RTM 38MK2

Version 1.05

User's Manual

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Introduction 1

The Geomar RTmap38MK2 Data Logging System consists of a data logging program RTmap38MK2 and associated PC computer program RTM38MK2. The program RTmap38MK2 is designed for the Windows CE based Allegro CX field computer.

The program RTM38MK2 is used to process data files recorded under the control of program RTmap38MK2. It recognizes data file formats created with various versions of RTmap38MK2 automatically.

1.1 About the RTM38MK2

The program RTM38MK2 is a Windows based program for IBM PC compatible computers operating under Windows 95/98/XP/NT(V4.0) and Windows 2000. The program RTM38MK2 is designed to process data collected by a field computer under the control of programs RTmap38MK2. The program can be used to position EM38-MK2 sensor based on real time GPS data or by using a postprocessed GPS file. The program allows you also to convert data to Geonics DAT38MK2 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 (latency) caused by the system time constant.

Main function of this program is to position Geonics EM38-MK2 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 EM38-MK2 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 EM38-MK2 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 recorded by data acquisition software RTmap38MK2: 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 RTM38MK2 also allows you to correct the collected GPS positions with post-processed GPS files.

The RTM38MK2 uses data files in RTmap38MK2 format which have extension name TM8. 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 RTmap38MK2 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 RTM38MK2.

One sample RTmap38MK2 data file, 031722B.TM8, and one external (postprocessed) GPS file Trext04.txt are included on the program disk. They allow the user to become familiar with running the RTM38MK2 program.

1.2 Contents of RTM38MK2 Distribution Disk

Program RTmap38MK2 software is supplied on one CD disk. Disk contains following files and directories:

Setup38MK2R	-	setup program for RTM38MK2
Documentation	-	directory containing all RTmap38MK2 and RTM38MK2, and other Geomar manuals in PDF format.
RTmap38MK2	-	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 RTM38MK2 Software Installation

RTmap38MK2 software uses a setup program to load files necessary for data processing onto your computer. The following section describes the installation process. To install RTM38MK2: Insert the RTmap38MK2 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).

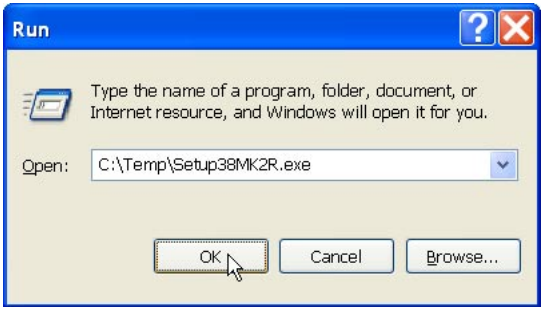


Figure 1.1: Run Dialog window

Browse for the file SETUP38MK2R.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).

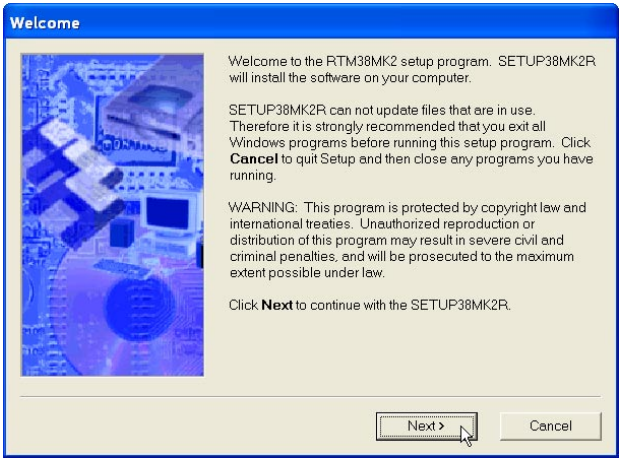


Figure 1.2: Welcome window

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

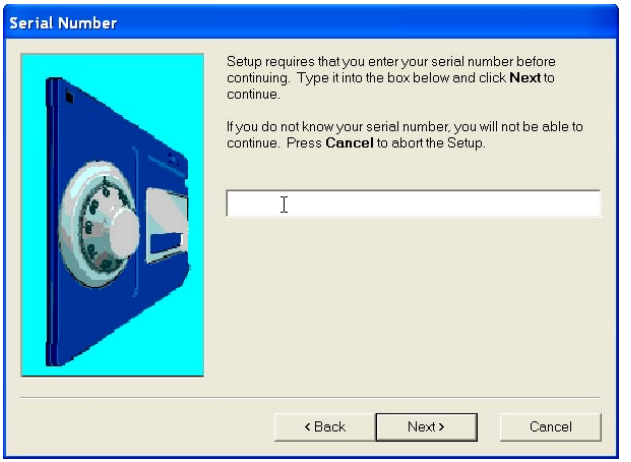


Figure 1.3: Serial Number window

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).

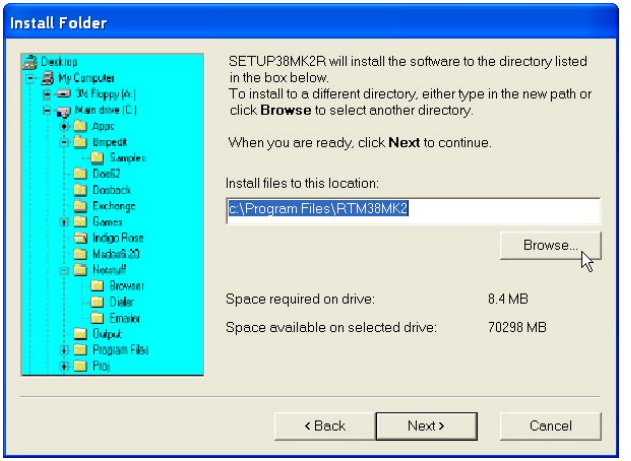


Figure 1.4: Installation Directory window

The default directory is C:\Program Files\RTM38MK2. Click the **Next** button to install the program to this directory. If you wish to install RTM38MK2 to another directory, click the **Browse** button, and the Select Installation Directory window will open (Figure 1.5).

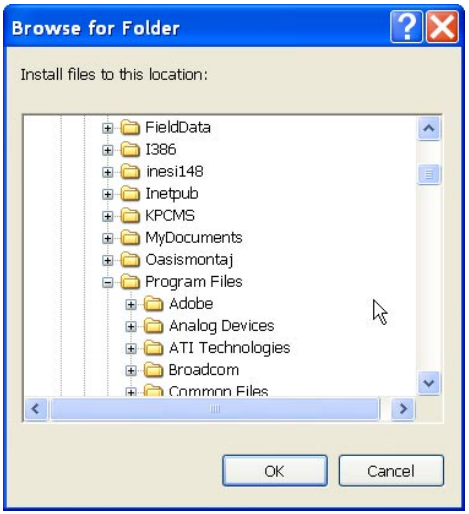


Figure 1.5: Select Installation Directory window

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).

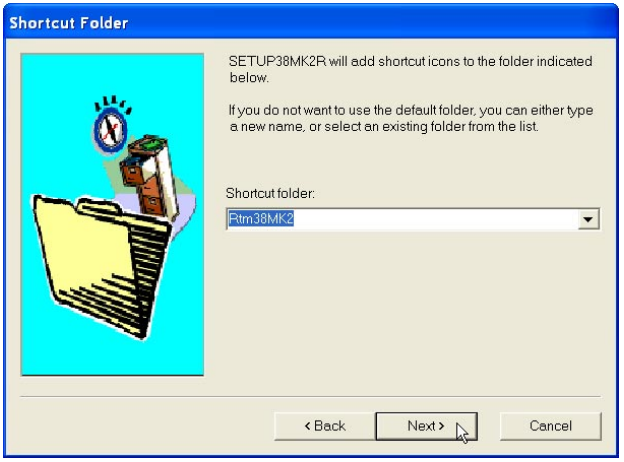


Figure 1.6: Select Shortcut Folder window

The setup program will create a RTM38MK2 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).

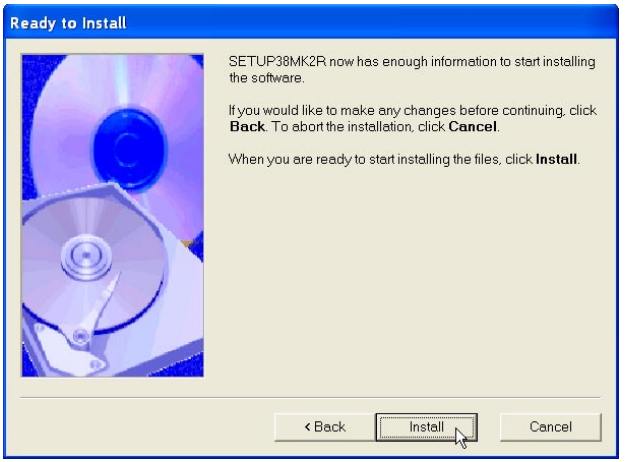


Figure 1.7: Ready to Install window

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).

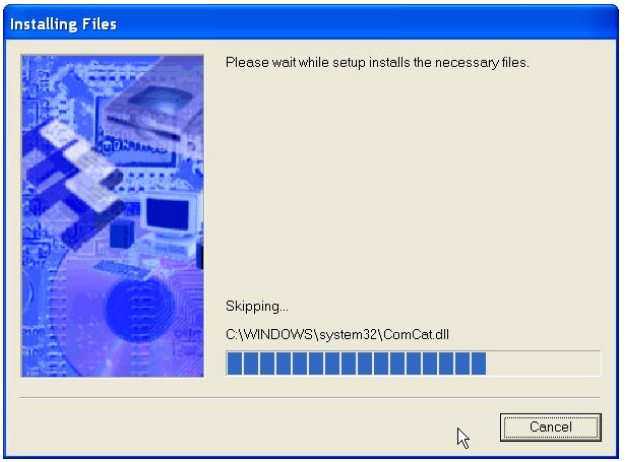


Figure 1.8: Installing Files

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. Setup38MK2R creates a RTM38MK2 program group and places **RTM38MK2** and **Uninstall** icons into it. The setup program creates also a **RTM38MK2** menu item in the Program menu accessible by clicking **Start**. A reminder to restart the system may 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 RTM38MK2 by double clicking the RTM38MK2 icon in the **Start|Programs** menu, in Windows Explorer, or on the desktop if a shortcut was created. At the start, RTM38MK2 displays the following screen (Figure 1.10):

Figure 1.10: RTM38MK2 Main Screen

The RTM38MK2 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: RTM38MK2 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.

RTM38MK2 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.TM8".

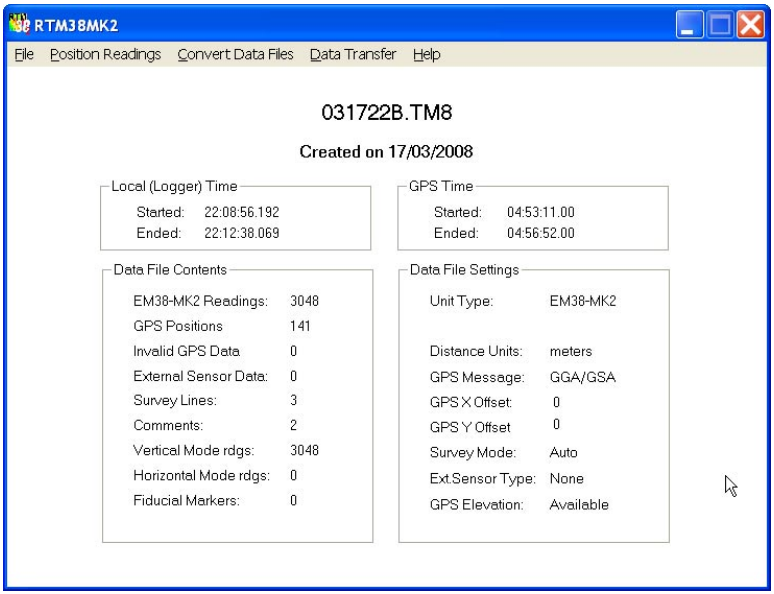


Figure 1.12: RTM38MK2 Main Screen after Loading data file

The information displayed by the RTM38MK2 contains Local and UTC time, number and type of EM38-MK2 data points and GPS positions, number of survey lines, specified distance units and GPS antenna offsets, etc. (see Figure 1.12). Four parameters: Instrument Type, Distance Units, GPS X and Y offsets can be adjusted using the Edit Parameters item (see Figure 1.13).

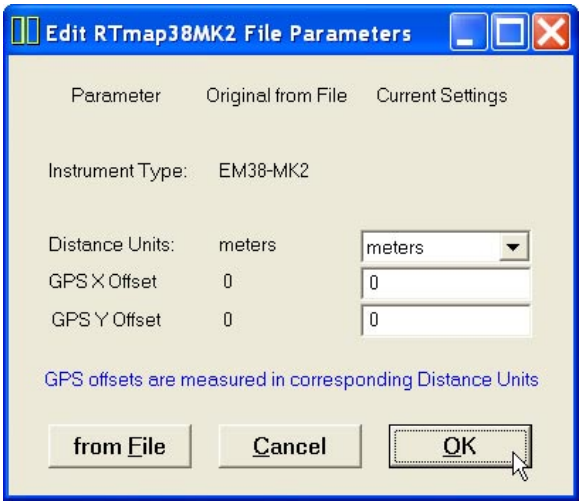


Figure 1.13: Edit Parameters window

The Position Readings menu represents the main function of the program: positioning of the EM38-MK2 sensor based on the system geometry and GPS positioning (Figure 1.14).

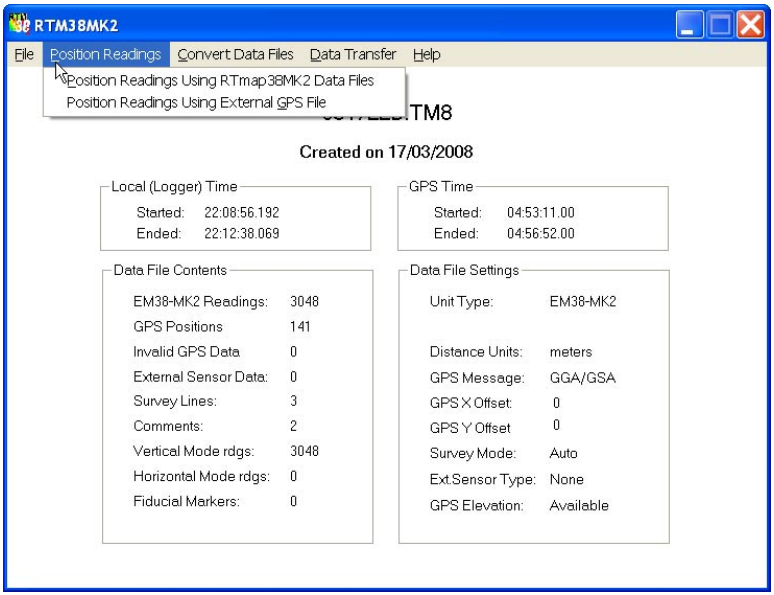


Figure 1.14: RTM38MK2 Position Sensors menu

The first item of the menu, Position Sensors using RTmap38MK2 Data File allows you to position sensors based on Real Time GPS data embedded in RTmap38MK2 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 RTmap38MK2 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 Convert Data menu has five functions available. The menu is shown in Figure 1.15.

