button will display first 63 Kbytes of the created file.

The created file can be loaded to the Geonics DAT61MK2 program. It should be noted that the created file contains original GPS positions, without corrections for GPS X and Y Offsets specified during the survey.

Clicking **Cancel** button will clear text box at **Output File (M61)** button. Click on **Exit** button to close the Convert RTmap61M Files (T61) to Geonics M61 Format window.

An example of data file in Geonics DAT61MK2 (M61) format is given in Appendix B.

4.2 Convert RTmap61M Data to ASCII Format

The Convert RTmap61M Data to ASCII Format option allows you to convert RTmap61M binary files to ASCII format, which can be viewed with any text editor and then easily converted to the other format. Select **Convert|RTmap61M to ASCII Format** from the main program menu, as shown in Figure 4.2.

After the selected menu item is clicked the Convert RTmap61M Files to ASCII Format window will be displayed in the centre of the screen, Figure 4.6.

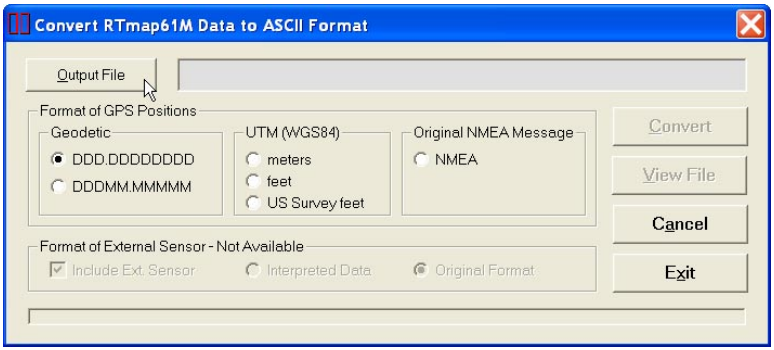


Figure 4.6: Convert RTmap61M Files to ASCII Format window

Parameters in Convert RTmap61M Data to ASCII Format Window

Several parameters which affect the contents and format of the created output (ASC) file must be specified. These are the ASCII file name, and Format of GPS Positions (co-ordinates format or original NMEA statement). The External Sensor option is not used in this version of the program.

Output File

Click on the **Output File** button. The Select Output File window is displayed (Figure 4.7).

Select a file name and click the **Save** button. The Select ASC Output File window will close and the selected file name will be displayed beside the **Output File (ASC)** button in the Convert RTmap61M Files to ASCII Format window.

When Output file is specified the **Convert** button in the Convert RTmap61M Data to ASCII Format window becomes active.

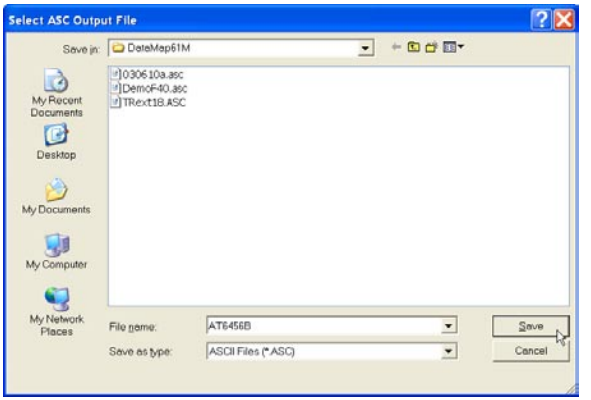


Figure 4.7: Select ASC Output File window

Format of GPS Positions

Positions can be written in the output file as geodetic (geographical) coordinates (Latitude/Longitude), they can be converted to UTM coordinates, or written to file as original NMEA messages (exactly as streamed by a GPS receiver). The program uses the WGS1984 datum. To select coordinates click the appropriate radio buttons in the sections labeled **Geodetic** or **UTM** (Figure 4.6).

Geodetic coordinates, Latitude and Longitude are given in degrees. They can be written in two formats DD.DDDDDDDD or DDMM.MMMMM (native format found in NMEA GPS messages). To select which format click the appropriate radio button in the section labeled **Geodetic** (Figure 4.6).

UTM coordinates can be generated in meters, feet or US Survey feet. To select units for UTM coordinates click one of the radio buttons located in the Units section located at the UTM radio button (Figure 4.6).

Converting RTmap61M Data to ASCII Format

When all parameter are set and output file name is specified, the **Convert** button is activated in the Convert RTmap61M Data to ASCII Format window. After you click the **Convert** button, the program begins to read the data, converts data to ASCII format and writes results to the output file. A progress bar at the bottom of the screen shows the percentage read (Figure 4.8).

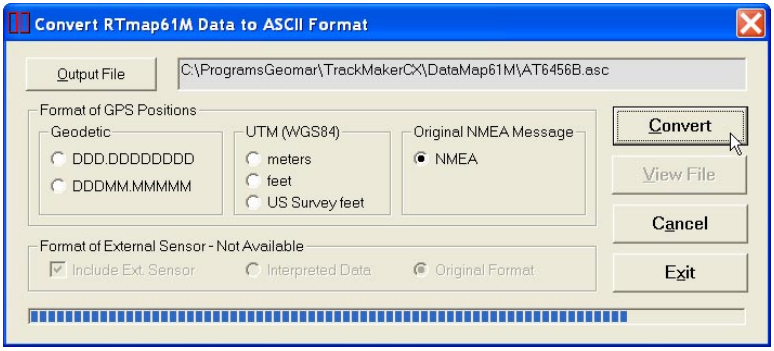


Figure 4.8: Convert RTmap61M Files to ASCII Format window during data processing

The speed of this operation depends on the size of the input file. After the output file is created the **View Converted File** button becomes active. Clicking on this button will display first 63 Kbytes of the created file.

The created file contains EM61 readings, GPS positions, and entire information related to the instrument and survey settings. Example of the output file in ASCII format is given in Appendix B.

Clicking **Cancel** button will clear text box at **Output File** button. Click on **Exit** button to close the Convert RTmap61M Data to ASCII Format window.

4.3 Retrieve and Position Field Comments

The Retrieve and Position Field Comments option allows you to convert retrieve field comments from RTmap61M binary files. At the same time the program assigns GPS positions to indicate where these comments were entered by the operator. The position can be assigned either as a GPS position preceding or position following the comment entry. The resulting output file consists of coordinates and corresponding text of the comment. Select **Convert|Retrieve and Position Field Comments** from the main program menu, as shown in Figure 4.2.

After the selected menu item is clicked the Position Comments Recorded in RTmap61M File window will be displayed in the centre of the screen, Figure 4.9.

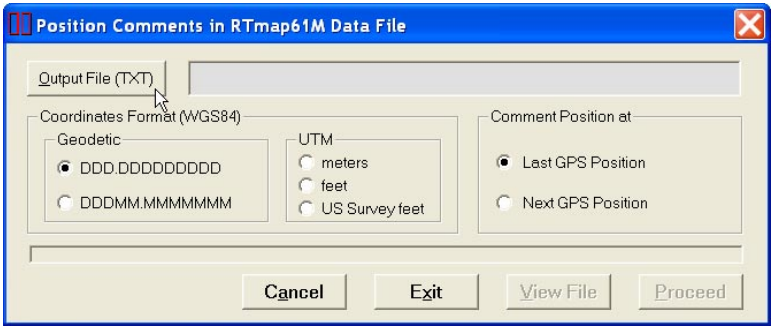


Figure 4.9: Position Comments in RTmap61M Data window

Parameters in Position Comments Recorded in RTmap61M File Window

Several parameters which affect the contents and format of the created output (TXT) file must be specified. These are the output file names, coordinates format, and indicating type of position of the comment - using a preceding or following GPS reading.

Output File (TXT)

Click on the **Output File (TXT)** button. The Select Output File window is displayed (Figure 4.10).

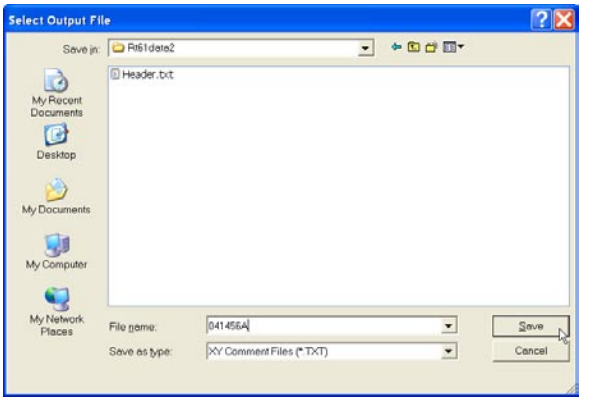


Figure 4.10: Select Output File window

Select a file name and click the **Save** button. The Select Output File window will close and the selected file name will be displayed beside the **Output File (TXT)** button in the Position Comments Recorded in RTmap61M File window.

When both, Input and Output files are specified the **Proceed** button in the Position Comments Recorded in RTmap61M File window becomes active.

Coordinates Format

Positions can be written in the output file as geodetic (geographical) coordinates (Latitude/Longitude) or they can be converted to UTM coordinates. The program uses the WGS1984 datum. To select coordinates click the appropriate radio buttons in sections labeled **Geodetic** or **UTM** (Figure 4.9).

Geodetic coordinates, Latitude and Longitude are given in degrees. They can be written in two formats DD.DDDDDDDD or DDMM.MMMMM (native format found in NMEA GPS messages). To select which format click the appropriate radio button in section labeled **Geodetic** (Figure 4.9).

UTM coordinates can be generated in meters, feet or US Survey feet. To select units for UTM coordinates click one of the radio buttons located in the Units section located at the **UTM** radio button (Figure 4.9).

Comment Position at

This section specifies how GPS positions are assigned to the comment. There are two choices: Comment can be assigned to the last position that was recorded by the RTmap61M program, or to the position that follows comment entry. In most cases any choice is right since comments are usually taken while collecting data (including GPS positions) and during comment entry operator stops recording for a moment. However the option **Last GPS Position** appears to be more natural since after the comment entry the operator may stop taking readings and later continue survey from other location.

To select comment position option click one of the radio buttons labeled **Last GPS Position** and **Next GPS Position** located in the Comment Position at section of the window (Figure 4.9).

Positioning Comments Recorded in RTmap61M File

When all parameter are set and input and output file names are specified, the **Proceed** button is activated in the Position Comments Recorded in RTmap61M File window. After you click the **Proceed** button, the program begins to read the input file, converts data to ASCII format and writes results to the output file. A progress bar at the bottom of the screen shows the percentage read (Figure 4.11).

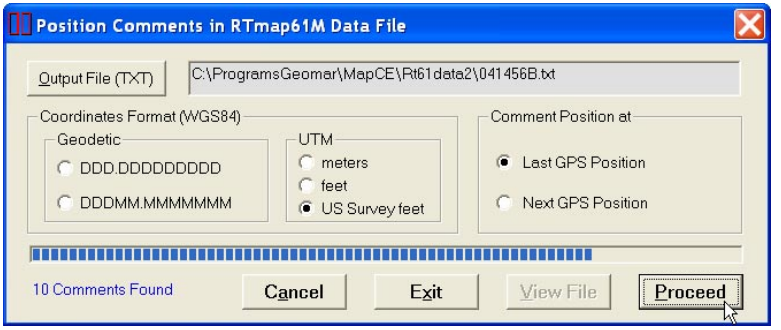


Figure 4.11: Position Comments Recorded in RTmap61M File during data processing

The speed of the operation depends on the size of the input file. After the output file is created the **View File** button becomes active. Clicking on this button will display first 63 Kbytes of the created file.