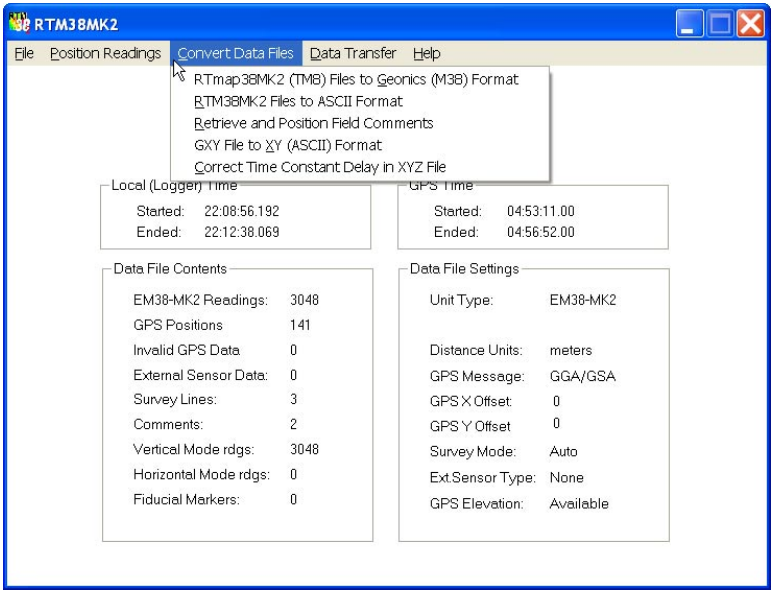


Figure 1.15: RTM38MK2 Convert Data menu

The first item, RTmap38MK2 Files to Geonics M38 Format allows you to convert RTmap38MK2 data files to files that can be loaded and processed by the Geonics DAT38MK2 program.

The second item, RTmap38MK2 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 RTmap38MK2 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 RTmap38MK2 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 EM38-MK2 and GPS receiver) time constant delay in two dimensional XYZ files generated during positioning EM38-MK2 data.

Data Transfer Menu

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

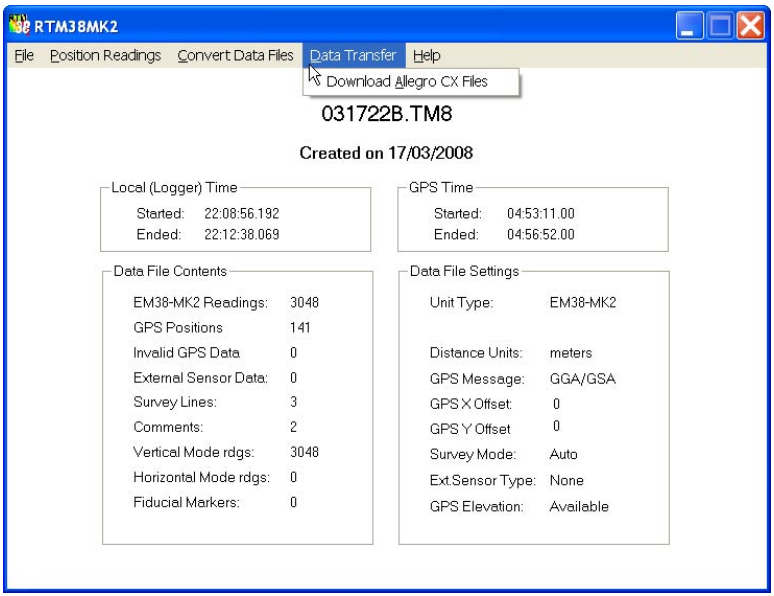


Figure 1.16: RTM38MK2 Data Transfer menu

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).

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

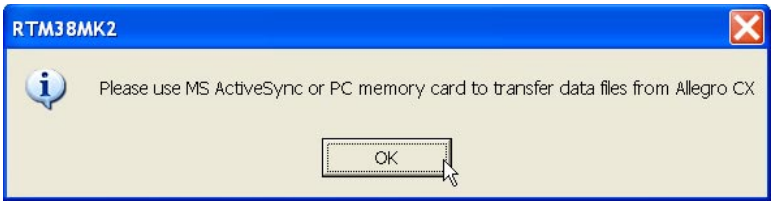


Figure 1.17: Allegro CX data transfer info

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 and version of the program, as shown in Figure 1.19. Help function is not available in this version of the RTM38MK2.

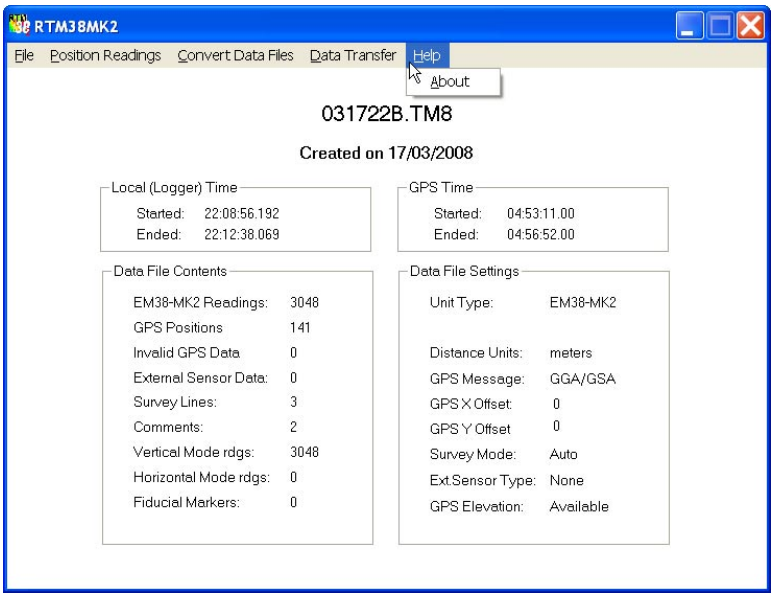


Figure 1.18: RTM38MK2 Help menu

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

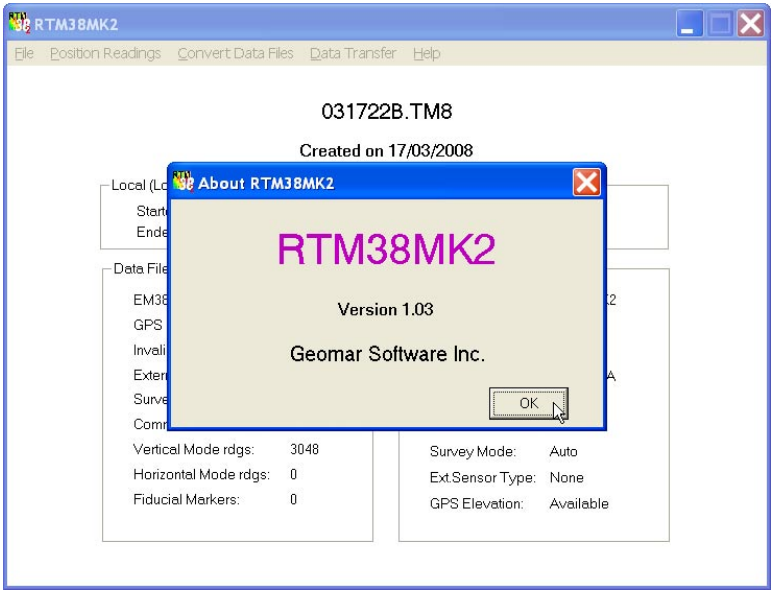


Figure 1.18: About RTM38MK2 window

File Menu 2

File menu of RTM38MK2 program is shown in Figure 2.1. There are several items associated with the File menu:

- Open File (loads RTmap38MK2 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 any XYZ file),
- Exit (terminates RTM38MK2 program).

Figure 2.1: RTM38MK2 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 RTM38MK2 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 RTmap38MK2 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 RTmap38MK2 Input File window will be displayed in the centre of the screen, Figure 2.2.

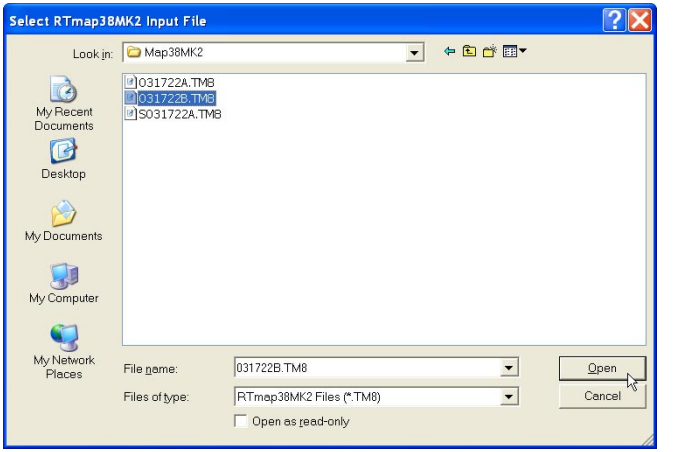


Figure 2.2: Select RTmap38MK2 Input File window

The window lists files with extension name TM8. Select a file name and click the **Open** button. The Select RTmap38MK2 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 RTM38MK2 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 EM38-MK2 readings, number of GPS positions recorded, number of invalid GPS positions (with not valid checksum), number of survey lines, comments, number of readings in each dipole mode, and number of used fiducial markers in the field are given. In the right frame labeled **Data File Settings** listed are: the EM38-MK2 Type, type of used GPS NMEA message, GPS X and Y offsets (in Distance Units), and survey mode.

Figure 2.3: Progress bar indicating loading the RTmap38MK2 file

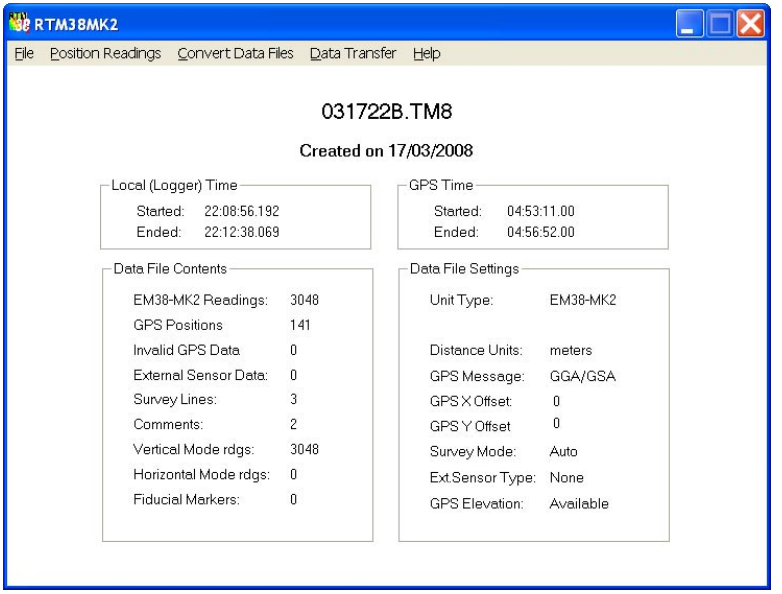


Figure 2.4: RTM38MK2 Main Screen after data file is loaded

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 02/03/2008 as 020310A", (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 17/03/2008 as 031722B" provides information that the original file name was 031722B.TM8 (Figure 2.5). Otherwise this label would provide only date of the created file (see Figure 2.6).

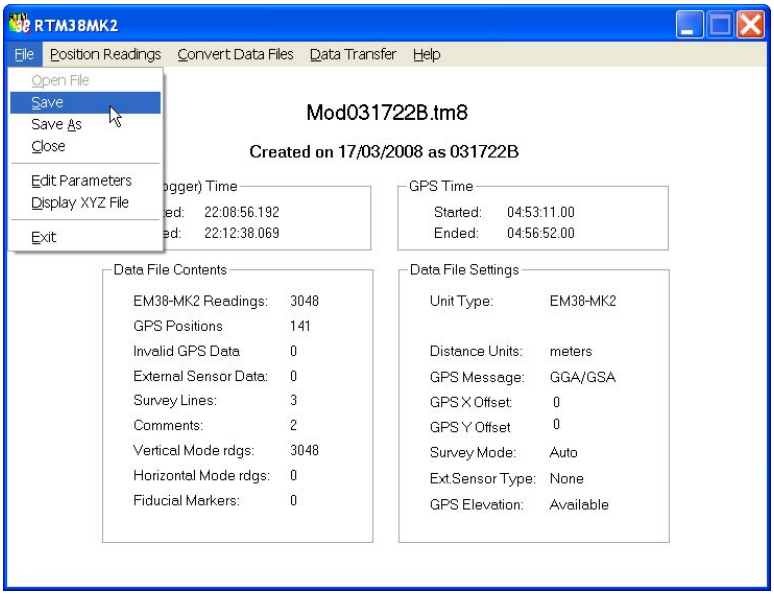


Figure 2.5: RTM38MK2 Main Screen with item Save enabled after not original file was loaded

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,

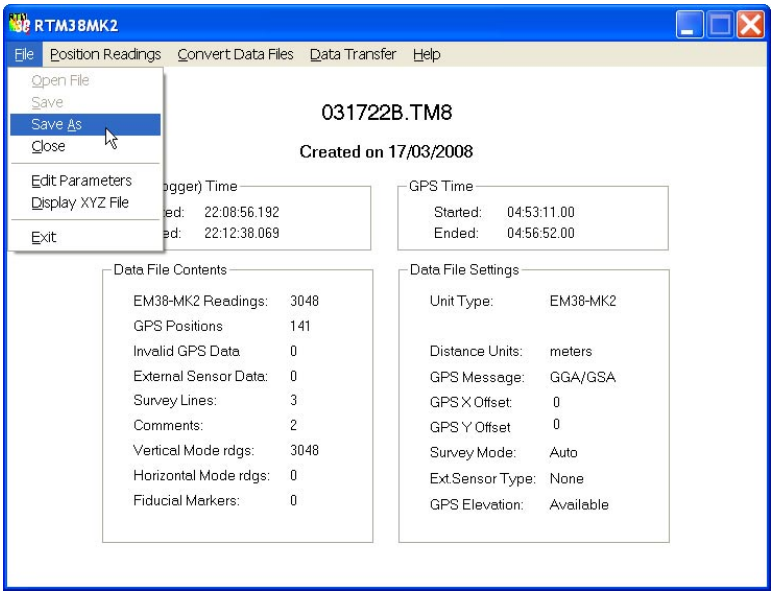


Figure 2.6: RTM38MK2 Screen with loaded original data file, disabled Save option, and selected Save As item

the Save As RTmap38MK2 Input File window will be displayed in the centre of the screen, Figure 2.7.

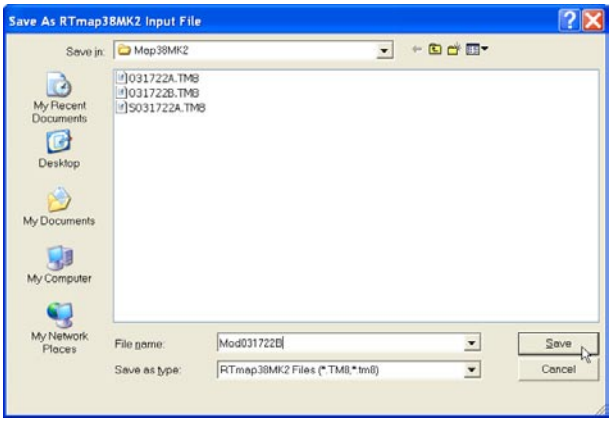


Figure 2.7: Save As RTmap38MK2 Input File window

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 RTM38MK2 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).

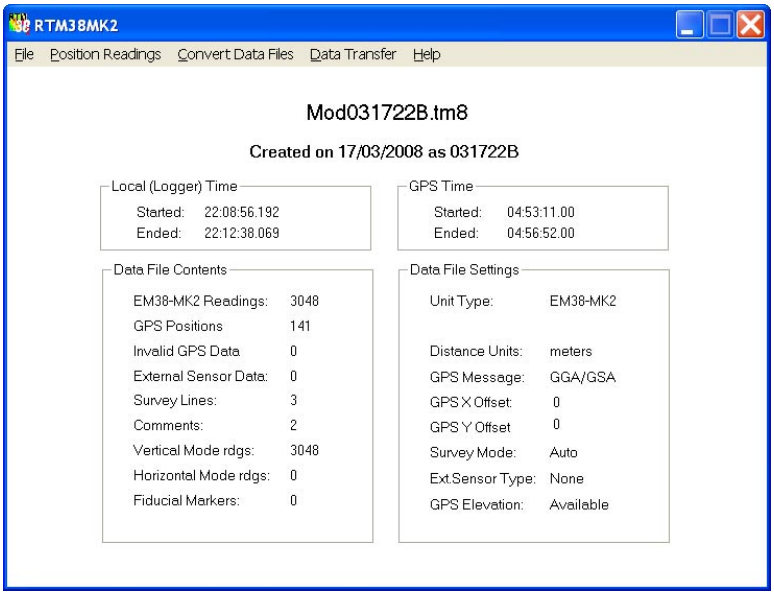


Figure 2.8: RTM38MK2 Main Screen after completed Save As option

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 RTmap38MK2 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 RTmap38MK2 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: EM38-MK2 Type (EM38-MK2 and EM38-MK2-1), 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. Instrument Type and Distance Units can be selected from combo list boxes, while GPS X and GPS

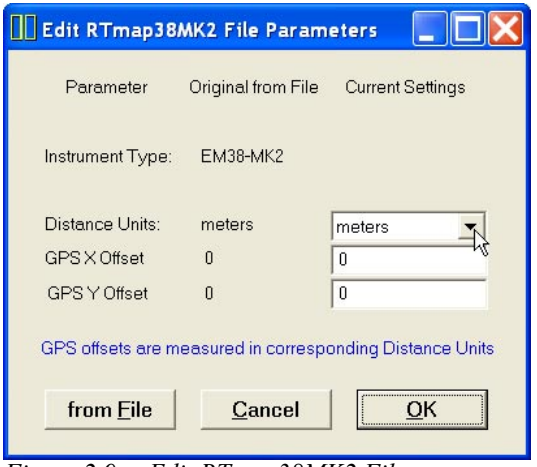


Figure 2.9: Edit RTmap38MK2 File Parameters window

Y offsets must be entered in appropriate text boxes. Example of RTmap38MK2 File Info window with modified parameters is shown in Figure 2.10.

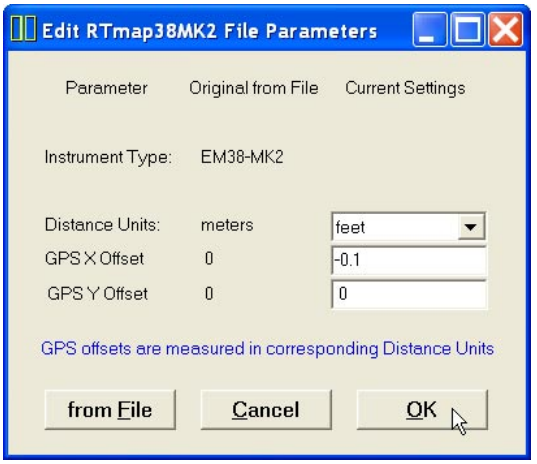


Figure 2.10: Modified parameters in Edit Parameters window

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 RTmap38MK2 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.

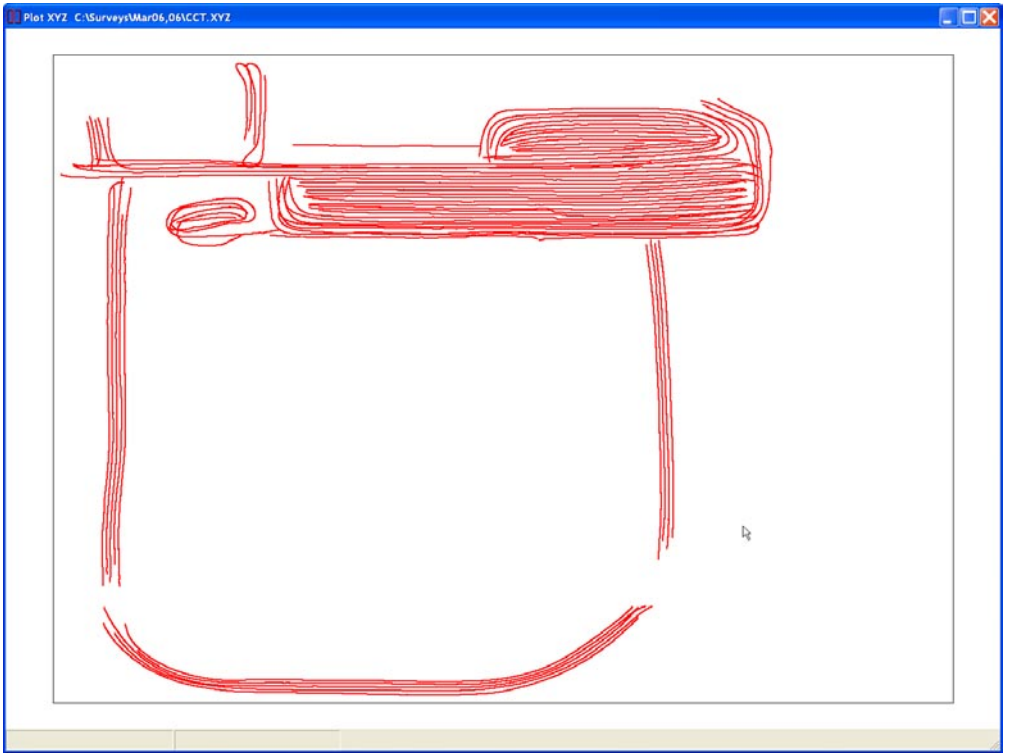


Figure 2.11: Two dimensional layout of stations in XYZ File

Position Readings 3

Positioning of the Geonics EM38-MK2 is the main function of the RTM38MK2. 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 two methods of positioning sensors in RTM38MK2: Position Sensors using RTmap38MK2 Data File and Position Sensors using External GPS File. The first method allows you to position sensors based on Real Time GPS data embedded in RTmap38MK2 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 RTmap38MK2 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.

Description of functions involved in positioning the EM38-MK2 is preceded by a short description of the system geometry.

3.1 The RTmap38MK2 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 EM38-MK2 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 EM38-MK2 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 EM38-MK2 antenna to the center of the GPS antenna, while facing direction of the movement, see Figure 3.1.

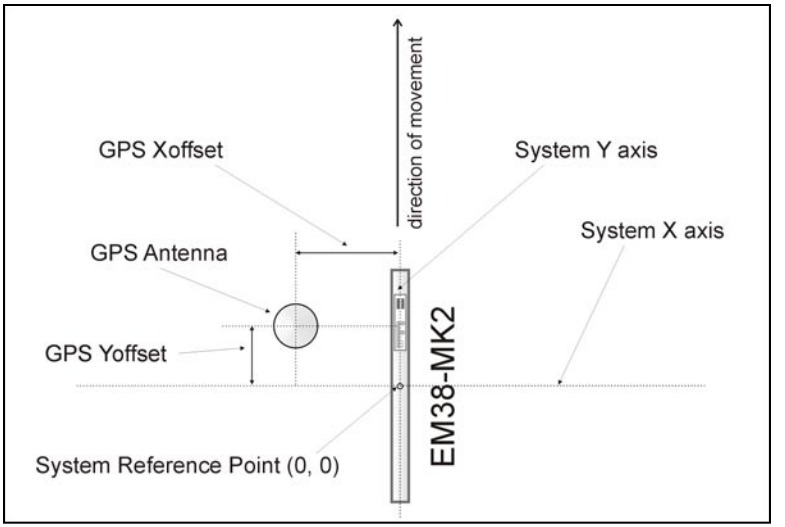


Figure 3.1: The EM38-MK2 and GPS antenna geometry

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 carries the EM38-MK2, 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 relatively small (less than 0.5 m), and GPS Y Offset will be usually very small as well and its sign will depend on whether the center of the instrument is in front or behind the GPS antenna. 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 EM38-MK2 sensor (Figure 3.2). As it was mentioned earlier, the best placement of the GPS antenna is located above the center of the EM38-MK2 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.

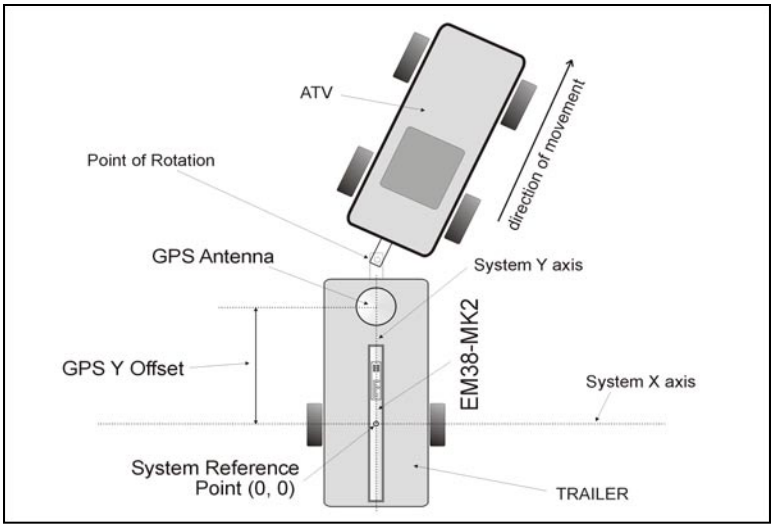


Figure 3.2: Geometry of the EM38-MK2 sensor and GPS antenna during towing

If GPS antenna is located i.e. on ATV and the EM38-MK2 is placed on the trailer (there is a point of rotation between them) then the program RTM38MK2 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 RTM38MK2.

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 RTmap38MK2 Data File

After a data file is loaded the RTM38MK2 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 EM38-MK2 readings, number of GPS positions recorded, number of invalid GPS positions (with not valid checksum), number of survey lines, comments, number of readings in Vertical and Horizontal dipole modes, 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, units, type of used GPS NMEA message, GPS X and Y offsets (in Distance Units), and survey mode.

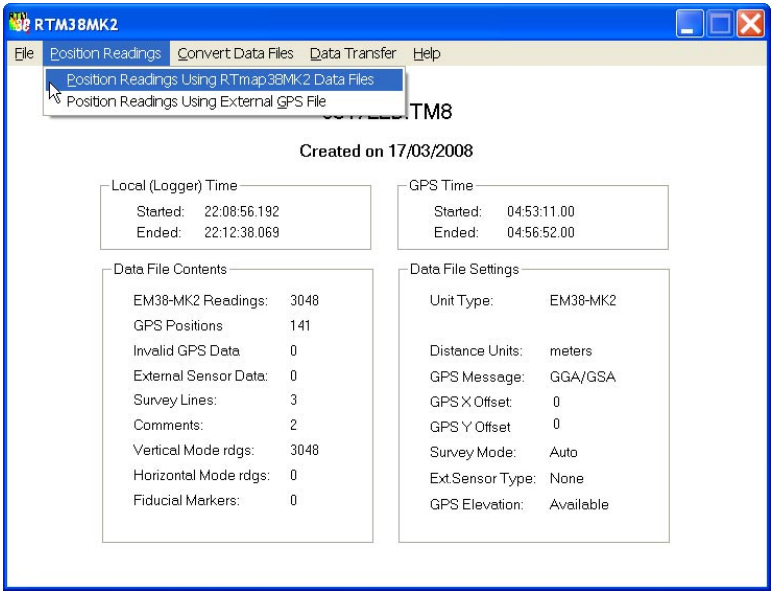


Figure 3.3: Position Readings menu

The Position Readings Using RTmap38MK2 Data option allows you to position EM38-MK2 stations based on Real Time GPS data which were recorded in RTmap38MK2 data file during the survey. Select **Position Sensors|Position Readings Using RTmap38MK2 Data Files** from the main program menu, as shown in Figure 3.3.

After the selected menu item is clicked the Position EM38-MK2 Readings Using RTmap38MK2 Data File window will be displayed in the centre of the computer screen, Figure 3.4.