The created file contains GPS positions in the first two columns followed by the text of comment as recorded in the field. Example of the output file containing comments is given in Appendix B.

Clicking **Cancel** button will clear text boxes at **Input File (T61)** and **Output File (TXT)** buttons. Click on **Exit** button to close the Position Comments Recorded in RTmap61M File window.

4.4 Convert GXY Files to XY (ASCII) Format

Files GXY are created by the RTmap61M when only GPS data are collected (EM61 is Disabled). This type of file contains GPS positions and optionally field comments. The Convert GXY File to XY (ASCII) Format option allows you to convert GXY binary file to simple XY type of file. This file contains coordinates placed in first two columns with optional field comments, elevation, UTC time, local time, and GPS station number located in following columns. All parameters are always placed in above order. This format can be viewed with any text editor and it can be easily converted to other formats.

It should be noted that GXY files created with any other Geomar data acquisition programs (i.e. ML61MK2, NAV61MK2, NAV31, NAV38, etc.) can be converted to ASCII format using this option of RTM61M.

Select **Convert|GXY Files to XY (ASCII) Format** from the main program menu, as shown in Figure 4.1. After the selected menu item is clicked the Convert GXY File to XY Format window will be displayed in the centre of the screen, Figure 4.12.

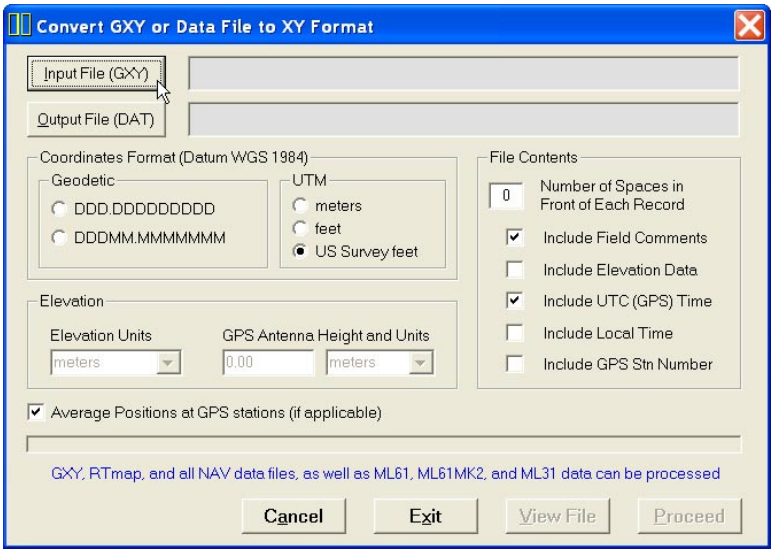


Figure 4.12: Convert GXY Files to XY Format window

Parameters in Convert GXY to XY Format Window

Several parameters which affect the contents and format of the created output (DAT) file must be specified. These are the input and output names, Coordinates Format, and contents of the output file.

Input File (GXY)

Click on **Input File (GXY)** button. The Select GXY Input File window is displayed (Figure 4.13).

The window lists files with extension name GXY. Select a file name and click the **Open** button. The Select GXY File window will close and the selected file name will be displayed beside the **Input File (GXY)** button in the Convert GXY File to XY Format window.

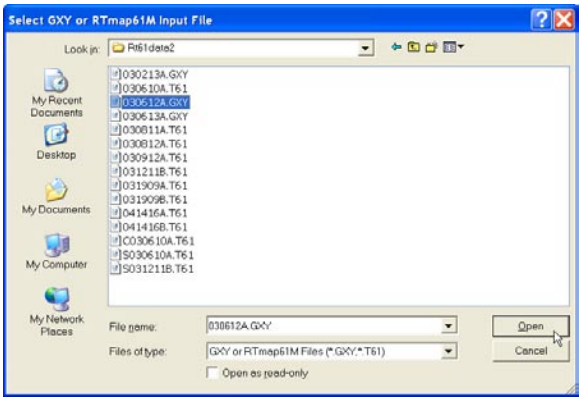


Figure 4.13: Select GXY Input File window

Output File (DAT)

Click on the **Output File (DAT)** button. The Select Output File window is displayed (Figure 4.14).

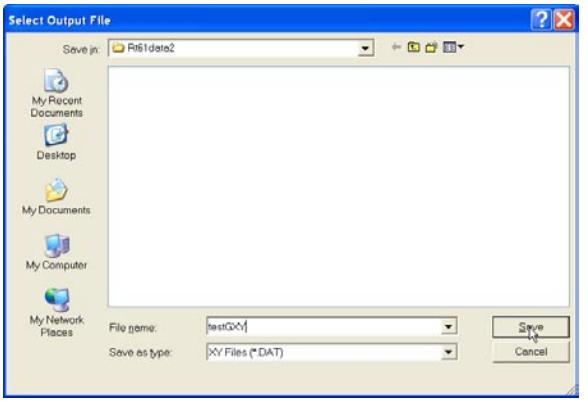


Figure 4.14: Select Output File window

Select a file name and click the **Save** button. The Select Output File window will close and the selected file name will be displayed beside the **Output File (DAT)** button in the Convert GXY File to XY Format window.

When both, Input and Output files are specified the **Proceed** button in the Convert GXY File to XY Format window becomes active.

Coordinates Format

Positions can be written in the output file as geodetic (geographical) coordinates (Latitude/Longitude) or they can be converted to UTM coordinates. The program uses the WGS1984 datum. To select coordinates click appropriate radio buttons in sections labeled **Geodetic** or **UTM** (Figure 4.12).

Geodetic coordinates, Latitude and Longitude are given in degrees. They can be written in two formats DD.DDDDDDDD or DDMM.MMMMM (native format found in NMEA GPS messages). To select which format click the appropriate radio button in section labeled **Geodetic** (Figure 4.12).

UTM coordinates can be generated in meters, feet or US Survey feet. To select units for UTM coordinates click one of the radio buttons located in the Units section located at the UTM radio button (Figure 4.12).

File Contents

This section affects the output file format and contents. It contains one text box labeled **Number of Spaces in Front of Each Record** and five check boxes labeled **Include Field Comments**, **Include Elevation Data**, **Include UTC (GPS) Time**, **Include Local Time**, and **Include GPS Stn Number**.

Number entered in the text box will specify number of spaces in front of each record. This option may be useful while using created files as control files in mapping software. To ignore this option enter zero.

Checking box labeled Include Field Comments will cause the program to write text of all field comment (entered by the operator during the survey) in to the created file.

The Include Elevation Data option allows you to place elevation values in the created file. When this option is checked then a set of options in the frame labeled Elevation is enabled.

When Include GPS Time box is checked the program will write a column containing time of GPS position, and if the Include Local Time box is checked local (field computer) time will be written to the file.

When the Include GPS Stn (station) Number is checked then sequential GPS station will be placed in the file. If averaging was used during GPS data collection (and check box Average Positions... is not checked) then several recorded GPS positions may have same station number.

Elevation

If Elevation check box is checked then window controls associated with Elevation are enabled. Please select units for elevation values (these can be meters, feet, or US Survey feet). To obtain ground elevation values please specify GPS antenna height and units that were used to measure height of the antenna.

Average Positions at GPS stations

If averaging was used during GPS data collection and the check box labeled Average Positions at GPS stations is checked then the program will calculate averaged position from all readings taken at each station and one resulting value will be written to the file. When the check box is not checked then all recorded positions will be placed in the file.

Converting GXY File to XY (ASCII) Format

When all parameter are set and input and output file names are specified, the **Proceed** button is activated in the Convert GXY to XY Format window. After you click the **Proceed** button, the program begins to read the input file, converts data to ASCII format and writes results to the output file. A progress bar at the bottom of the screen shows the percentage read (Figure 4.15).

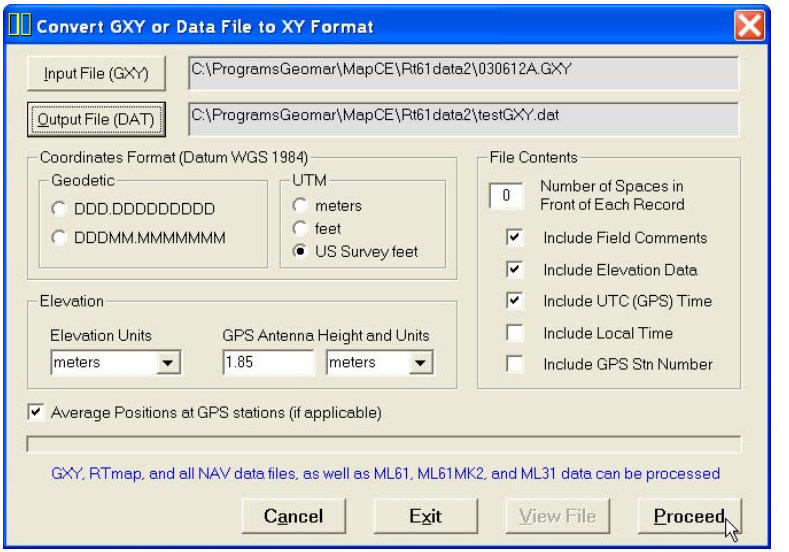


Figure 4.15: Convert GXY Data Files to XY Format window during data processing

The speed of this operation depends on the size of the input file. After the output file is created the **View File** button becomes active. Clicking on this button will display first 63 Kbytes of the created file.

The created file contains GPS positions as recorded in the field. Example of the output file in ASCII format is given in Appendix B.

Clicking **Cancel** button will clear text boxes at **Input File (GXY)** and **Output File (DAT)** buttons. Click on **Exit** button to close the Convert GXY Files to XY Format window.

4.5 Correct Time Constant Delay in XYZ File

This option allows for the system time constant delay correction. The procedure acts on two dimensional, GPS positioned data.

While the EM61 time constant is known the time constant of the combined EM61 and GPS receiver system is a function of these two devices. The easiest method to determine the time constant of the system is to survey a known buried pipe. After the proper time constant delay correction is applied the linear anomaly associated with the pipe should be free of any “hearing bone” effect. Another method to determine the time delay is to survey a few lines (in two directions) with varying speeds over the same small metallic target. When displaying the image the anomaly associated with the sample target may be slightly displaced or extended in size on neighboring lines. After the correct time constant for the system is determined the anomaly should be at the same location for each survey line.

Since the image of two dimensional data can be displayed in a mapping system (after griding) the procedure can be time consuming, however it only needs to be done once for a given GPS receiver and EM61.

In order to apply the correction the generated XYZ file must have time stamps. In the event input file does not have time stamp at each reading the program will display a warning message.

The correction acts on any XYZ type of file so care should be taken that data is not corrected twice.

To access this option select **Convert|Correct Time Constant Delay in XYZ File** in the menu (Figure 4.1). The Correct Time Constant Delay window will appear on the screen (Figure 4.16).

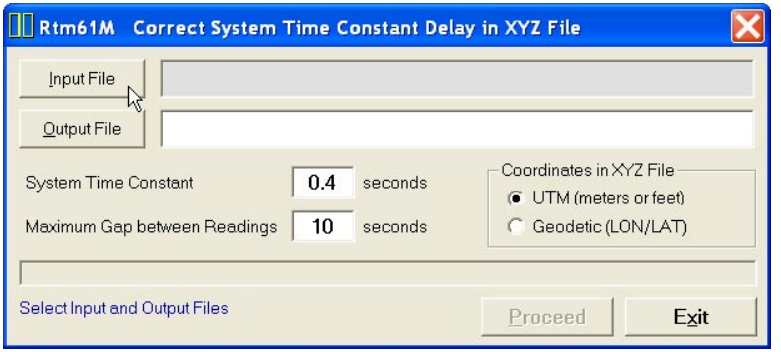


Figure 4.16: Correct Time Constant Delay in XYZ File window

Parameters in Correct Time Constant Delay Window

Several parameters which affect the contents of the created output (XYZ) file must be specified. These are the Input and Output XYZ file names, System Time Constant, Maximum Gap between Readings, and type of coordinates in the input XYZ file.

Input File

Click on **Input File** button. The Select Input XYZ File window is displayed (Figure 4.17).

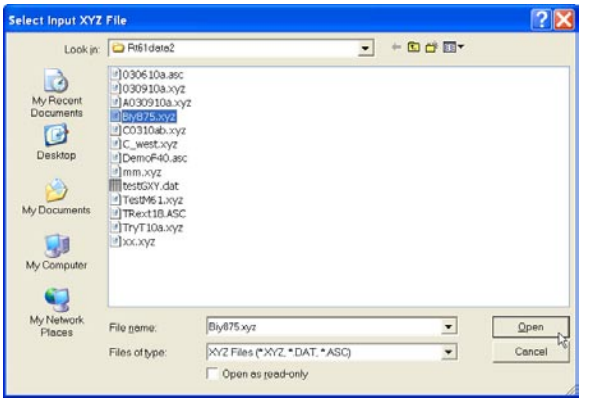


Figure 4.17: Select Input XYZ File window

The window lists files with extension names XYZ, DAT, and ASC. Select a file name and click the **Open** button. The Select Input XYZ File window will close and the selected file name will appear next to the **Input File** button in the Correct Time Constant Delay window.

Output File

Click on the **Output File** button. The Select XYZ File window is displayed (Figure 4.18).

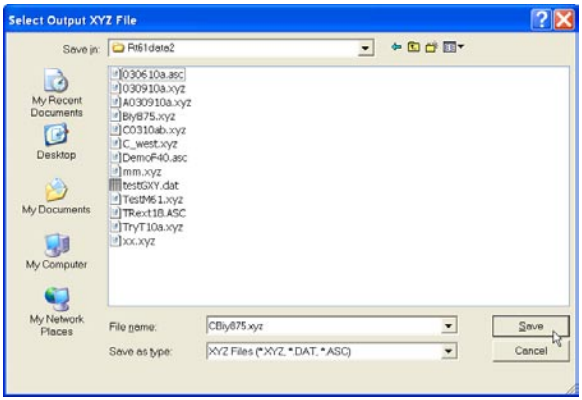


Figure 4.18: Select Output XYZ File window

As a default the Input File name with prefix C is given. Accept the default, enter, or select a file name and click the **Save** button. The Select Output XYZ File window will close and the selected file name will be displayed beside the **Output File** button in the Correct Time Constant Delay window.

When Input and Output files are specified the **Proceed** button in the Correct Time Constant Delay window becomes active (Figure 4.19).

System Time Constant

Time delay 0.4 seconds is given as a default. This value can be changed (0 to 2 seconds), however the user should experiment before choosing a final value.

Maximum Gap Between Readings

This parameter specifies the maximum time during which the EM61 data will be treated as continuous data set. If the gap between two stations is larger than specified maximum gap the station that follows the gap will be assumed the first station of a new line.

Enter this parameter (in seconds) in the edit box labeled Maximum Gap between Readings. In most cases a value 2 to 3 times larger than the GPS acquisition frequency is adequate.

Coordinates in XYZ File

Specify type of coordinates in the input file. The output file will be written with the same type of coordinates.

Creating XYZ File With Time Delay Corrections

When all parameter are set and input and output file names are specified, the **Proceed** button is activated in the Correct Time Constant Delay window. After you click the **Proceed** button, the program begins to read and analyze the input file. A label Analyzing File is displayed at the bottom of the window. The program then calculates corrections for each station based on the instant velocity of the system at each station. A progress bar at the bottom of the screen shows the percentage read (Figure 4.19).

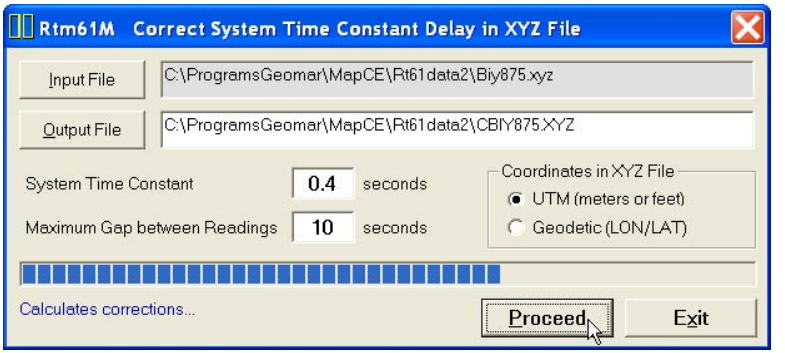


Figure 4.19: Correct Time Constant Delay in the XYZ File window during data processing

If the input file does not contain time stamp information, the program will display a warning message, and it will pause operation till the **OK** button is clicked in the warning window.

RTmap61M Data File

A

A.1 Description of RTmap61M Data File Format (T61)

Each record created by the RTmap61M for Allegro CX program contains 27 characters, including line feed at the end of each record.

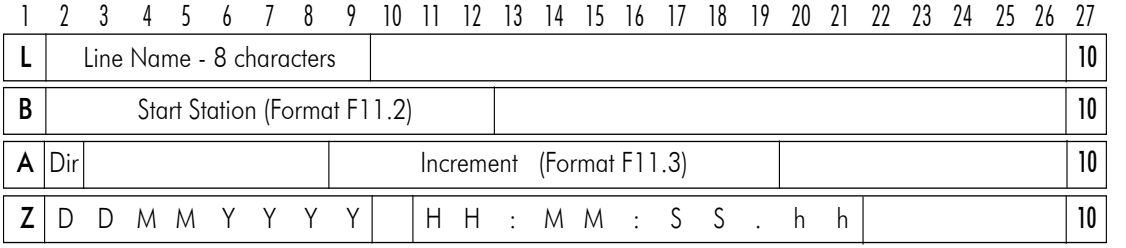
Header of the file contains 7 records starting with characters R, H, G, and then four records starting with O.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
R	T	M	6	1	M			W	1	0	1	Survey Type			UT	IT	IM	ST								10
H		File Name										Time/Wheel/Samples							TG	Latency ms							10
G	GPS X Offset (F7.2)							GPS Y Offset (F7.2)											GP	GS	GR						10
O	Offset for Ch1 (F9.2)																									10
O	Offset for Ch2 (F9.2)																									10
O	Offset for Ch3 (F9.2)																									10
O	Offset for Ch4 (or T) (F9.2)																									10

RTM61M	-	identification of program file, if rTM61M (lower case r) is present later in the file, it indicates start of appended file header
W101	-	version number (V1.01), W indicates Allegro CX
Survey Type	-	GPS (if GPS Input Enabled) or GRD (grid)
UT	-	unit type (0 = meters, 1 = ft, 2 = US Survey ft)
IT	-	sensor size (0 = 1 x 1 m, 1 = 1 x 0.5 m, 2 = 0.5 x 0.5 m)
IM	-	instrument mode (0 = Auto, 1 = Wheel, and 2 = Manual)
ST	-	instrument type (=0 fixed, not used)
File Name	-	file name, maximum 8 characters
Time/Wheel/Samples	-	this field depends on EM61M survey mode

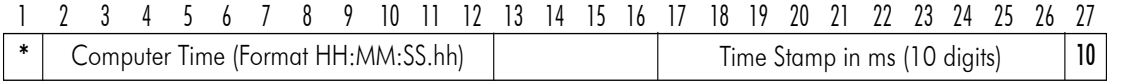
		Auto Mode - Time Increment in seconds Wheel Mode - Wheel Increment (user units, IT) Manual Mode - Samples/Reading
TG	-	File tag (space=original, 1=Saved As / edited)
Latency ms	-	System Latency used during data collection in milliseconds (up to four digits)
GPS X Offset	-	Offset of GPS antenna in X direction
GPS Y Offset	-	Offset of GPS antenna in Y direction
GP	-	type of GPS NMEA message (0 = GGA/GSA, 1= GGA, 2 = POS, 3 = LLK, 4=LLQ, 5=GLL, 6 = GGK, 7 = Leica TPS)
GS	-	GPS state (0=disabled, 1=Enabled, >1 indicates averaging number for GXY files)
GR	-	GPS update rate (= 0, fixed, not used)
O	-	nulling value for corresponding channel
10	-	Line Feed character

Header at the start of survey line (contains four records starting with L, B, A, and Z)



Line Name	-	Line Name, maximum 8 characters
Start Station	-	Start Station for the Line, format F11.2
Time	-	Time when Line was created in milliseconds
Dir	-	Direction of the Line (E, W, N, or S)
Station Inc.	-	Station Increment, format F11.3
Date	-	Date when Line was created, format DD-MM-YYYY
Time	-	Time when Line was created, format HH:MM:SS.hh
10	-	Line Feed character

Timer Reset



Indicates reset time of the program timer. This record links timer in milliseconds and computer time (local time) in format HH:MM:SS.hh. This record is

written to the file each time after the program switches from the Stand By to Log mode. In case when data are taken continousely the timer is automatically reset every hour.

Reading

1	2	3 4	5 6	7 8	9 10	11 12	13	14 15	16	17 18 19 20 21 22 23 24 25 26	27
I	Gn	1h 1l	2h 2l	3h 3l	4h 4l	5h 5l	6	7h 7l	8	Time Stamp in ms (10 digits)	10

I - indicator (one ASCII character). Number of the ASCII character represents type of reading (standard or Hand Held sensor and Mode 4 or D), and presence of fiducial marker (in Auto and Wheel modes).