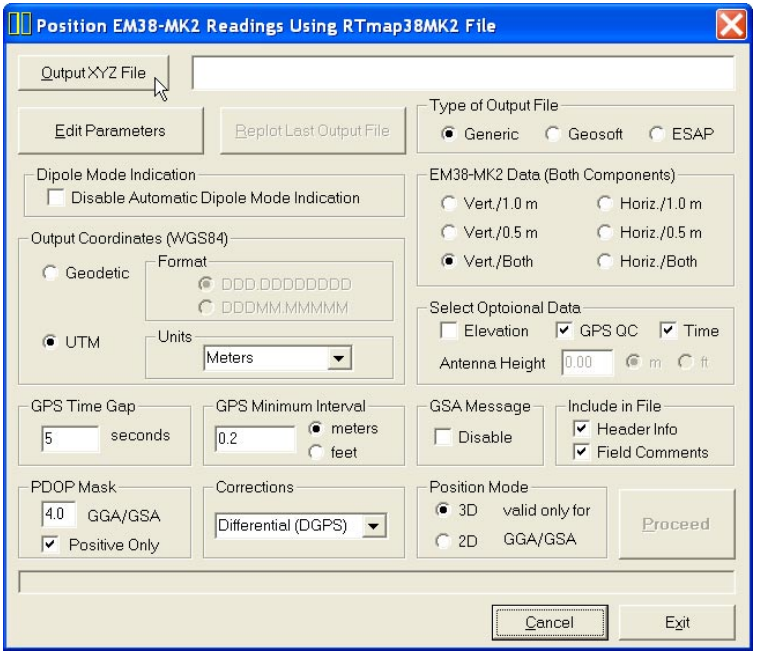


Figure 3.4: Position EM38-MK2 Readings Using RTmap38MK2 Data File window

Parameters in Positioning Readings Using RTmap38MK2 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 RTM38MK2 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 RTM38MK2 main screen). Click on the **Edit Parameters** button and Edit RTmap38MK2 File Parameters window will appear (Figure 3.5).

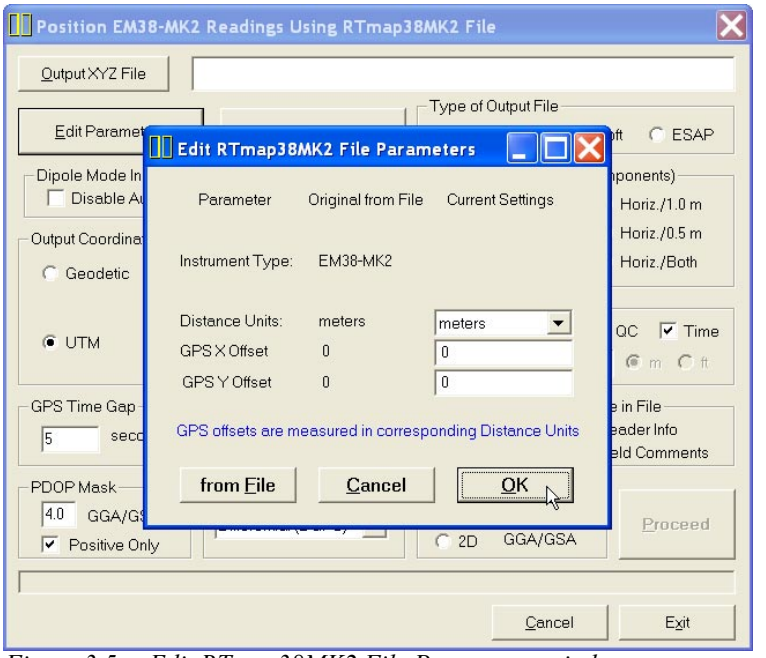


Figure 3.5: Edit RTmap38MK2 File Parameters window

The window displays parameters that the user can edit. These are: the EM38-MK2 type, 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. EM38-MK2 Type 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 RTmap38MK2 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 RTmap38MK2 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 is **Saved** or **Saved As** in File menu.

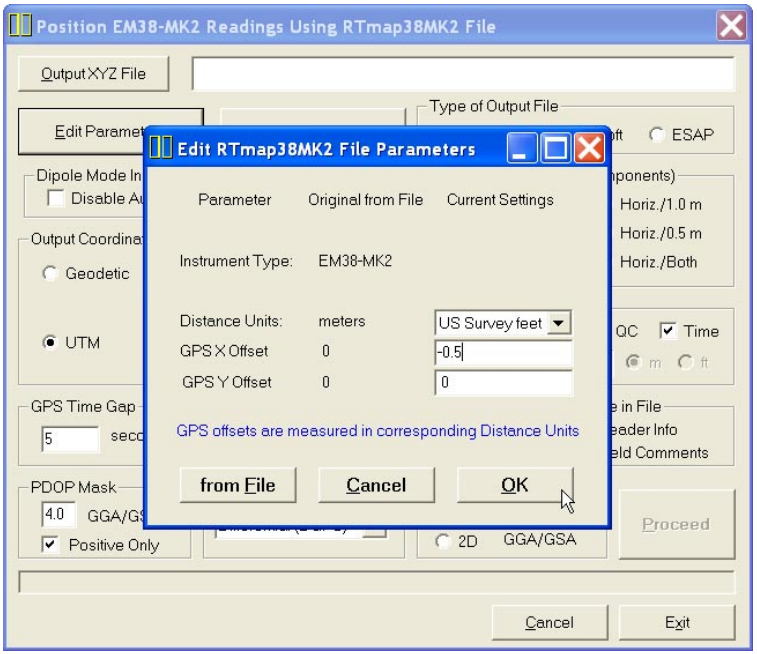


Figure 3.6: Modified parameters in Edit Parameters window

Output File

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

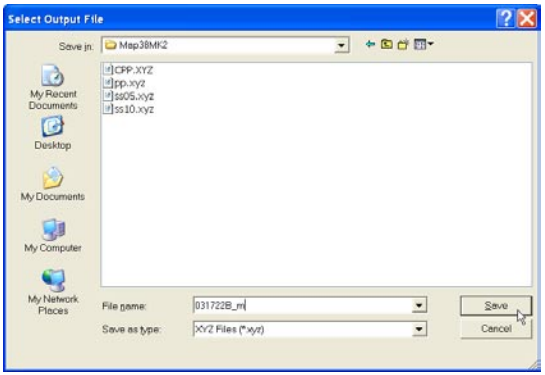


Figure 3.7: Select Output File window

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 EM38-MK2 Readings Using RTmap38MK2 File window.

When Output file is specified the **Proceed** button in the Position EM38-MK2 Readings Using RTmap38MK2 File becomes active (Figure 3.8).

EM38-MK2 Data (Both Components) (Select EM38-MK2 Data Type)

To select a data type (dipole mode and coils separation) click on desired radio buttons labeled **Vert./1.0m**, **Vert./0.5m**, **Vert./Both** for vertical dipole mode, and similarly for Horizontal dipole mode **Horiz./1.0m**, **Horiz./0.5m**, **Horiz./Both**. Both components Conductivity and Inphase are written in the file by default. Data is always placed in the created XYZ file in the following order: X coordinate (Easting or Longitude), Y coordinate (Northing or Latitude), and Conductivity and Inphase for selected coil separation, 1,0 or 0.5 m. If data type containing separation "Both" was selected (Vert./Both or Horiz./Both) then the order is Conductivity and Inphase for 1.0 m and then Conductivity and Inphase for 0.5 m coils separation follows. This data may be followed by one or more columns containing Elevation, GPS Quality parameters, and Time Stamp (this optional parameters are located in a section Select Optional Scale).
If the EM38-MK2-1 instrument is used, then only options with coils separation 1.0 m, **Vert./1.0m** or **Horiz./1.0m** can be used.
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.

Dipole Mode Indication

If the checkbox labeled **Disable Automatic Dipole Mode Indication** is checked the program will ignore reading dipole mode tags and it will write all data (within selected coil separation) in XYZ file, regardless dipole mode selection in EM38-MK2 Data section.

This option may be very useful when the survey is performed using trailer mounted instrument. In this case a dipole mode indicator in the instrument may output false information due to strong vibrations caused by terrain obstructions. Therefore, while carrying survey with trailer or in harsh terrain in lets say Vertical mode, it is possible to have some Vertical readings tagged as Horizontal dipole mode reading.

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

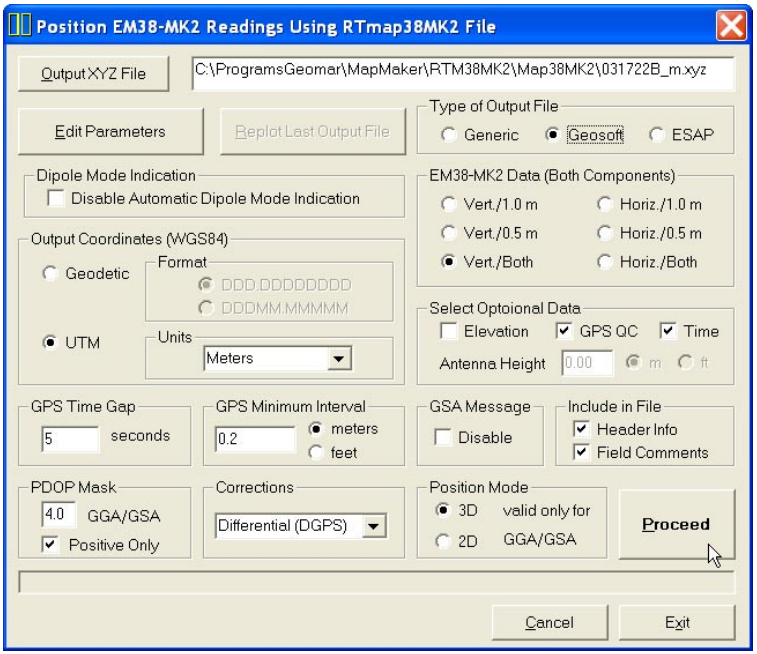


Figure 3.8: Position EM38-MK2 Readings Using RTmap38MK2 Data File window

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 coordinate (Northing or Latitude), EM38-MK2 data type (as selected, 2 or 4 values), 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. The XYZ file in ESAP format is designed to be an input file for the ESAP software package developed by United States Department of Agriculture, Agricultural Research Service. Please refer to ESAP manual for description of the format. Since the ESAP input is limited to 32000 readings per file, the RTM38MK2 will open new files named _1, _2, etc. should the data set is larger than 32000 readings. Data written in this format will not contain any additional parameters including time stamp, nor headers even if they are selected, only sequential number of station, coordinates, and conductivity readings (for one or both coils separations) will be placed in the file. The example of the file in the ESAP format is given in Appendix B.

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 RTM38MK2 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 EM38-MK2 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 EM38-MK2 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 RTM38MK2 will calculate positions of sensor in case offset values (GPS X and/or GPS Y Offsets) are different than zero, positions of the EM38-MK2 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 (RTmap38MK2) that the GPS Message will be pair GGA/GSA and for any reason message GSA was not recorded. In such case the RTM38MK2 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 EM38-MK2 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 EM38-MK2 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 RTM38MK2.

When all parameter are set and output file name is specified, the **Proceed** button is activated in the Position Readings Using RTmap38MK2 File window. After you click the **Proceed** button, the program begins to filter loaded data, calculates EM38-MK2 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 3.9).

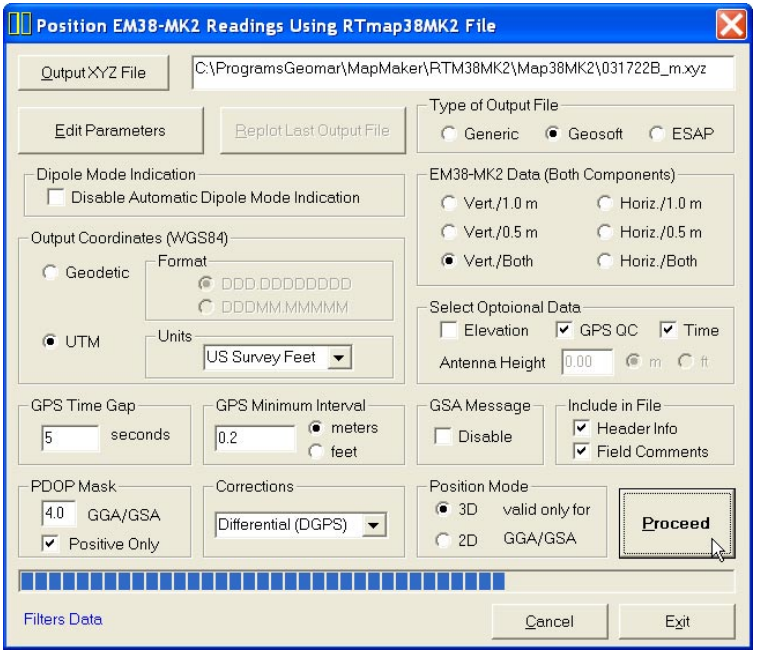


Figure 3.9: Position EM38-MK2 Readings Using RTmap38MK2 File window during creating XYZ file

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 3.10).

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 EM38-MK2 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).

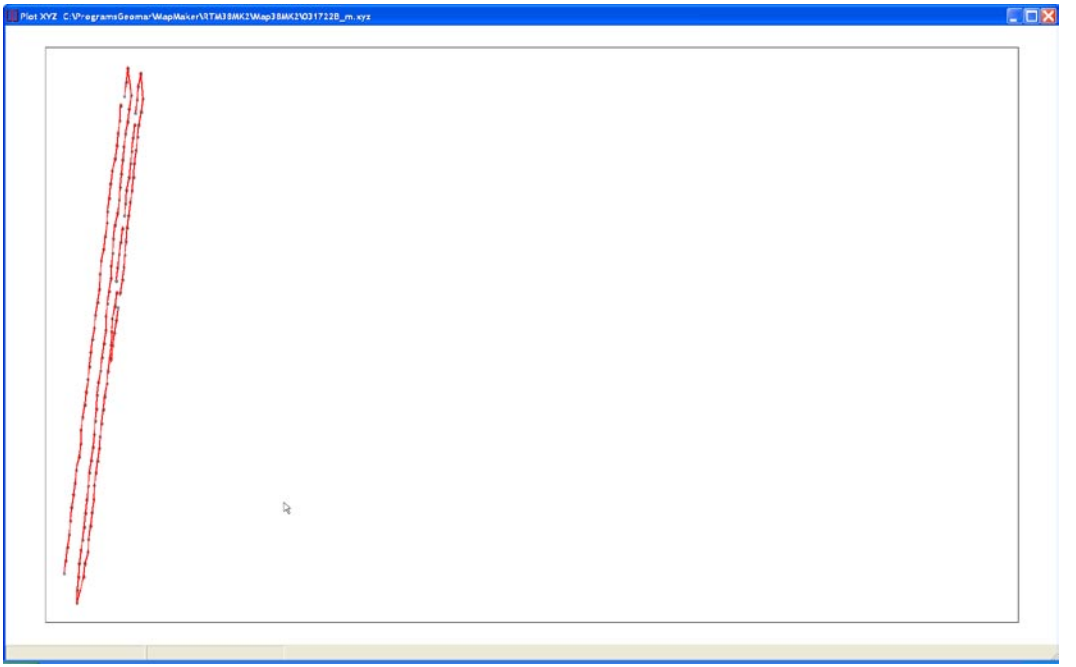


Figure 3.10: Two dimensional layout of stations taken with the Geonics EM38-MK2. The GPS X and Y offsets were set to zero (GPS antenna was located above the center of the EM38-MK2 sensor).