84	-	Standard,	Mode 4,	channels 1, 2, 3, 4	
68	-	Standard,	Mode D,	channels 1, 2, 3, T	
69	-	Hand Held,	Mode 4,	channels 1, 2, 3, 4	
70	-	Hand Held,	Mode D,	channels 1, 2, 3, T	
77	-	Standard,	Mode 4,	channels 1, 2, 3, 4	Marker
78	-	Standard,	Mode D,	channels 1, 2, 3, T	Marker
80	-	Hand Held,	Mode 4,	channels 1, 2, 3, 4	Marker
81	-	Hand Held,	Mode D,	channels 1, 2, 3, T	Marker

Gn - one character parameter (Hex format), contains Gain, see table of ranges at the end of this section.

1h - higher byte of the 2's complement Hex number of Channel 1
1l - lower byte of Channel 1

2h - higher byte of the 2's complement Hex number of Channel 2
2l - lower byte of Channel 2

3h - higher byte of the 2's complement Hex number of Channel 3
3l - lower byte of Channel 3

4h - higher byte of the 2's complement Hex number of Channel 4
4l - lower byte of Channel 4

5h - higher byte of the 2's complement Hex number of TX averaged current
5l - lower byte of TX averaged current
6 - fraction of averaged current (5h 5l), Hex number

7h - higher byte of the 2's complement Hex number of TX current
7l - lower byte of TX current

8 - instrument battery voltage, Hex number

Time - time stamp of the reading in milliseconds, this is time elapsed from the start (creation) of the current data. The time in milliseconds can be linked with the computer local time by using Times in lines B and Z of Line Header.

10 - Line Feed character

Comment

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
C	Comment (maximum 11 characters)															Time Stamp in ms (10 digits)										10

New Station

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
S	New Station (Format 11.2)															Time Stamp in ms (10 digits)										10

Records starting with X

Several informative records, for example X$STARTED indicates start of Logging mode, X$PAUSED indicates Pause (activated by Pause key stroke), etc.

GPS Data Message Records

Each GPS record (GGA Message) is broken in to several 25 characters strings and placed in the RTmap61M data file which contains 27 characters records, including one character indicator and line feed at the end of each record. The GPS sequence starts at the line which contains the character @ as the first character, then records that contain a continuation of the same message start with the character **#**. The GPS sequence ends with a line starting with the character **!**. The last line contains sequential number of GPS recorded position and a logger time stamp for the given GPS reading. A sample of the GPS message written in RTmap61M format is given below.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
@	$	G	P	G	G	A	,	h	h	m	m	s	s	.	s	s	,	d	d	m	m	.	m	m	m	10
#	m	m	,	s	,	d	d	d	m	m	.	m	m	m	m	m	,	s	,	n	,	q	q	,	p	10
#	p	.	p	,	s	a	a	a	a	a	.	a	a	,	u	,	±	x	x	x	x	.	x	,	M	10
#	,	s	s	s	,	a	a	a	*	c	c	CR	LF													10
!	0	0	4	3	5											Time Stamp in ms (10 digits)										10

The GPS sequence may contain 4 to 7 records. The components of the GGA message may differ in length, however they are placed in the same number of columns. Refer to Appendix B (section B.2) for the definition of each component of the GGA data message. Other available GPS messages in NMEA format, GSA, POS, LLK, LLQ, GLL, and GGK, are recorded similarly. The structure of these NMEA sentences is given in section B.2 of Appendix B.

If the Checksum in NMEA message is invalid then starting character @ is replaced by **?**, and **#** is replaced by " (ASCII character code 34). The starting character of Time Stamp record **!** remains the same.

A.2 Conversion Factors

EM61M has four channels. Channels 1, 2, and 3 are common for Mode 4 and Mode D. Channel 4 in Mode D is named Channel T (it corresponds to Top coil).
The instrument response is converted to output voltage in mV for each sampling channel as given below.

Channel 1 to 4 - converted data
DATA (1 to 4) - instrument output for each channel as recorded in logger
RANGE - range is controlled by the EM61-MK2, it can be 1, 10, or 100

EM61M - **Mode 4** (One Sensor 1 x 0.5 m or 1 x 1 m)
Channel 1=(DATA1 x 4.8333 x 2)/RANGE
Channel 2=(DATA2 x 4.8333 x 2)/RANGE
Channel 3=(DATA3 x 4.8333 x 2)/RANGE
Channel 4=(DATA4 x 4.8333 x 2)/RANGE

EM61M - **Mode D** (Two Sensors 1 x 0.5 m or 1 x 1 m, Top and Bottom coils))
Channel 1=(DATA1 x 4.8333 x 2)/RANGE
Channel 2=(DATA2 x 4.8333 x 2)/RANGE
Channel 3=(DATA3 x 4.8333 x 2)/RANGE
Channel T=(DATA4 x 4.8333 x 4)/RANGE
if coil is 1 x 0.5 m Channel T is further multiplied by a factor 1.117.

Further each channel is normalized by current following formula:

EM61M Channel = Channel x 3000/Current
where, current is a value represented by **5h**, **5l**, and **6** in reading record of RTmap61M data file (see section A.1)

Table of Ranges Determined by the EM61-MK2 Microprocessor

HEX	Ch1	Ch2	Ch3	Ch4
0	**1**	**1**	**1**	**1**
1	**1**	**1**	**1**	**10**
3	**1**	**1**	**1**	**100**
4	**1**	**1**	**10**	**1**
5	**1**	**1**	**10**	**10**
7	**1**	**1**	**10**	**100**
C	**1**	**1**	**100**	**1**
D	**1**	**1**	**100**	**10**
F	**1**	**1**	**100**	**100**
10	**1**	**10**	**1**	**1**
11	**1**	**10**	**1**	**10**
13	**1**	**10**	**1**	**100**
14	**1**	**10**	**10**	**1**
15	**1**	**10**	**10**	**10**
17	**1**	**10**	**10**	**100**
1C	**1**	**10**	**100**	**1**
1D	**1**	**10**	**100**	**10**
1F	**1**	**10**	**100**	**100**
30	**1**	**100**	**1**	**1**
31	**1**	**100**	**1**	**10**
33	**1**	**100**	**1**	**100**
34	**1**	**100**	**10**	**1**
35	**1**	**100**	**10**	**10**
37	**1**	**100**	**10**	**100**
3C	**1**	**100**	**100**	**1**
3D	**1**	**100**	**100**	**10**
3F	**1**	**100**	**100**	**100**

HEX	Ch1	Ch2	Ch3	Ch4
40	**10**	**1**	**1**	**1**
41	**10**	**1**	**1**	**10**
43	**10**	**1**	**1**	**100**
44	**10**	**1**	**10**	**1**
45	**10**	**1**	**10**	**10**
47	**10**	**1**	**10**	**100**
4C	**10**	**1**	**100**	**1**
4D	**10**	**1**	**100**	**10**
4F	**10**	**1**	**100**	**100**
50	**10**	**10**	**1**	**1**
51	**10**	**10**	**1**	**10**
53	**10**	**10**	**1**	**100**
54	**10**	**10**	**10**	**1**
55	**10**	**10**	**10**	**10**
57	**10**	**10**	**10**	**100**
5C	**10**	**10**	**100**	**1**
5D	**10**	**10**	**100**	**10**
5F	**10**	**10**	**100**	**100**
70	**10**	**100**	**1**	**1**
71	**10**	**100**	**1**	**10**
73	**10**	**100**	**1**	**100**
74	**10**	**100**	**10**	**1**
75	**10**	**100**	**10**	**10**
77	**10**	**100**	**10**	**100**
7C	**10**	**100**	**100**	**1**
7D	**10**	**100**	**100**	**10**
7F	**10**	**100**	**100**	**100**

HEX	Ch1	Ch2	Ch3	Ch4
C0	**100**	**1**	**1**	**1**
C1	**100**	**1**	**1**	**10**
C3	**100**	**1**	**1**	**100**
C4	**100**	**1**	**10**	**1**
C5	**100**	**1**	**10**	**10**
C7	**100**	**1**	**10**	**100**
CC	**100**	**1**	**100**	**1**
CD	**100**	**1**	**100**	**10**
CF	**100**	**1**	**100**	**100**
D0	**100**	**10**	**1**	**1**
D1	**100**	**10**	**1**	**10**
D3	**100**	**10**	**1**	**100**
D4	**100**	**10**	**10**	**1**
D5	**100**	**10**	**10**	**10**
D7	**100**	**10**	**10**	**100**
DC	**100**	**10**	**100**	**1**
DD	**100**	**10**	**100**	**10**
DF	**100**	**10**	**100**	**100**
F0	**100**	**100**	**1**	**1**
F1	**100**	**100**	**1**	**10**
F3	**100**	**100**	**1**	**100**
F4	**100**	**100**	**10**	**1**
F5	**100**	**100**	**10**	**10**
F7	**100**	**100**	**10**	**100**
FC	**100**	**100**	**100**	**1**
FD	**100**	**100**	**100**	**10**
FF	**100**	**100**	**100**	**100**

A.3 Example of RTmap61M Data File

The RTmap61M data file records are written in binary format, therefore characters may have a different shape when displayed or printed, depending on particular video or printer settings.

```
RTM61M  W100GPS1000
H 022422B    0.200 1 350
G   0.00   0.00    010
O   694.05
O   342.40
O   185.74
O    79.72
L0
B       0.00
AS          1.000
Z24022006 22:51:08
O   694.05       0.00
O   342.40       0.00
O   185.74       0.00
O    79.72       0.00
*22:51:08.000    321892745
@$GPGSA,A,3,,,,23,25,20,16,
#14,,,06,01,,,02.2,01.2,01.
#8*09
!                321894566
DÿQñB  ·Ì ‡^ ‹O 321894763
DÿQÇOÀ
.© ‡_ ‡O 321894964
DÿRÅsT
:Ì ‡Y ƒO 321895165
DÿSjfÓ Ðí ‡^  O 321895366
@$GPGGA,055055.00,4336.593
#76,N,07936.65029,W,2,7,1,
#139.98,M,-35,M,5,119*54
!                321895487
@$GPGSA,A,3,,,,23,25,20,16,
#14,,,06,01,,,02.2,01.2,01.
#8*09
!                321895544
DÿRØ,  ç/  ‡X †O 321895567
DÿRfp
)ã ‡a ŠO 321895768
DÿR6/
Xã ^ ^O 321895969
DÿSoæ
=þ ^ ‡O 321896170
DÿSy   Þ/ ^ ŠO 321896371
@$GPGGA,055056.00,4336.593
#90,N,07936.65024,W,2,7,1,
#139.97,M,-35,M,6,119*52
!                321896486
@$GPGSA,A,3,,,,23,25,20,16,
#14,,,06,01,,,02.2,01.2,01.
#8*09
!                321896543
DÿRd¦  ·/ ^      O 321896572
DÿQ¹X¨ ÐÖ ^ ŠO 321896773
DÿQ”2Ÿ
& ¹ ^  O 321896974
DÿRq3@
 ö ^ - ŠO 321897175
DÿSA6ø  ¶ å ^  ‹O 321897376
.........................
```

A.4 Format of GXY Data File

The RTmap61M data file with extension GXY contains GPS records. The structure of this file is identical to the standard RTmap61M (T61) file. The difference is that it does not contain any EM61M records. This file is created by RTmap61M when the EM61M option is Disabled in the System Setup menu. In this case the program acts as a GPS logging program.

It should be noted that any RTmap61M data file, as well as GXY and data files created by other Geomar data acquisition programs (RTmap31, NAV31, NAV61, ML61, ML31, etc.) can be used as an GXY file in the data processing programs TrackMaker61M and TrackMaker for any other supported Geonics instrument (TrackMaker31, 61, etc.). The extension name GXY indicates that the file does not contain electromagnetic data.

File Formats

B

B.1 Description of Geonics DAT61MK2 (M61) File Format

A DAT61MK2 (with extension name M61) ASCII data file is comprised of one file header, one or more line header, one or more station records after each line header and GPS info (if GPS was used during data acquisition). The file starts with a file header. In the body of file there are line headers and station records. Line header, station record and GPS info can be distinguished by a type of **id** which is the first character in each record.

File Header starts and ends by a double line separators and it contains three lines, as shown below:

```
================ EM61MK2 FILE HEADER ================
EM61MK2 V1.00 GPS U I M
FileName   TimeI
Channel 1   Channel 2   Channel 3   Channel 4
=====================================================
```

First line contains following parameters:

EM61MK2	-	identification of program file
V120	-	version number (V1.20)
Survey Type	-	GPS (if GPS Input Enabled) or GRD (grid)
U	-	unit type (0 = meters, 1 = feet)
I	-	instrument type (0 = sensor 1x0.5m, 1 = 1x1m, 2 = 0.5x0.5m, 3 = HH61)
M	-	instrument mode (0 = Auto, 1 = Wheel, and 2 = Manual)

Second Line contains file name and time increment if Auto Mode was used:

File Name	-	file name, maximum 8 characters
Time Increment	-	time increment (if Auto Mode was used) in seconds

The last line of file header contains offsets for each channel that were used during data acquisition:

Offsets	-	four values for channel 1, 2, 3, and 4 respectively.

Line Header contains four lines, each line starts with identifier **id** as shown below:

```
L LineName FileName GPS U I M
B        Start
A D        StationIncrement
Z Date      Time
```

The first line of Line Header starts with L and contains:

Line Name	-	line name, maximum 8 characters
File Name	-	file name, maximum 8 characters (original file for this line)
Survey Type	-	GPS (if GPS Input Enabled) or GRD (grid)
U	-	unit type (0 = meters, 1 = feet)
I	-	instrument type (0 = sensor 1x0.5m, 1 = 1x1m, 2 = 0.5x0.5m, 3 = HH61)
M	-	instrument mode (0 = Auto, 1 = Wheel, and 2 = Manual)

Second line starts with B and contains Start Station for the Line, format F11.2

The third line starts with A and contains:

Dir	-	Direction of the Line (E, W, N, or S)
Station Inc.	-	Station Increment, format F11.3

The fourth line starts with Z and includes:

Date	-	Date when Line was created, format MM-DD-YYYY
Time	-	Time when Line was created, format HH:MM:SS

Each reading starts with indicator **id** specifying type of the data. The indicator is followed by six columns: Station, Channel 1, Channel 2, Channel 3, Channel 4 or T, and Time Stamp.

id	-	indicator T, D, E, F, M, N, P, or Q. Each record representing reading starts with one of the following character, which indicates type of reading:			
	T	-	Standard, Mode 4,	channels 1, 2, 3, 4	
	D	-	Standard, Mode D,	channels 1, 2, 3, T	
	E	-	Hand Held, Mode 4,	channels 1, 2, 3, 4	
	F	-	Hand Held, Mode D,	channels 1, 2, 3, T	
	M	-	Standard, Mode 4,	channels 1, 2, 3, 4	+Marker
	N	-	Standard, Mode D,	channels 1, 2, 3, T	+Marker
	P	-	Hand Held, Mode 4,	channels 1, 2, 3, 4	+Marker
	Q	-	Hand Held, Mode D,	channels 1, 2, 3, T	+Marker

Reading containing GPS data starts with character @. This character is followed by eight columns separated by commas.

Column 1	-	UTC time in hours, minutes, seconds of the GPS position
Column 2	-	Latitude (ddmm.mmmmm) in degrees, minutes, and decimal minutes
Column 3	-	N for North or S for South latitude
Column 4	-	Longitude (dddmm.mmmmm) in degrees, minutes, and decimal minutes
Column 5	-	W for West or E for East longitude
Column 6	-	Quality indicator, 0 = no position, 1 = raw (GPS), 2 = differentially corrected position (DGPS), 3 = RTK, 4 = Code Phase Only
Column 7	-	Number of satellites used in position computation
Column 8	-	Field computer time

For more informations regarding GPS parameters refer to Appendix B of the RTmap61M manual.

Example of DAT61MK2 File

```
=======================EM61MK2 FILE HEADER=======================
EM61MK2 V1.20 GPS 0 2 0
022623A_1    0.250
 -1087.69  -707.90  -378.35  -168.02
=================================================================
L 102      022623A  GPS 0 2 0
B     332.00 0
AW            1.000
Z 02/26/2002 23:59:03
@,051101.00,4336.59257,N,07936.65004,W,2,8,2,23:59:04.378
E    332.00     102.65     112.36      81.00      71.76 23:59:04.566
E    333.00     112.24     107.84      71.14      67.23 23:59:04.870
E    334.00     135.44     114.72      80.37      70.85 23:59:05.171
@,051102.00,4336.59257,N,07936.65005,W,2,8,2,23:59:05.378
E    335.00     138.67     102.66      85.52      63.74 23:59:05.504
E    336.00     127.49     120.12      84.50      71.75 23:59:05.955
E    337.00     110.63     133.76     100.53      71.45 23:59:06.245
@,051103.00,4336.59257,N,07936.65008,W,2,8,2,23:59:06.370
E    338.00     115.39     128.53      75.45      76.12 23:59:06.561
E    339.00     120.10     102.35      99.17      65.99 23:59:06.812
E    340.00     113.46     138.90      93.98      70.52 23:59:07.113
E    341.00     114.28     130.08      81.69      66.59 23:59:07.415
@,051104.00,4336.59255,N,07936.65006,W,2,8,2,23:59:07.419
E    342.00     116.97     136.68      75.19      72.02 23:59:07.704
E    343.00     123.37     103.47      87.65      74.59 23:59:08.007
E    344.00     103.80     106.45      75.66      82.90 23:59:08.313
@,051105.00,4336.59250,N,07936.65008,W,2,8,2,23:59:08.379
E    345.00     133.68     113.31      89.55      63.24 23:59:08.613
E    346.00     122.31     108.70      79.38      92.57 23:59:08.874
E    347.00     123.32     103.15      84.96      77.44 23:59:09.164
@,051106.00,4336.59248,N,07936.65009,W,2,8,2,23:59:09.378
E    348.00     111.04     112.19      72.24      59.90 23:59:09.563
E    349.00     152.32     107.07      84.50      68.20 23:59:09.855
E    350.00     128.25     116.60      84.48      77.73 23:59:10.154
@,051107.00,4336.59250,N,07936.65000,W,2,8,2,23:59:10.377
E    351.00     123.58     108.23      79.79      60.93 23:59:10.554
E    352.00     112.02     117.47      87.28      56.54 23:59:10.805
E    353.00     127.77      90.24      84.32      66.51 23:59:11.202
@,051108.00,4336.59250,N,07936.65001,W,2,8,2,23:59:11.379
E    354.00     118.30      94.10      75.16      82.39 23:59:11.560
E    355.00     143.09      93.08      97.17      74.82 23:59:11.862
E    356.00     124.63     118.26      79.18      64.83 23:59:12.152
@,051109.00,4336.59251,N,07936.65002,W,2,8,2,23:59:12.380
E    357.00     134.12     120.75      65.24      64.21 23:59:12.551
```

B.2 Description of RTmap61M File in ASCII Format

The RTmap61M data file converted to ASCII format is similar to file in DAT61MK2 however it contains additional information related to some parameters that are not supported by DAT61MK2 format. The format of the file is self explanatory.

The file starts with a header block, which starts with the line **RTM61M File Header** and it ends with line **End of file header**. The file header includes: RTmap61M version number, type of positioning, distance units, sensor type, survey mode, name of data file (as entered during the survey), GPS Antenna location, GPS NMEA message type, sensor separation, and offsets for all channels.

The file contains at least one survey line (even if survey lines are not used with GPS positioning). Each survey line starts with a Line Header Block. The Line Header Block contains four lines describing: survey line name, start station, station increment, date (MM/DD/YYYY) and time (HH:MM:SS) of line creation.

Lines containing readings start with one of the reading indicators: T, D, E, F, M, N, P, and Q. These reading indicators are described in section B.1 of this Appendix. Reading identifier is floowed by six columns: station number, Channel 1, Channel 2, Channel 3, Channel 4 (or T), and local time stamp (format HH:MM:SS.ttt).

Line that starts with C corresponds to field comment, and line that starts with N indicates entry of New Station.

GPS data consists of one or two lines starting with GP and GQ. Line containing GP is always present and it contains position, while line starting with GQ corresponds to quality of GPS reading.

Line that starts with GP contains position, UTC time, and local time. If Geodetic Coordinates were selected the position is indicated by Latitude and Longitude. In case when UTM coordinates were selected the position is described by UTM Zone number, Easting and Northing (see example of the file below). The second line that starts with GQ describes quality of GPS position and it contents depends on the NMEA message used during the survey. In the example of the file GQ statement is given for NMEA message pair GGA/GSA and contains: Position Quality, status of differential corrections, and index PDOP. For other NMEA messages contents of line starting with GQ may differ.

Line containing GPS position may also include original NMEA message if this option was selected in Convert RTmap61M File to ASCII Format window.