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. To do this, click **Edit Parameters** button, the Edit RTmap38MK2 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.

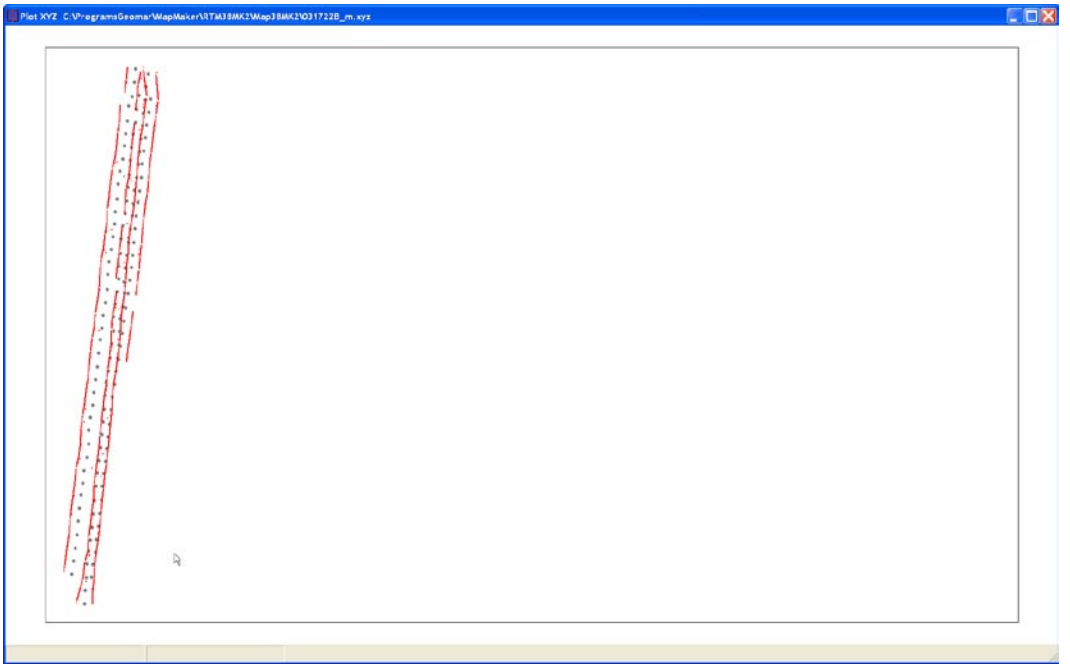


Figure 3.11: Two dimensional layout of stations taken with the EM38-MK2. The GPS antenna location: GPS X Offset = 0.6 m and GPS Y Offset = 0.05 m (the first W line was surveyed in S direction).

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 EM38-MK2 channels specified in Select Data section, etc..

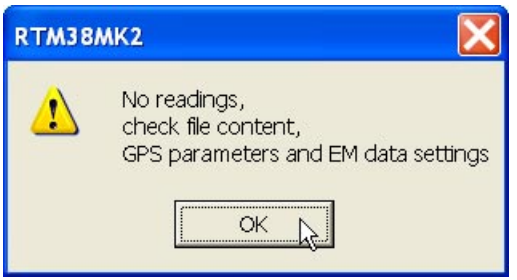


Figure 3.12: Warning window

3.3 Positioning Readings Using External GPS File

After a data file is loaded the RTM38MK2 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 EM38-MK2 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 Vertical and Horizontal dipole mode, 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, units, 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 EM38-MK2 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 RTmap38MK2 program during the survey. Select **Position Sensors|Position Readings Using External GPS File** from the main program menu, as shown in Figure 3.13.

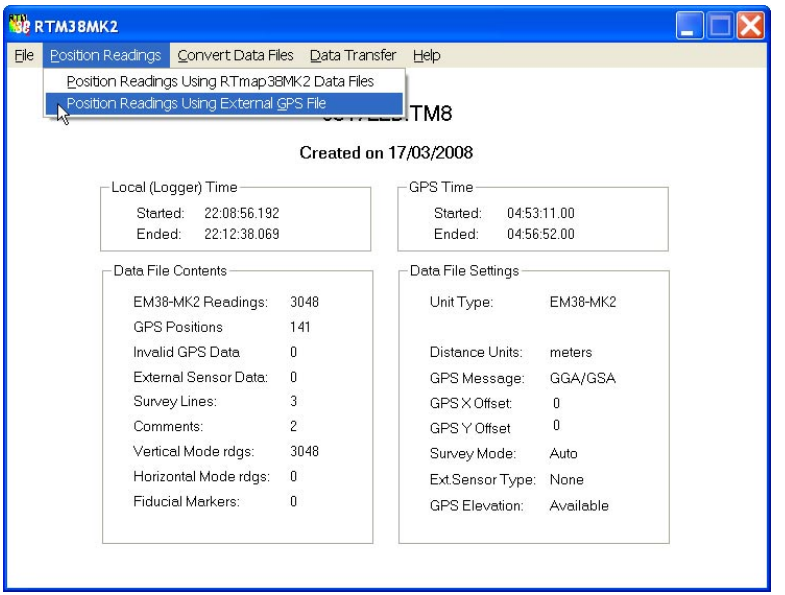


Figure 3.13: Position Readings menu

After the selected menu item is clicked the Position EM38-MK2 Readings Using External GPS File window will be displayed in the centre of the screen, Figure 3.14.

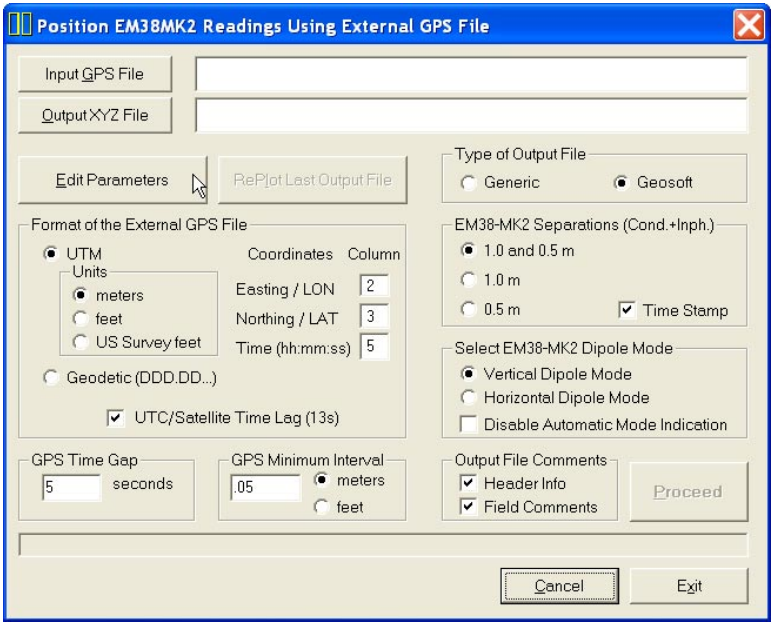


Figure 3.14: Position EM38-MK2 Readings Using External GPS File window

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 RTM38MK2 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 RTM38MK2 main screen). Click on the **Edit Parameters** button and Edit RTmap38MK2 File Parameters window will appear (Figure 3.15).

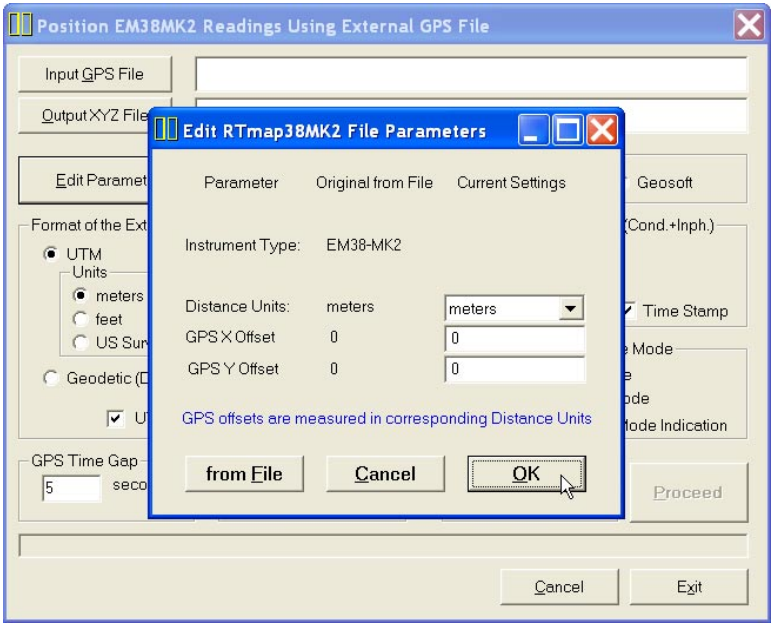


Figure 3.15: Edit RTmap38MK2 File Parameters window

The window displays parameters that the user can edit. These are: the EM38-MK2 Type, 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 Type 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 RTmap38MK2 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 RTmap38MK2 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.

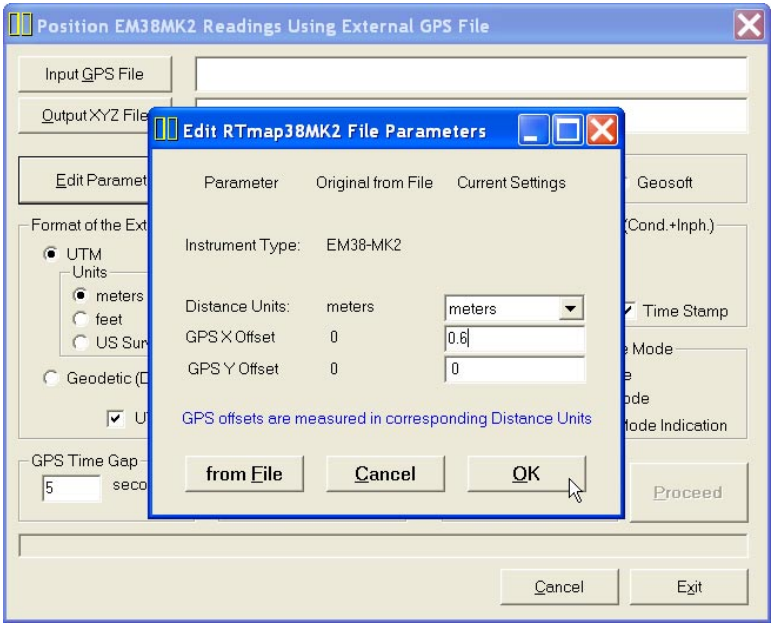


Figure 3.16: Modified parameters in Edit Parameters window

Input GPS File

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

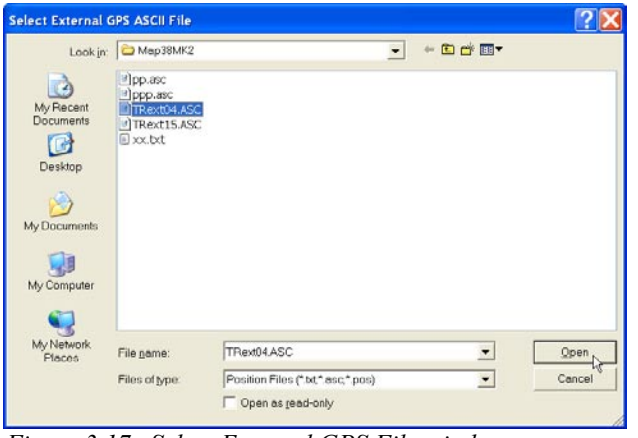


Figure 3.17: Select External GPS File window

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 delimiter 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).

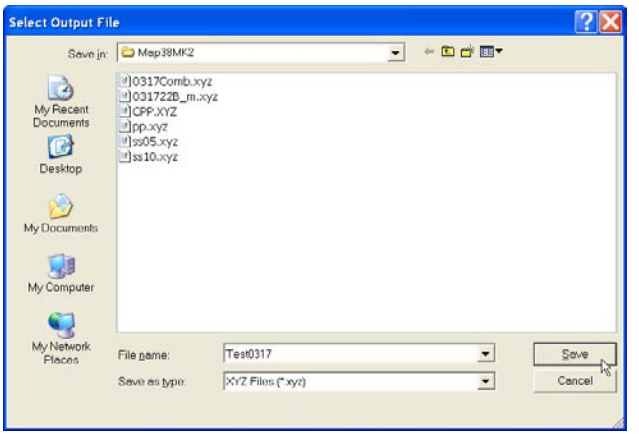


Figure 3.18: Select Output File window

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 RTmap38MK2, Input GPS and Output files are specified the **Proceed** button in the Position EM38-MK2 Readings Using External GPS File becomes active (Figure 3.19).