Examples of RTmap61M files in ASCII format

```
RTM61M File Header  Version V1.00
Positioning: GPS          Distance units: meters
Sensor Type: Hand Held    Survey Mode   : Auto
Data File  : 041710B.T61
GPS Message   : GGA/GSA
GPS Antenna Position
      GPS X offset: 0.00
      GPS Y offset: 0.00
Offsets:
    EM61 Ch1  :      0.00
    EM61 Ch2  :      0.00
    EM61 Ch3  :      0.00
    EM61 Ch4/T:      0.00
End of file header

Survey Line      : 0
Start Station    : 0.00
Station Increment: 1.000
Date: 04/17/2002  Time: 10:56:57
HH-4           0.000    103.92      47.29      24.45      12.66  10:57:00.949
HH-4           1.000    100.67      45.23      22.20      11.95  10:57:01.150
HH-4           2.000     97.44      45.77      24.17      12.79  10:57:01.347
GP   79.610852167,W,   43.609896000,N, 15:56:32.00           10:57:01.351
GQ Position: 3D      Differential (DGPS)   PDOP: 02.3    10:57:01.351
HH-4           3.000     97.05      44.73      24.17      12.79  10:57:01.546
HH-4           4.000     94.44      43.70      22.20      11.43  10:57:01.743
HH-4           5.000     95.28      44.14      22.52      12.26  10:57:01.946
HH-4           6.000     93.38      43.42      20.39      11.62  10:57:02.146
HH-4           7.000     93.01      42.94      21.71      12.87  10:57:02.347
GP   79.610851000,W,   43.609900000,N, 15:56:33.00           10:57:02.351
GQ Position: 3D      Differential (DGPS)   PDOP: 02.3    10:57:02.351
HH-4           8.000     91.60      40.38      21.08      11.28  10:57:02.546
HH-4           9.000     92.75      41.12      21.80      12.10  10:57:02.745
HH-4          10.000     91.08      40.63      20.36      10.70  10:57:02.896
HH-4          11.000     90.80      41.41      20.07      11.24  10:57:03.146
HH-4          12.000     88.55      40.41      20.79      10.62  10:57:03.345
GP   79.610850500,W,   43.609905000,N, 15:56:34.00           10:57:03.355
GQ Position: 3D      Differential (DGPS)   PDOP: 02.3    10:57:03.355
HH-4          13.000     87.86      39.09      20.08      11.51  10:57:03.546
HH-4          14.000     87.38      40.22      19.95      11.43  10:57:03.722
HH-4          15.000     86.98      39.46      19.03      11.18  10:57:03.921
HH-4          16.000     86.55      40.74      20.37      10.43  10:57:04.120
HH-4          17.000     85.16      39.39      19.88       9.89  10:57:04.321
GP   79.610850500,W,   43.609909833,N, 15:56:35.00           10:57:04.330
GQ Position: 3D      Differential (DGPS)   PDOP: 02.3    10:57:04.330
HH-4          18.000     84.78      39.20      20.75       9.89  10:57:04.502
HH-4          19.000     85.51      37.95      19.14       9.99  10:57:04.728
HH-4          20.000     85.68      38.48      19.27      10.80  10:57:04.927
HH-4          21.000     85.75      37.92      18.26      10.70  10:57:05.127
```

```
RTM61M File Header  Version V1.00
Positioning: GPS          Distance units: meters
Sensor Type: Hand Held    Survey Mode   : Auto
Data File  : 050808A.T61
GPS Message   : GGA/GSA
GPS Antenna Position
      GPS X offset: 0.00
      GPS Y offset: 0.00
Offsets:
    EM61 Ch1  :     68.25
    EM61 Ch2  :     50.29
    EM61 Ch3  :     12.98
    EM61 Ch4/T:     32.64
End of file header

Survey Line      : 0
Start Station    : 0.00
Station Increment: 1.000
Date: 05/08/2002  Time: 08:32:27
$GPGGA,154129.00,4339.97271,N,07938.91285,W,2,8,1,168.38,M,-35,M,6,119*5B  08:33:48.988
$GPGSA,A,3,30,,04,24,20,13,,,07,05,01,,02.1,01.4,01.6*01      08:33:48.988
STD-D          0.000     43.28      77.31      58.10      77.85  08:33:49.198
STD-D          1.000     43.05      78.30      58.25      76.83  08:33:49.397
STD-D          2.000     42.97      77.23      57.26      75.31  08:33:49.597
STD-D          3.000     42.97      75.94      58.40      78.36  08:33:49.796
STD-D          4.000     43.12      76.62      57.79      75.47  08:33:49.996
$GPGGA,154130.00,4339.97326,N,07938.91261,W,2,8,1,168.84,M,-35,M,4,119*5F  08:33:50.044
$GPGSA,A,3,30,,04,24,20,13,,,07,05,01,,02.1,01.4,01.6*01      08:33:50.044
STD-D          5.000     40.30      75.32      56.26      73.43  08:33:50.197
STD-D          6.000     36.79      73.64      57.02      75.63  08:33:50.398
STD-D          7.000     36.86      73.33      56.33      72.40  08:33:50.597
STD-D          8.000     34.49      70.43      54.65      68.32  08:33:50.796
STD-D          9.000     28.63      67.07      54.57      66.79  08:33:50.997
$GPGGA,154131.00,4339.97340,N,07938.91232,W,2,8,1,168.75,M,-35,M,5,119*57  08:33:51.045
$GPGSA,A,3,30,,04,24,20,13,,,07,05,01,,02.1,01.4,01.6*01      08:33:51.045
STD-D         10.000     24.89      66.23      52.67      59.16  08:33:51.198
STD-D         11.000     20.93      63.26      50.23      52.88  08:33:51.397
STD-D         12.000     19.33      61.66      51.22      54.74  08:33:51.597
STD-D         13.000     19.33      62.04      50.46      51.18  08:33:51.797
STD-D         14.000     17.81      61.36      49.24      53.05  08:33:51.997
$GPGGA,154132.00,4339.97356,N,07938.91228,W,2,8,1,168.77,M,-35,M,6,119*59  08:33:52.045
$GPGSA,A,3,30,,04,24,20,13,,,07,05,01,,02.1,01.4,01.6*01      08:33:52.045
STD-D         15.000     16.36      59.75      49.62      53.38  08:33:52.197
STD-D         16.000     14.45      58.00      48.25      51.34  08:33:52.397
STD-D         17.000      7.75      52.97      45.20      48.80  08:33:52.597
STD-D         18.000     -0.86      48.25      43.75      49.48  08:33:52.796
STD-D         19.000     -7.48      43.68      39.64      44.73  08:33:52.996
$GPGGA,154133.00,4339.97354,N,07938.91194,W,2,8,1,168.75,M,-35,M,5,119*5F  08:33:53.045
$GPGSA,A,3,30,,04,24,20,13,,,07,05,01,,02.1,01.5,01.6*00      08:33:53.045
STD-D         20.000    -20.88      32.94      33.78      40.15  08:33:53.197
STD-D         21.000    -36.65      23.04      28.45      36.24  08:33:53.398
STD-D         22.000    -51.04      13.98      25.02      32.68  08:33:53.597
STD-D         23.000    -59.04       7.74      19.46      27.09  08:33:53.797
STD-D         24.000    -69.54       0.58      15.27      24.54  08:33:53.996
$GPGGA,154134.00,4339.97374,N,07938.91173,W,2,8,1,168.78,M,-35,M,6,119*5D  08:33:54.045
$GPGSA,A,3,30,,04,24,20,13,,,07,05,01,,02.1,01.5,01.6*00      08:33:54.045
STD-D         25.000    -80.05      -6.12      12.84      21.32  08:33:54.199
STD-D         26.000    -87.67     -11.22       8.57      16.90  08:33:54.398
STD-D         27.000    -95.82     -16.40       5.60      15.21  08:33:54.597
STD-D         28.000   -101.45     -20.51       4.69      14.36  08:33:54.798
```

B.3 RTmap61M GXY File in ASCII Format

The GXY type of file while converted to ASCII format with extension name DAT consists of coordinates in UTM or Geodetic format. While in UTM format Easting coordinate is located in the first column and Northing in the second column. If Geodetic format was selected then Longitude is written in the first column and Latitude in the second column. Optionally the file may include GPS UTC time and text of field comments.

Example of GXY file in ASCII format (UTM coordinates)

```
          612102.229   4829484.278  01:59:17.00
          612102.255   4829484.352  01:59:18.00
          612102.241   4829484.389  01:59:19.00
          612102.349   4829484.391  01:59:20.00
          612102.268   4829484.408  01:59:21.00
Comment: "Stake #3"
          612102.578   4829484.339  01:59:32.00
          612102.564   4829484.376  01:59:33.00
          612102.578   4829484.339  01:59:34.00
          612102.579   4829484.284  01:59:35.00
          612102.718   4829484.045  01:59:36.00
Comment: "bldg corner"
          612102.730   4829484.101  01:59:53.00
          612102.784   4829484.121  01:59:54.00
          612102.853   4829483.992  01:59:55.00
          612102.813   4829483.973  01:59:56.00
```

Example of GXY file in ASCII format (Geodetic coordinates)

```
         -79.610841500    43.609900500  01:59:17.00
         -79.610841167    43.609901167  01:59:18.00
         -79.610841333    43.609901500  01:59:19.00
         -79.610840000    43.609901500  01:59:20.00
         -79.610841000    43.609901667  01:59:21.00
Comment: "Stake #3"
         -79.610837167    43.609901000  01:59:32.00
         -79.610837333    43.609901333  01:59:33.00
         -79.610837167    43.609901000  01:59:34.00
         -79.610837167    43.609900500  01:59:35.00
         -79.610835500    43.609898333  01:59:36.00
Comment: "bldg corner"
         -79.610835333    43.609898833  01:59:53.00
```

B.4 Retrieved and Positioned Field Comments

File containing retreived and positioned comments starts with a header indicating name of the original RTmap61M data file. This is followed by coordinates and text of comment enclosed in double quotes. Coordinates can be written in UTM or Geodetic format. Column one includes Easting or Longitude, and second column contains Northing or Latitude. The optional, fourth column of the file includes local time.

Example of file containing positioned comments (Geodetic coordinates)

```
Comments in Data File  : 052818A.P61
  -79.610851833    43.609890333  "Stake#10"      18:17:41.934
  -79.610850500    43.609890167  "Stake#20"      18:29:32.187
  -79.610833500    43.609879500  "Stake#30"      18:29:36.834
  -79.610833500    43.609879500  "Stahe#40"      18:29:41.974
  -79.610833500    43.609879500  "WoodPile"      18:29:47.636
  -79.610835167    43.609885833  "Fence"        18:37:11.833
```

B.5 Output File (XYZ)

The output XYZ file may be written in two output formats: Generic and Geosoft type of XYZ file. The only difference between these two formats is that Geosoft format contains line labeled Line # at the beginning of each survey line.

Coordinates can be written in UTM or Geodetic format. Column one includes Easting or Longitude, and second column contains Northing or Latitude. The optional columns that include Elevation, three GPS QC parameters (Quality Indicator, PDOP, Number of Satellites), and a reading time stamp (local time) are always placed as last columns in the file.

The XYZ file may also contain field comments. All lines containg description text start with character "\" with the exception of label Line# if Geosoft data type is used. If the Include Header Info option was used then each file contains header fully describing XYZ file contents. See the example of the XYZ file given below. This sample file is in UTM coordinates and it contains elevation data.

Example of XYZ file created by RTM61M

```
/ UTM zone = 16, Datum: WGS1984
/ Easting [USft], Northing [USft], Ch1[mV],   Ch2[mV],   Ch3[mV],   Ch4[mV], ChD[mV], Elev.[ft], Quality, Sat., HDOP, Time
    1436849.874   15252399.259       8.78       7.06       0.59       3.12       2.53   612.463   2   7   1.20    08:20:29.173
    1436850.118   15252399.230       8.04       5.97       0.14       1.80       1.66   612.459   2   7   1.20    08:20:29.240
    1436850.366   15252399.200       7.41       4.66      -0.53       1.13       1.65   612.455   2   7   1.20    08:20:29.308
    1436850.603   15252399.172       1.36      -2.30      -1.30      -0.63       0.67   612.450   2   7   1.20    08:20:29.372
    1436850.843   15252399.143      -2.75      -6.54      -2.94      -4.12      -1.18   612.446   2   7   1.20    08:20:29.439
    1436851.091   15252399.114      -6.63      -9.90      -3.28      -5.00      -1.73   612.442   2   7   1.20    08:20:29.507
    1436851.332   15252399.085     -13.34     -15.44      -3.94      -5.45      -1.51   612.437   2   7   1.20    08:20:29.573
    1436851.572   15252399.056     -14.94     -16.52      -4.82      -5.90      -1.08   612.433   2   7   1.20    08:20:29.638
    1436851.816   15252399.027     -13.94     -15.76      -5.48      -8.95      -3.47   612.429   2   7   1.20    08:20:29.706
    1436852.053   15252398.999      -9.79     -12.40      -6.90     -11.13      -4.23   612.425   2   7   1.20    08:20:29.771
    1436852.294   15252398.971      -8.69     -11.64      -8.21     -14.83      -6.62   612.420   2   7   1.20    08:20:29.836
    1436852.545   15252398.941      -9.21     -10.55      -7.24     -11.80      -4.56   612.416   2   7   1.20    08:20:29.905
    1436852.830   15252398.907      -9.41      -8.06      -4.32      -5.74      -1.42   612.411   2   7   1.20    08:20:29.984
    1436853.078   15252398.877      -7.45      -5.67      -3.99      -5.96      -1.96   612.406   2   7   1.20    08:20:30.051
    1436853.512   15252398.840      -6.66      -6.43      -4.98      -7.27      -2.29   612.406   2   7   1.20    08:20:30.170
    1436853.762   15252398.820      -6.86      -5.89      -3.36      -2.95       0.42   612.406   2   7   1.20    08:20:30.238
    1436854.001   15252398.800      -7.83      -4.05      -0.33       3.33       3.66   612.406   2   7   1.20    08:20:30.302
    1436854.248   15252398.780      -8.46      -4.27       0.42       4.62       4.20   612.406   2   7   1.20    08:20:30.369
    1436854.498   15252398.760     -10.39      -5.78      -0.35       4.61       4.96   612.406   2   7   1.20    08:20:30.438
    1436854.734   15252398.740     -10.93      -5.68       0.62       6.12       5.50   612.406   2   7   1.20    08:20:30.502
    1436854.976   15252398.721      -9.71      -4.70       2.35      10.44       8.09   612.406   2   7   1.20    08:20:30.567
    1436855.227   15252398.700      -8.08      -3.08       2.88      12.81       9.93   612.406   2   7   1.20    08:20:30.636
    1436855.466   15252398.681      -2.55       1.47       3.20      13.02       9.82   612.406   2   7   1.20    08:20:30.701
    1436855.713   15252398.660       0.71       4.17       3.84      13.66       9.81   612.406   2   7   1.20    08:20:30.768
    1436855.963   15252398.640       2.02       5.47       3.95      14.52      10.57   612.406   2   7   1.20    08:20:30.835
    1436856.202   15252398.621       3.11       6.87       4.59      15.16      10.57   612.406   2   7   1.20    08:20:30.901
    1436856.500   15252398.596       2.79       6.11       3.51      11.47       7.97   612.406   2   7   1.20    08:20:30.981
    1436856.740   15252398.577      -1.85       0.60       1.66       7.79       6.13   612.406   2   7   1.20    08:20:31.047
    1436857.172   15252398.549      -8.00      -6.65      -4.07      -6.71      -2.64   612.409   2   7   1.20    08:20:31.168
    1436859.302   15252398.415      -7.64      -6.76      -2.62      -2.25       0.37   612.429   2   7   1.20    08:20:31.765
    1436859.534   15252398.401      -2.02      -0.18      -0.03       3.15       3.18   612.431   2   7   1.20    08:20:31.831
    1436859.769   15252398.386      -0.28       2.41       4.06      12.20       8.14   612.433   2   7   1.20    08:20:31.897
    1436860.011   15252398.371      -0.16       3.17       5.35      14.79       9.43   612.436   2   7   1.20    08:20:31.965
    1436860.243   15252398.357      -1.99       1.98       5.67      15.86      10.19   612.438   2   7   1.20    08:20:32.030
    1436860.756   15252398.355      -3.27      -0.07       3.18      11.32       8.13   612.425   2   7   1.20    08:20:32.175
    1436860.995   15252398.355      -3.81      -1.26       2.21       7.86       5.65   612.418   2   7   1.20    08:20:32.244
    1436861.224   15252398.356      -4.66      -2.45       0.70       5.48       4.78   612.411   2   7   1.20    08:20:32.309
    1436861.459   15252398.356      -5.19      -2.77      -0.82       0.94       1.76   612.405   2   7   1.20    08:20:32.376
    1436861.698   15252398.356      -6.15      -3.10      -1.36       1.59       2.95   612.398   2   7   1.20    08:20:32.443
    1436861.926   15252398.357      -6.36      -1.69      -0.18       3.31       3.48   612.391   2   7   1.20    08:20:32.509
    1436862.158   15252398.357      -7.54      -2.23      -0.29       1.79       2.08   612.384   2   7   1.20    08:20:32.575
    1436862.401   15252398.358      -9.36      -3.53      -1.70      -1.88      -0.19   612.377   2   7   1.20    08:20:32.644
    1436862.626   15252398.358      -9.14      -4.93      -2.99      -5.55      -2.56   612.371   2   7   1.20    08:20:32.708
    1436862.858   15252398.359      -9.35      -5.36      -3.86      -6.63      -2.78   612.364   2   7   1.20    08:20:32.774
    1436863.097   15252398.359      -9.24      -5.47      -4.40      -6.85      -2.45   612.357   2   7   1.20    08:20:32.842
    1436863.423   15252398.360      -9.45      -6.33      -5.26      -7.50      -2.24   612.348   2   7   1.20    08:20:32.935
    1436863.652   15252398.360      -9.02      -6.98      -5.26      -8.58      -3.32   612.341   2   7   1.20    08:20:33.000
    1436864.206   15252398.337      -6.10      -4.93      -4.84      -8.80      -3.96   612.335   2   7   1.20    08:20:33.162
    1436864.428   15252398.327      -4.36      -3.42      -4.52      -7.30      -2.78   612.333   2   7   1.20    08:20:33.226
    1436864.653   15252398.317      -2.73      -2.24      -2.58      -4.50      -1.92   612.331   2   7   1.20    08:20:33.293
    1436864.885   15252398.307       0.19      -0.41      -0.97      -0.41       0.56   612.329   2   7   1.20    08:20:33.361
    1436865.104   15252398.297       5.37       3.90       1.50       4.54       3.04   612.327   2   7   1.20    08:20:33.424
    1436865.332   15252398.286       6.89       4.76       4.30       9.92       5.62   612.325   2   7   1.20    08:20:33.492
    1436865.564   15252398.276       7.54       5.09       4.94      12.50       7.56   612.322   2   7   1.20    08:20:33.560
    1436865.786   15252398.266       7.12       5.08       5.58      12.06       6.48   612.320   2   7   1.20    08:20:33.625
    1436949.135   15252468.330    1022.27     774.30     546.19     583.53      37.34   613.111   2   8   1.10    08:33:47.592
    1436949.398   15252468.332    1010.26     766.44     539.64     577.41      37.77   613.106   2   8   1.10    08:33:47.659
    1436949.649   15252468.335     986.68     749.51     532.96     571.71      38.75   613.102   2   8   1.10    08:33:47.725
    1436949.908   15252468.338     971.73     738.60     519.98     556.01      36.02   613.098   2   8   1.10    08:33:47.792
    1436950.170   15252468.340     956.09     727.20     512.28     546.89      34.61   613.093   2   8   1.10    08:33:47.860
    1436950.422   15252468.343     928.34     704.02     503.59     537.76      34.18   613.089   2   8   1.10    08:33:47.925
    1436950.677   15252468.345     912.19     691.58     490.82     526.85      36.03   613.084   2   8   1.10    08:33:47.991
    1436950.943   15252468.348     896.57     679.99     484.91     522.46      37.55   613.080   2   8   1.10    08:33:48.060
    1436951.194   15252468.351     874.34     663.54     479.25     517.02      37.77   613.076   2   8   1.10    08:33:48.125
    1436951.449   15252468.353     864.15     655.98     467.66     504.78      37.11   613.071   2   8   1.10    08:33:48.191
    1436951.708   15252468.356     854.36     648.80     461.79     498.90      37.11   613.067   2   8   1.10    08:33:48.258
    1436951.959   15252468.359     835.09     633.88     456.79     495.21      38.42   613.063   2   8   1.10    08:33:48.323
```

B.6 Samples of GPS External Files

GPS files created by a GPS data processing software can be written in large variety of ASCII formats. The RTM61M can read any ASCII format of the file as long as delimiters between columns consists of comma or string of spaces, and time is in the format hh:mm:ss. These files are used in Position Readings Using External GPS Files option of RTM61M. The user must specify where parameters needed by RTM61M are located (column number). The user must also specify what type of coordinates is used in the GPS file.

Example of GPS file with Geodetic coordinates

The GPS file presented below contains coordinates in Geodetic format. Longitude is located in column 1, Latitude in column 2, and Time in column 4. Please note, that in this example Comma as well as Space is used as column delimiter which is acceptable for RTM61M.

```
-106.259952057,42.861338618,11/15/01 21:37:32.000
-106.259951531,42.861337514,11/15/01 21:37:33.000
-106.259951500,42.861337541,11/15/01 21:37:34.000
-106.259943814,42.861333925,11/15/01 21:37:35.000
-106.259951552,42.861337587,11/15/01 21:37:36.000
-106.259951917,42.861337327,11/15/01 21:37:37.000
-106.259952005,42.861337432,11/15/01 21:37:38.000
-106.259952763,42.861337307,11/15/01 21:37:39.000
-106.259944641,42.861333833,11/15/01 21:37:40.000
-106.259953247,42.861337437,11/15/01 21:37:41.000
-106.259958166,42.861337142,11/15/01 21:37:42.000
-106.259960245,42.861336674,11/15/01 21:37:43.000
-106.259960253,42.861336690,11/15/01 21:37:44.000
-106.259952104,42.861333303,11/15/01 21:37:45.000
-106.259960094,42.861336962,11/15/01 21:37:46.000
-106.259960121,42.861336957,11/15/01 21:37:47.000
-106.259960098,42.861336920,11/15/01 21:37:48.000
-106.259959918,42.861336612,11/15/01 21:37:49.000
-106.259952091,42.861333332,11/15/01 21:37:50.000
-106.259945692,42.861333854,11/15/01 21:41:05.000
-106.259954063,42.861338929,11/15/01 21:41:06.000
-106.259954276,42.861338752,11/15/01 21:41:07.000
-106.259954388,42.861338732,11/15/01 21:41:08.000
-106.259957706,42.861338375,11/15/01 21:41:09.000
-106.259959301,42.861333148,11/15/01 21:41:10.000
-106.259979673,42.861337490,11/15/01 21:41:11.000
```