EM38-MK2 Separations and **Select EM38-MK2 Dipole Mode**

To select a data type (dipole mode and coils separation) click on desired radio buttons labeled **1.0 and 0.5m**, **1.0m**, or **0.5m** in the EM38-MK2 Separations section and click on one of the radio buttons labeled **Vertical Dipole Mode** or **Horizontal Dipole Mode** in the section Select EM38-MK2 Dipole Mode section. Both components Conductivity and Inphase are written in the file by default. Data is always placed in the created XYZ file in the following order: X coordinate (Easting or Longitude), Y coordinate (Northing or Latitude), and Conductivity and Inphase for selected coil separation, 1,0 or 0.5 m. If data type containing both separations was selected (**1.0 and 0.5m** in the EM38-MK2 Separations section) then the order is as follows: Conductivity and Inphase for 1.0 m

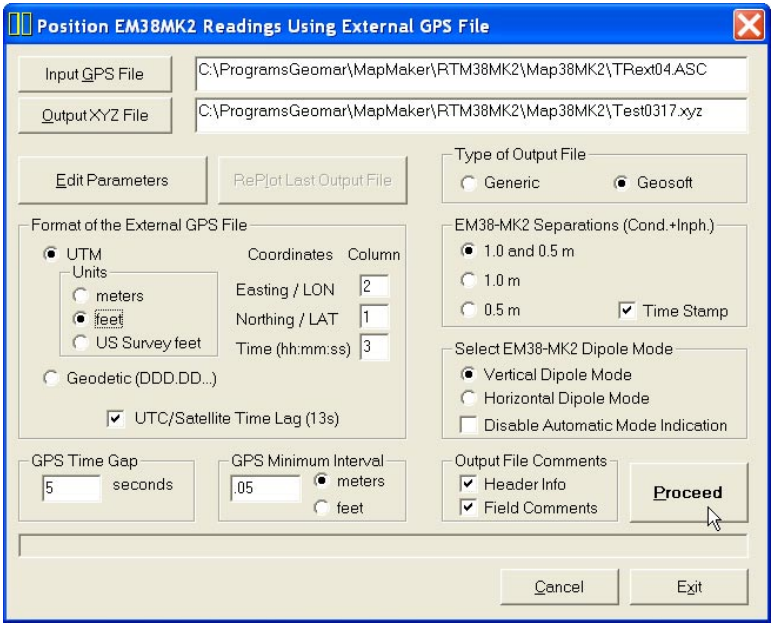


Figure 3.19: Position EM38-MK2 Readings Using External GPS File window

and then Conductivity and Inphase for 0.5 m coils separation This data may be followed by one more columns containing Time Stamp if this option is selected (check box button located in the EM38-MK2 Separations section).
If the EM38-MK2-1 instrument is used, then only option with coils separation 1.0 m, (**1.0m** in EM38-MK2 Separations section) can be used.
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.

If the checkbox labeled **Disable Automatic Dipole Mode Indication** is checked in the Select EM38-MK2 Dipole Mode section the program will ignore reading dipole mode tags and it will write all data (within selected coil separation) in XYZ file, regardless dipole mode selection in EM38-MK2 Data section.

This option may be very useful when the survey is performed using trailer mounted instrument. In this case a dipole mode indicator in the instrument may output false information due to strong vibrations caused by terrain obstructions. Therefore, while carrying survey with trailer or in harsh terrain in lets say Vertical mode, it is possible to have some Vertical readings tagged as Horizontal dipole mode reading.

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 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 RTM38MK2 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 EM38-MK2 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 EM38-MK2 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 RTM38MK2 will calculate positions of sensor in case offset values (GPS X and/or GPS Y Offsets) are different than zero, positions of the EM38-MK2 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 3.19).

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 RTM38MK2 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 RTM38MK2. 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 RTmap38MK2 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 EM38-MK2 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).

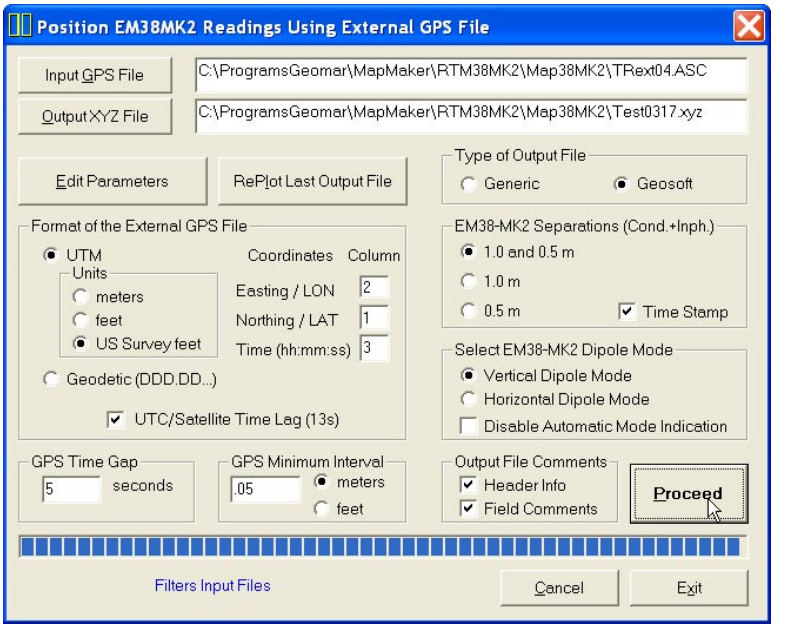


Figure 3.20: Position Sensors Using External GPS File window during creating XYZ file

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 EM38-MK2 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).

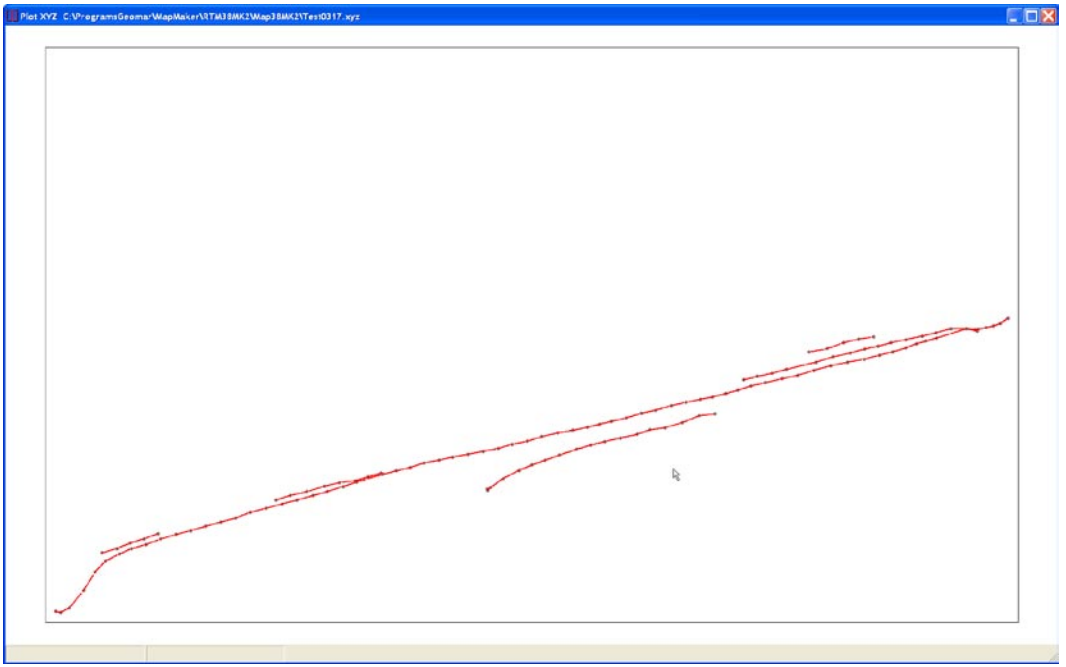


Figure 3.21: Two dimensional layout of stations taken with the Geonics EM38-MK2 and GPS. The GPS antenna was located above the center of the EM38-MK2 sensor (GPS X and Y offsets are set to zero).

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 RTmap38MK2 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.

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.

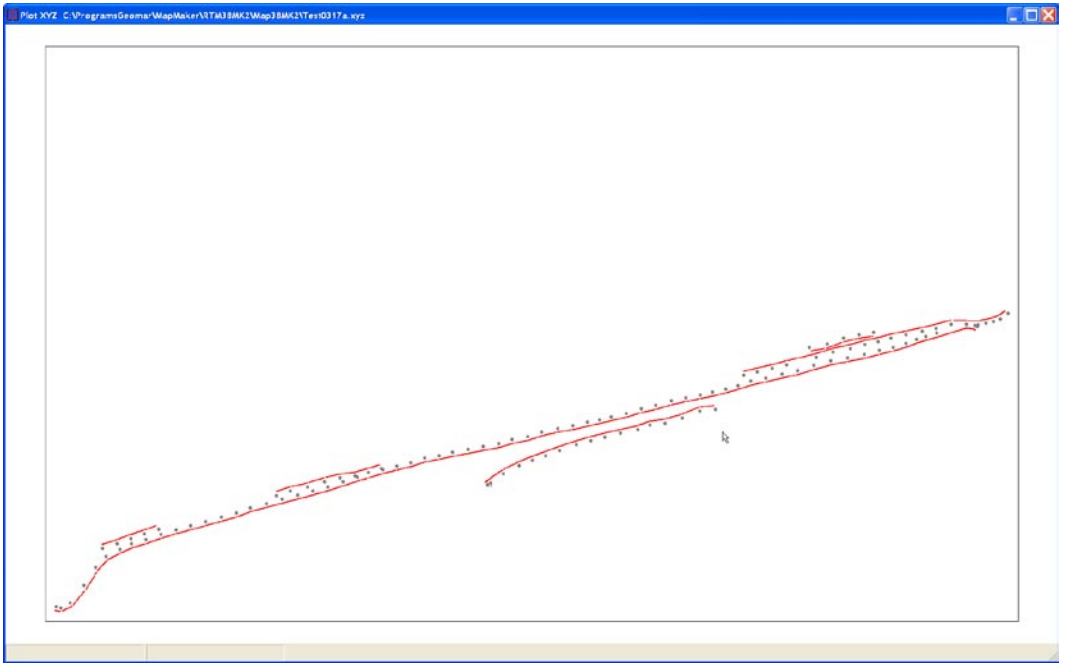


Figure 3.22: Two dimensional layout of stations taken with the Geonics EM38-MK2 and GPS. The GPS antenna was located off the center of the EM38-MK2 sensor (GPS X offset = 1.0 m and GPS Y offset =0).

Convert Data Files 4

Convert menu of RTM38MK2 program allows you to convert the RTmap38MK2 binary file to other formats. There are five items associated with the Convert menu (Figure 4.1):

- convert RTmap38MK2 file to Geonics DAT38MK2 (.M38) format,
- convert RTmap38MK2 file to general format ASCII file,
- retrieve and position field comments from RTmap38MK2,
- convert GXY file to ASCII file containing positions,
- correct system time constant delay in XYZ files.

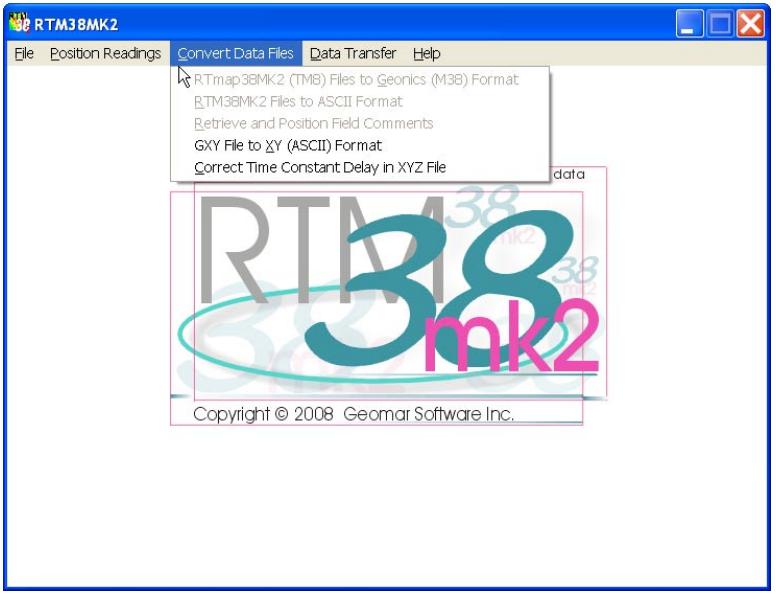


Figure 4.1: Convert Data Files menu

Files converted to Geonics M38 format can be further processed by the Geonics DAT38MK2 program, while files converted to general ASCII format can be easily reformatted and used by other software. While retrieving comments from RTmap38MK2 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 RTmap38MK2 data file is loaded in File menu (Figure 4.2).

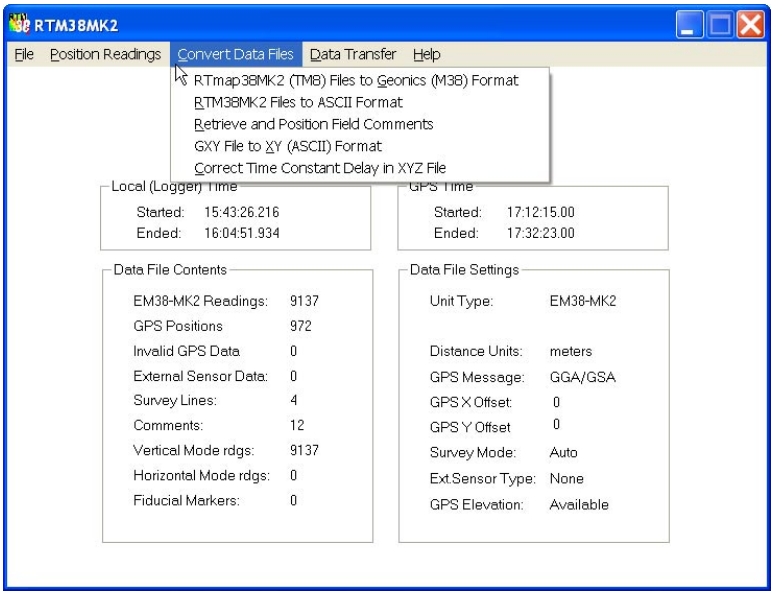


Figure 4.2: Convert Data Files menu after RTmap38MK2 file is loaded to the program

Selected examples of file formats created by RTM38MK2 are given in Appendix B of this manual.

4.1 Convert RTmap38MK2 Data to Geonics DAT38MK2 (M38) Format

The Convert RTmap38MK2 to Geonics M38 Format option allows you to convert RTmap38MK2 files to Geonics DAT38MK2 format. Select **Convert|RTmap38MK2 to Geonics M38 Format** from the main program menu, as shown in Figure 4.2.

After the selected menu item is clicked the Convert RTmap38MK2 Files (TM8) to Geonics M38 Format window will be displayed in the centre of the screen, Figure 4.3.