Example of GPS file with UTM coordinates

The GPS file presented below contains coordinates in UTM format. Easting in meters is located in column 4, Northing in meters is placed in column 3, and Time is located in column 3.

```
03/28/02,18:36:02,1285840.932,462524.261,0.24,0.34,0.72
03/28/02,18:36:04,1285840.923,462524.266,0.24,0.34,0.72
03/28/02,18:36:06,1285840.922,462524.266,0.24,0.34,0.71
03/28/02,18:36:08,1285840.927,462524.268,0.24,0.34,0.71
03/28/02,18:36:10,1285840.930,462524.285,0.24,0.34,0.72
03/28/02,18:36:12,1285840.944,462524.290,0.24,0.34,0.72
03/28/02,18:36:14,1285840.957,462524.290,0.24,0.34,0.72
03/28/02,18:36:16,1285840.962,462524.298,0.24,0.34,0.72
03/28/02,18:36:18,1285840.960,462524.303,0.24,0.34,0.72
03/28/02,18:36:20,1285840.955,462524.311,0.24,0.34,0.73
03/28/02,18:36:22,1285840.947,462524.301,0.24,0.34,0.73
03/28/02,18:36:24,1285840.945,462524.301,0.24,0.34,0.73
03/28/02,18:36:26,1285840.946,462524.310,0.24,0.34,0.73
03/28/02,18:36:28,1285840.952,462524.313,0.24,0.34,0.73
03/28/02,18:36:30,1285840.958,462524.316,0.24,0.34,0.73
03/28/02,18:36:32,1285840.959,462524.311,0.24,0.34,0.70
03/28/02,18:36:34,1285840.957,462524.289,0.24,0.34,0.70
03/28/02,18:36:36,1285840.954,462524.284,0.24,0.34,0.70
03/28/02,18:36:38,1285840.957,462524.290,0.24,0.34,0.70
03/28/02,18:36:40,1285840.957,462524.296,0.24,0.34,0.70
03/28/02,18:36:42,1285840.966,462524.288,0.24,0.34,0.70
03/28/02,18:36:44,1285840.974,462524.294,0.24,0.34,0.70
03/28/02,18:36:46,1285840.973,462524.286,0.24,0.34,0.70
03/28/02,18:36:48,1285840.975,462524.282,0.24,0.34,0.70
03/28/02,18:36:50,1285840.974,462524.296,0.24,0.34,0.70
03/28/02,18:36:52,1285840.977,462524.298,0.24,0.34,0.70
03/28/02,18:36:54,1285840.971,462524.291,0.24,0.34,0.71
03/28/02,18:36:56,1285840.976,462524.291,0.24,0.34,0.71
03/28/02,18:36:58,1285840.973,462524.289,0.24,0.34,0.71
03/28/02,18:37:00,1285840.974,462524.300,0.24,0.34,0.71
03/28/02,18:37:02,1285840.983,462524.311,0.24,0.34,0.71
03/28/02,18:37:04,1285840.980,462524.319,0.24,0.34,0.71
03/28/02,18:37:06,1285840.979,462524.297,0.24,0.34,0.71
03/28/02,18:37:08,1285840.978,462524.296,0.24,0.34,0.71
03/28/02,18:37:10,1285840.982,462524.279,0.24,0.34,0.71
03/28/02,18:37:12,1285840.985,462524.281,0.24,0.34,0.71
03/28/02,18:37:14,1285840.984,462524.289,0.24,0.34,0.71
03/28/02,18:37:16,1285840.984,462524.282,0.24,0.34,0.71
```

Selected NMEA Messages

C

GGA Data Message

The GGA message contains the GPS position information and it is the most widely used NMEA data message. This message takes the following form:

$GPGGA,hhmmss.ss,ddmm.mmmmm,s,dddmm.mmmmm,s,n,qq,pp.p,saaaaa.aa,u,
±xxxx.x,M,sss,aaaa*cc<CR><LF>

Definition of GGA message component:

hhmmss.ss	UTC time in hours, minutes, seconds of the GPS position
ddmm.mmmmm	Latitude in degrees, minutes, and decimal minutes
s	s=N or s=S, for North and South latitude
dddmm.mmmmm	Longitude in degrees, minutes, and decimal minutes
s	s=E or s=W, for East and West longitude
n	Quality indicator, 0 = no position, 1 = raw, no differentially corrected position, 2 = differentially corrected position (DGPS), 4 = Real-time kinematic, fixed integers, 5 = Real-time kinematic, float integers, 9 = position computed using almanac information
qq	Number of satellites used in position computation
pp.p	HDOP = 0.0 to 99.9
saaaaa.aa	Antenna altitude
u	Altitude units, M=meters
±xxxx.x	Geoidal separation (requires geoidal height option)
M	Geoidal separation units, M = meters
sss	Age of differential corrections in seconds
aaaa	Base station identification
***cc**	Checksum
<CR><LF>	Carriage return and Line feed

GSA Data Message

The GSA message contains active satellites and PDOP value. The GSA message is given in the following form:

$GPGSA,c1,d1,d2,d3,d4,d5,d6,d7,d8,d9,d10,d11,d12,d13,f1,f2,f3*cc<CR><LF>

Definition of GSA message components:

c1	Mode, M = manual, A = automatic
d1	Mode, 2 = 2D, 3 = 3D
d2-d13	Satellites used in position computation (range 0 to 32)
f1	PDOP (range 0 to 99.9)
f2	HDOP (range 0 to 99.9)
f3	VDOP (range 0 to 99.9)
***cc**	Checksum
<CR><LF>	Carriage return and Line Feed

POS Data Message

The POS message contains the GPS position information and PDOP value. The POS message is given in the following form:

$PASHR,POS,n,qq,hhmmss:ss,ddmm.mmmmm,s,dddmm.mmmmm,s,saaaaa.aa,seeeee, ttt,ggg,svvv,pp,hh,vv,tt,vvvv*cc<CR><LF>

Definition of POS message components:

n	Quality indicator, 0 = no differentially corrected position, 1 = differentially corrected position
qq	Number of satellites used in position computation
hhmmss:ss	UTC time in hours, minutes, seconds of the GPS position
ddmm.mmmmm	Latitude in degrees, minutes, and decimal minutes
s	s=N or s=S, for North and South latitude
dddmm.mmmmm	Longitude in degrees, minutes, and decimal minutes
s	s=E or s=W, for East and West longitude
saaaaa.aa	sensor computed altitude
seeeee	reserved

ttt	True track/true course over ground in degree
ggg	Speed over ground (knots)
svvv	Vertical velocity (decimeters per second)
pp	PDOP - position dilution of precision (00 to 99)
hh	HDOP - horizontal dilution of precision (00 to 99)
vv	VDOP - vertical dilution of precision (00 to 99)
tt	TDOP - time dilution of precision (00 to 99)
vvvv	firmware version ID
***cc**	Checksum
<CR><LF>	Carriage return and Line feed

LLK Data Message

The LLK (Leica Local Position and GDOP) message provides position in local coordinates in meters and GDOP value. The LLK message is given in the following form:

$GPLLK,hhmmss.ss,ddmmyy,xxxx.xxxx,M,xxxx.xxxx,M,x,x,xx.xx,xxxx.xxxx,M, *cc<CR><LF>

Definition of LLK message components:

hhmmss.ss	UTC time in hours, minutes, seconds of the GPS position
ddmmyy	UTC date (day, month, year)
xxxx.xxxx	Grid Easting, meters
M	Meters (fixed text “M”)
xxxx.xxxx	Grid Northing, meters
M	Meters (fixed text “M”)
x	Quality indicator, 0 = not valid, 1 = GPS Nav Fix (no differentially corrected position), 2 = DGPS Fix (differentially corrected position), 3 = RTK Fix
x	Number of satellites used in computation,
xx.xx	GDOP
xxxx.xxxx	Height, meters
M	Meters (fixed text “M”)
***cc**	Checksum
<CR><LF>	Carriage return and Line feed

LLQ Data Message

The LLQ (Leica Local Position and Quality) message provides position in local coordinates in meters and position quality in meters. The LLQ message is given in the following form:

$GPLLQ,hhmmss.ss,ddmmyy,xxxx.xxxx,M,xxxx.xxxx,M,x,x,xx.xx,xxxx.xxxx,M, *cc<CR><LF>

Definition of LLK message components:

hhmmss.ss	UTC time in hours, minutes, seconds of the GPS position
ddmmyy	UTC date (day, month, year)
xxxx.xxxx	Grid Easting, meters
M	Meters (fixed text "M")
xxxx.xxxx	Grid Northing, meters
M	Meters (fixed text "M")
x	Quality indicator, 0 = not valid, 1 = GPS Nav Fix (no differentially corrected position), 2 = DGPS Fix (differentially corrected position), 3 = RTK Fix
x	Number of satellites used in computation,
xx.xx	Position quality, meters
xxxx.xxxx	Height, meters
M	Meters (fixed text "M")
***cc**	Checksum
<CR><LF>	Carriage return and Line feed

GLL Data Message

The GLL message takes the following form:

$GPGLL,ddmm.mmmmm,s,dddmm.mmmmm,s,hhmmss.ss,s*cc<CR><LF>

Definition of GLL message component:

ddmm.mmmmm	Latitude in degrees, minutes, and decimal minutes
s	s=N or s=S, for North and South latitude

dddmm.mmmmm	Longitude in degrees, minutes, and decimal minutes
s	s=E or s=W, for East and West longitude
hhmmss.ss	UTC time in hours, minutes, seconds of the GPS position
s	Status, A = valid, V = invalid
***cc**	Checksum
<CR><LF>	Carriage return and Line feed

GGK Data Message

The GGK message contains the GPS position, Time, Date, Position Type, and DOP information. The GGK shown below is not a standard NMEA data message and it is used in several Trimble GPS receivers. If this message is used as a standard NMEA statement by a given GPS receiver it starts with $GPGGK and contains GDOP instead of DOP.

TrackMaker software automatically recognizes which type of GGK message is used.

The Trimble proprietary type of GGK message takes the following form:

$PTNL,GGK,hhmmss.ss,ddmmyy,ddmm.mmmmmmmm,s,dddmm.mmmmmmmm,s,n,qq,p.p,EHT-aa.aaa,M*cc<CR><LF>

Definition of GGK message component:

hhmmss.ss	UTC time in hours, minutes, seconds of the GPS position
ddmmyy	Date
ddmm.mmmmmmmm	Latitude in degrees, minutes, and decimal minutes
s	s=N or s=S, for North and South latitude
dddmm.mmmmmmm	Longitude in degrees, minutes, and decimal minutes
s	s=E or s=W, for East and West longitude
n	GPS Quality indicator, 0 = fix not valid or not available, 1 = Autonomous GPS fix, no differentially corrected position, 2 = differential, floating carrier phase integer based solution (FLOAT), 3 = differential, fixed carrier phase integer-based solution (FIXED), 4 = differential, code phase only solution (DGPS)
qq	Number of satellites used in fix

p.p	DOP of fix
EHT-aa.aaa	Ellipsoidal height of fix
M	unit of measure for ellipsoidal height in meters
***cc**	Checksum
<CR><LF>	Carriage return and Line feed