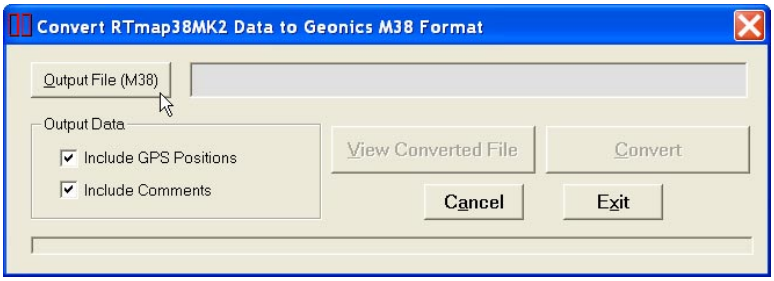


Figure 4.3: Convert RTmap38MK2 Files to Geonics M38 Format

Parameters in Convert RTmap38MK2 Data to Geonics M38 Format Window

Several parameters which affect the contents and format of the created output (M38) 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 (M38)

Click on the **Output File (M38)** button. The Select Output File window is displayed (Figure 4.4).

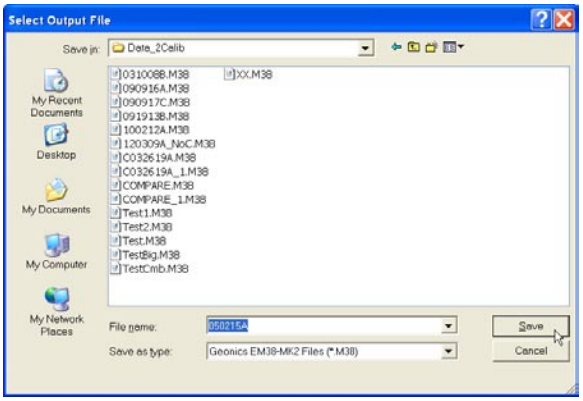


Figure 4.4: Select Output File window

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 (M38)** button in the Convert RTmap38MK2 to Geonics M38 Format window.

When Output file is specified the **Convert** button in the Convert RTmap38MK2 to Geonics M38 Format window becomes active.

Output Data

RTM38MK2 can generate a file with EM38-MK2 data as recorded by RTmap38MK2 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 DAT38MK2 format regardless which GPS message was used during the survey.

Converting RTmap38MK2 Data to Geonics DAT38MK2 (M38) Format

When all parameters are set and input and output file names are specified, the **Convert** button is activated in the Convert RTmap38MK2 File to Geonics M38 Format window. After you click the **Convert** button, the program begins to read the input file, converts data to DAT38MK2 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).

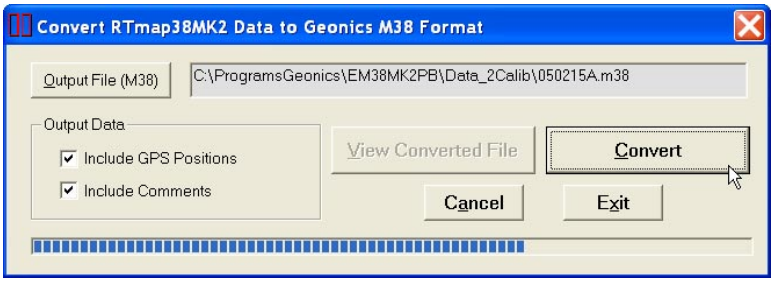


Figure 4.5: Convert RTmap38MK2 Files (TM8) to Geonics M38 Format window during data processing

The speed of this operation depends on the size of the input file. After the output (M38) 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 DAT38MK2 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 (M38)** button. Click on **Exit** button to close the Convert RTmap38MK2 Files (TM8) to Geonics M38 Format window.

An example of data file in Geonics DAT38MK2 (M38) format is given in Appendix B.

4.2 Convert RTmap38MK2 Data to ASCII Format

The Convert RTmap38MK2 Data to ASCII Format option allows you to convert RTmap38MK2 binary files to ASCII format, which can be viewed with any text editor and then easily converted to the other format. Select **Convert|RTmap38MK2 to ASCII Format** from the main program menu, as shown in Figure 4.2.

After the selected menu item is clicked the Convert RTmap38MK2 Files to ASCII Format window will be displayed in the centre of the screen, Figure 4.6.

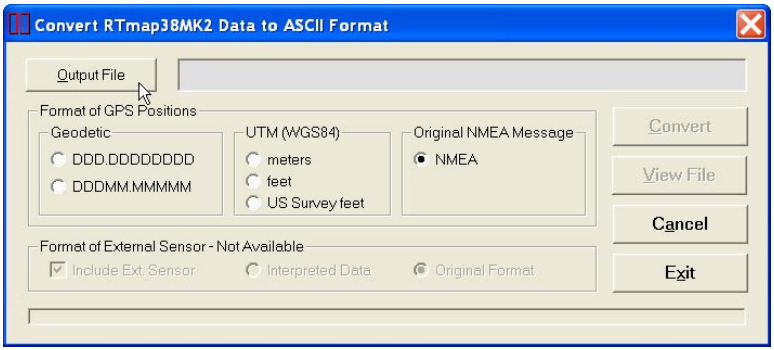


Figure 4.6: Convert RTmap38MK2 Files to ASCII Format window

Parameters in Convert RTmap38MK2 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 (coordinates 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 RTmap38MK2 Files to ASCII Format window.

When Output file is specified the **Convert** button in the Convert RTmap38MK2 Data to ASCII Format window becomes active.

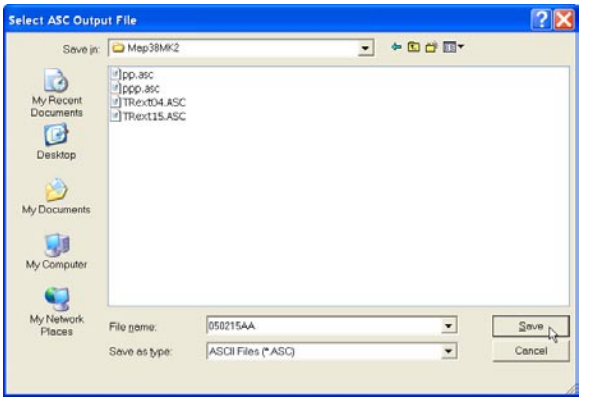


Figure 4.7: Select ASC Output File window

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 RTmap38MK2 Data to ASCII Format

When all parameter are set and output file name is specified, the **Convert** button is activated in the Convert RTmap38MK2 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).

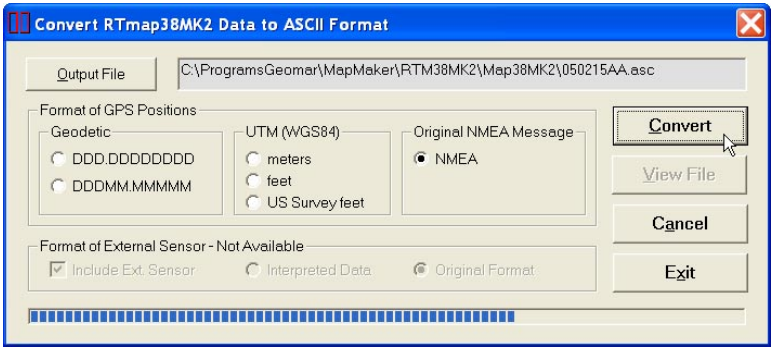


Figure 4.8: Convert RTmap38MK2 Files to ASCII Format window during data processing

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 EM38-MK2 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 RTmap38MK2 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 RTmap38MK2 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 RTmap38MK2 File window will be displayed in the centre of the screen, Figure 4.9.

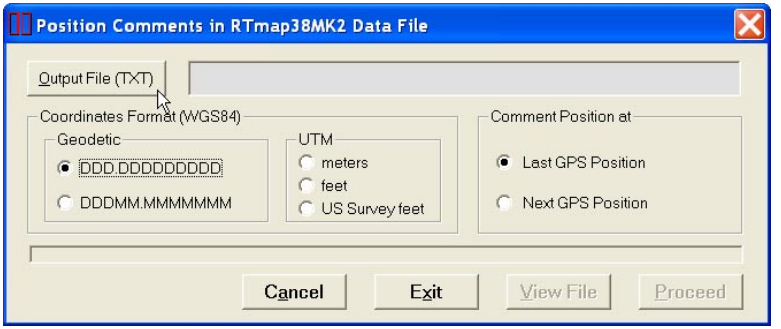


Figure 4.9: Position Comments in RTmap38MK2 Data

Parameters in Position Comments Recorded in RTmap38MK2 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 RTmap38MK2 File window.

When both, Input and Output files are specified the **Proceed** button in the Position Comments Recorded in RTmap38MK2 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 RTmap38MK2 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 RTmap38MK2 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 RTmap38MK2 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).

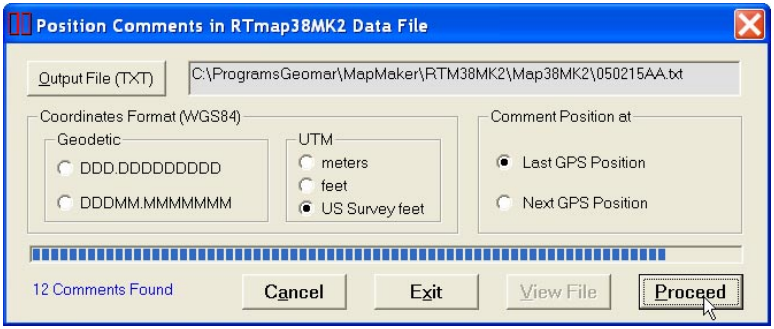


Figure 4.11: Position Comments Recorded in RTmap38MK2 File during data processing

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 (TM8)** and **Output File (TXT)** buttons. Click on **Exit** button to close the Position Comments Recorded in RTmap38MK2 File window.

4.4 Convert GXY Files to XY (ASCII) Format

Files GXY are created by the RTmap38MK2 when only GPS data are collected (EM38-MK2 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, RTmap38, NAV38, etc.) can be converted to ASCII format using this option of RTM38MK2.

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.

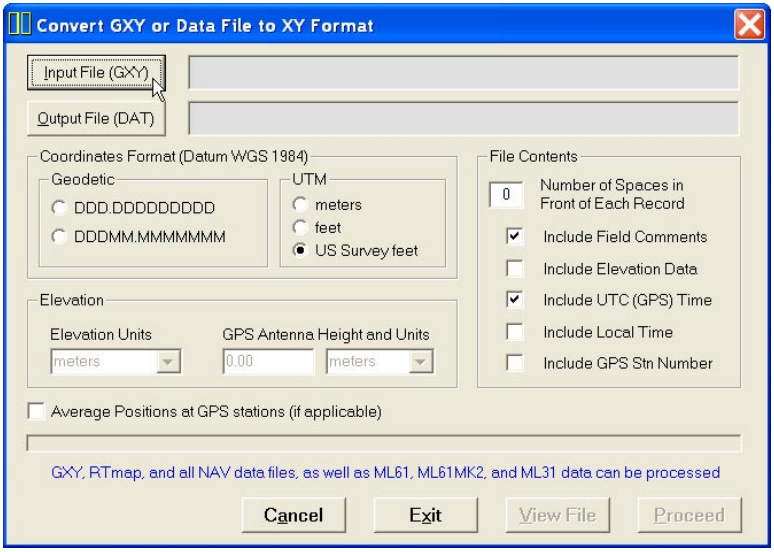


Figure 4.12: Convert GXY Files to XY Format window

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.

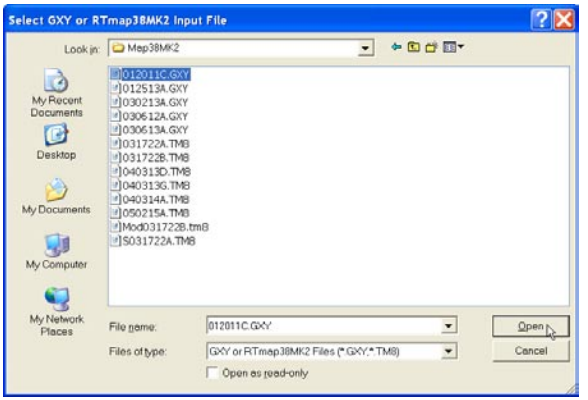


Figure 4.13: Select GXY Input File window

Output File (DAT)

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

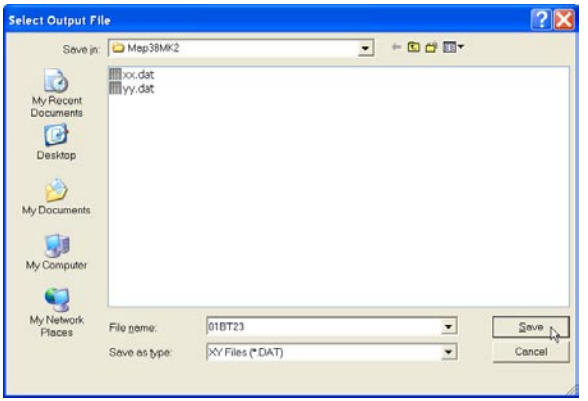


Figure 4.14: Select Output File window

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

This option can be used only if the similar option is provided in RTmap38MK2. 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).

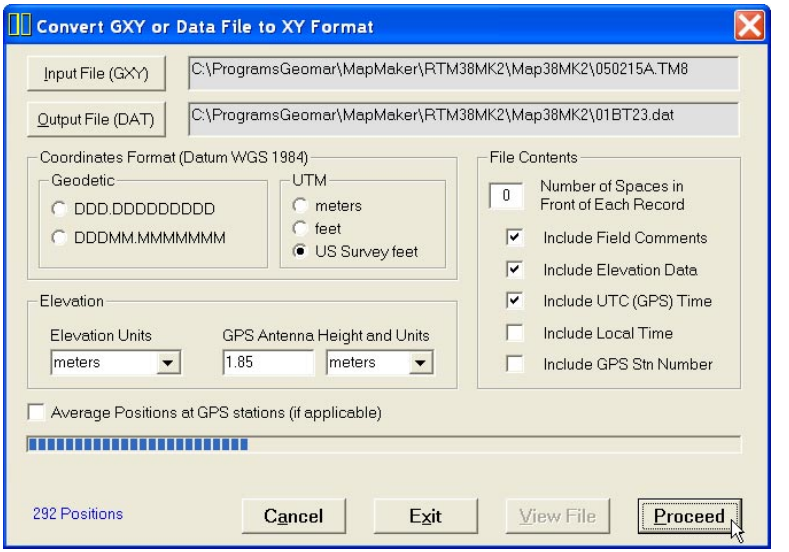


Figure 4.15: Convert GXY Data Files to XY Format window during data processing

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 EM38-MK2 time constant is known (approximately 0.5 s) the time constant of the combined EM38-MK2 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 EM38-MK2.

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).

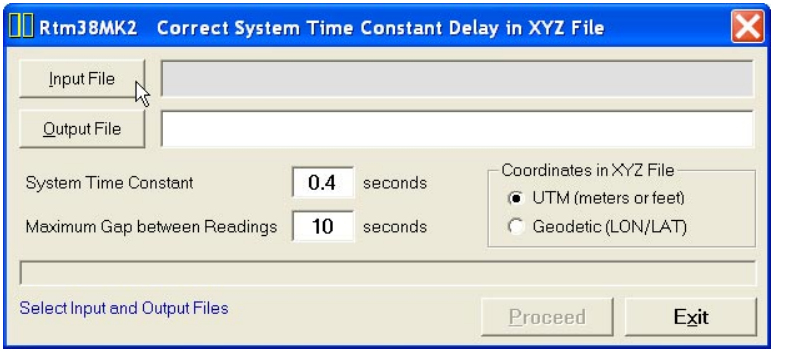


Figure 4.16: Correct Time Constant Delay in XYZ File window

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).

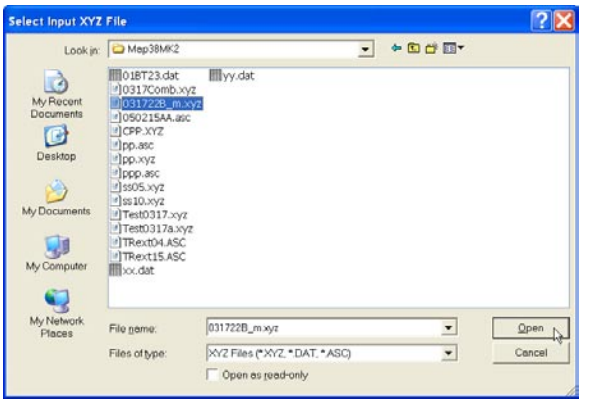


Figure 4.17: Select Input XYZ File window

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).

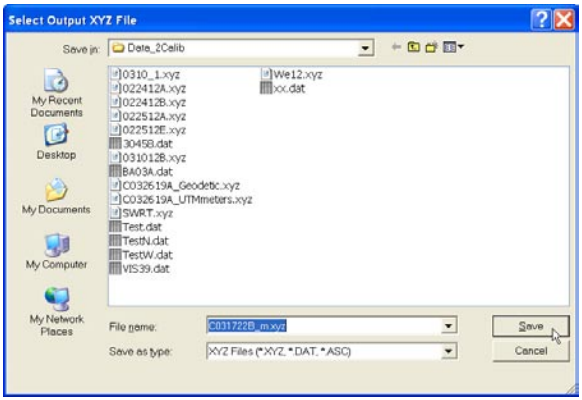


Figure 4.18: Select Output XYZ File window

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 EM38-MK2 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).

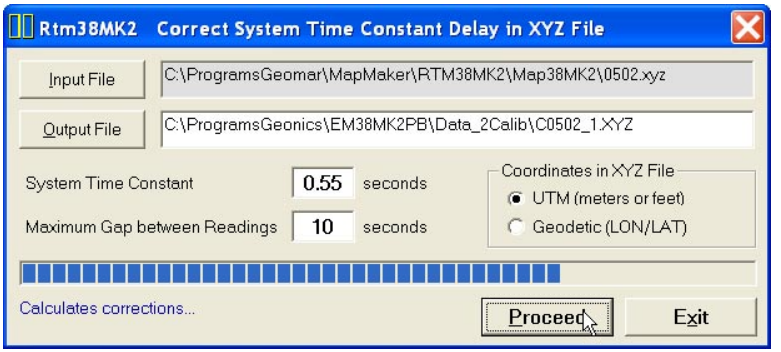


Figure 4.19: Correct Time Constant Delay in the XYZ File window during data processing

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.

RTmap38MK2 Data File

A

A.1 Description of RTmap38MK2 Data File Format (TM8)

Each record created by the RTmap38MK2 for Allegro CX program contains 27 characters, including line feed at the end of each record.

Header of the file contains 9 records starting with characters R, H, G, and then six records starting with O.

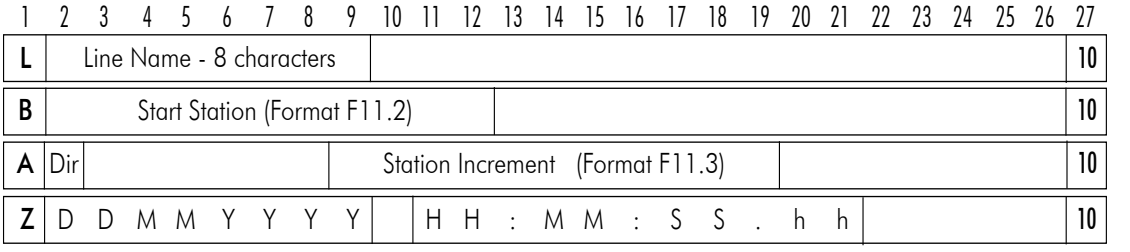
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
R	T	M	3	8	M	K	2	W	1	0	3	Survey Type			UT	ID	IM	IC	ST			LT	dD	svid		10
H		Data File Name										Time Inc./Samples							TG	Latency ms					svid		10
G	GPS X Offset (F7.2)							GPS Y Offset (F7.2)											GP	GS	GR				svid		10
O	1	Calibration Q 1.0m (F10.3)											Calibration Q 1.0m (F10.3) - OLD													10
O	2	Calibration Q 0.5m (F10.3)											Calibration Q 0.5m (F10.3) - OLD													10
O	3	Calibration IV 1.0 m (F10.3)											Calibration IV 1.0 m (F10.3) - OLD													10
O	4	Calibration IV 0.5 m (F10.3)											Calibration IV 0.5 m (F10.3) - OLD													10
O	5	Calibration IH 1.0 m (F10.3)											Calibration IH 1.0 m (F10.3) - OLD													10
O	6	Calibration IH 0.5 m (F10.3)											Calibration IH 0.5 m (F10.3) - OLD													10

RTM38MK2	-	identification of program file, if rTM38MK2 (lower case r) is present later in the file, it indicates start of appended file header
W103	-	version number (V1.03), 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)
ID	-	EM38-MK2 Dipole Mode (selected by operator) (0 = Vertical, 1 = Horizontal, 2 = Both)
IM	-	EM38-MK2 survey mode (0 = Auto, 2 = Manual)
IC	-	not used parameter (=0 fixed, not used)

ST	-	instrument type (1 = EM38-MK2-1, 2 = EM38-MK2)
LT	-	logger type (blank - Allegro CX, 1 - Win XP)
dD	-	display decimation factor (not used in processing)
svid	-	logger/software type id (not used)
Data File Name	-	file name, maximum 8 characters
Time/Samples	-	this field depends on EM38-MK2 survey mode Auto Mode - Time Increment in seconds 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)
O1	-	calibration factor conductivity 1.0 m (new, then old)
O2	-	calibration factor conductivity 0.5 m (new, then old)
O3	-	calibration factor Inphase Vert 1.0 m (new, then old)
O4	-	calibration factor Inphase Vert 0.5 m (new, then old)
O5	-	calibration factor Inphase Hor 1.0 m (new, then old)
O6	-	calibration factor Inphase Hor 0.5 m (new, then old)
10	-	Line Feed character

Sequence of six records **O1** to **O6** can be repeated in data file whenever the EM38-MK2 Automatic Calibration is performed. Former Calibration factors are always placed in the same respective record, following a new factor value.

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
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

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
*	Computer Time (Format HH:MM:SS.hh)															Time Stamp in ms (10 digits)										10

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 continuously 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	6h	6l			Time Stamp in ms (10 digits)										10

I - indicator T, t, or 2
- **T** - first reading at the EM38-MK2 station (default for Auto mode)
- **t** - first reading at the EM38-MK2-1 station (default for Auto mode), applies only to some models. Instrument type is described by parameter ST, located in the first line of File Header.
- **2** - second reading at station (possible only in Manual mode)

Gn - information byte, one character parameter, the ASCII number of this character indicates following:

Bit	Decimal	Value and Meaning		
7	128	0		*not used*
6	64	0		*not used*
5	32	0		*not used*
4	16	0		*not used*
3	8	0		*not used*
2	4	Marker	= 1	*trigger pressed*
			= 0	*otherwise*
1	2	Mode	= 1	*Vertical*
			= 0	*Horizontal*
0	1	0		*not used*

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 Channel 5
5l	-	lower byte of Channel 5
6h	-	higher byte of the 2's complement Hex number of Channel 6
6l	-	lower byte of Channel 6
Time	-	time in ms from the Windows start (resets every 49.7 days). The time in milliseconds can be linked with the computer local time by using Times in line started by * (see Timer Relation).
10	-	Line Feed character

Channel Information

Channel 1	-	Conductivity for coil separation 0.5 m
Channel 2	-	Inphase for coil separation 0.5 m
Channel 3	-	Conductivity for coil separation 1.0 m
Channel 4	-	Inphase for coil separation 1.0 m
Channel 5	-	Temperature for coil separation 0.5 m
Channel 6	-	Temperature for coil separation 1.0 m

Multiply Channels 1 to 4 according to the following formula to obtain Conductivity or Inphase readings in mS/m or ppt.
(In EM38-MK2-1 data only channels 3, 4, and 6 are valid).

$$\text{Reading (Conductivity or Inphase)} = (\text{Channel} \times 5 / 1024 - 160) \times 8$$

Multiply Channels 5 and 6 according to the expression given below obtain Temperature readings in degrees.

$$\text{Temperature (for 1.0 or 5.0 m)} = \text{Channel} \times 100 / 13107 - 50$$

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 15 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

Calibration

When Calibration is performed during data logging then record for each component/coil separation/dipole mode contains two factors. First value corresponds to the current calibration and the second, following value shows former calibration factor. Calibration values is always recorded as a block of six record (from **O1** to **O6**), each record represents values for different component/coil separation and in case of Inphase dipole mode settings.

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
O	1	Calibration Q 1.0m (F10.3)											Calibration Q 1.0m (F10.3) - OLD													10
O	2	Calibration Q 0.5m (F10.3)											Calibration Q 0.5m (F10.3) - OLD													10
O	3	Calibration IV 1.0 m (F10.3)											Calibration IV 1.0 m (F10.3) - OLD													10
O	4	Calibration IV 0.5 m (F10.3)											Calibration IV 0.5 m (F10.3) - OLD													10
O	5	Calibration IH 1.0 m (F10.3)											Calibration IH 1.0 m (F10.3) - OLD													10
O	6	Calibration IH 0.5 m (F10.3)											Calibration IH 0.5 m (F10.3) - OLD													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 or other NMEA message) is broken in to several 25 characters strings and placed in the RTmap38MK2 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 (GGA example) written in RTmap38MK2 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 Example of RTmap38MK2 Data File

The RTmap38MK2 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.

```
RTM38MK2W103GPS00002   103
H 031722B    0.050     01B
G   0.00   0.00    010  EE
01  -252.532      0.000
02   254.599      0.000
03   430.557      0.000
04  1276.376      0.000
05   587.093      0.000
06   736.105      0.000
L0
B       0.00
AN            1.000
Z17032008 22:08:55
*22:08:55.000   1431197131
X$STARTED       1431198282
T_É$ù»°Y¦T_Ù_Ø  1431198324
T_É_ùÇ°9¦U_Ù_Ø  1431198372
T_É_ùå°;¦S_Ù_Ø  1431198420
T_É@ù×°J¦[_Ù_Ø  1431198467
@$GPGGA,045311.00,4336.593
#59,N,07936.64523,W,2,7,1,
#143.58,M,-35,M,4,119*52
!000001p        1431198419
T_É2ùñ°k¦c_Ù_Ø  1431198547
@$GPGSA,A,3,,,,27,16,,23,,1
#9,13,06,03,,02.2,01.1,01.
#9*06
!000001         1431198548
T_É!ùà°q¦q_Ù_Ø  1431198567
T_É%ùÙ°z¦X_Ù_Ø  1431198609
T_É_ùê°a¦\_Ù_Ø  1431198657
T_É_ú_°N¦¯_Ù_Ø  1431198704
T_É&ú¯°¯¦Z_Ù_Ø  1431198752
T_É?ú¯°m¦N_Ù_Ø  1431198799
T_É-ùõ°[¦D_Ù_Ø  1431198847
T_É4ùÿ°ì¦@_Ù_Ø  1431198894
T_É,ú_°R¦7_Ù_Ø  1431198941
T_É ú¯°^¦>_Ù_Ø  1431198989
T_É7ú¯°M¦6_Ù_Ø  1431199037
T_É@ùþ°V¦7_Ù_Ø  1431199084
T_É1ùþ°[¦Q_Ù_Ø  1431199131
T_É4ú>°ã¦W_Ù_Ø  1431199179
T_ÉKú)°P¦O_Ù_Ø  1431199226
T_É2ú_°p¦M_Ù_Ø  1431199274
T_É$ú≡°b¦W_Ù_Ø  1431199321
T_É3ú@°f¦O_Ù_Ø  1431199369
T_ÉJú_°u¦K_Ø_×  1431199416
T_ÉJú7°u¦V_Ø_×  1431199464
@$GPGGA,045312.00,4336.594
#12,N,07936.64511,W,2,7,1,
#143.60,M,-35,M,5,119*59
!000002p        1431199446
T_Éeú=°f¦V_Ø_×  1431199551
@$GPGSA,A,3,,,,27,16,,23,,1
#9,13,06,03,,02.2,01.1,01.
#9*06
!000002         1431199551
T_Éaú:°d¦U_Ø_×  1431199569
T_ÉKùñ°j¦S_Ø_×  1431199606
.........................
```

A.3 Format of GXY Data File

The RTmap38MK2 data file with extension GXY contains GPS records. The structure of this file is identical to the standard RTmap38MK2 (TM8) file. The difference is that it does not contain any EM38-MK2 records. This file is created by RTmap38MK2 when the EM38-MK2 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 RTmap38MK2 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 RTM and TrackMaker for any other supported Geonics instrument (RTM31, TrackMaker31, TrackMaker61MK2, etc.). The extension name GXY indicates that the file does not contain electromagnetic data.

File Formats

B

B.1 Description of Geonics DAT38MK2 (M38) File Format

A DAT38MK2 (with extension name M38) 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.

The DAT38MK2 file header contains name of the instrument: EM38-MK2, the program version number, and original name of file, as shown below:

```
EM38-MK2 V1.15 031008B
```

The row started with L specifies beginning of the survey line, it is followed by the line name, and line parameters (three characters e.g. BV10):

1st component (B-both, fixed),

2nd dipole mode (B-both, V-vertical, H-horizontal),

3rd not used (=1),

4th not used (=0),

The next field specifies line direction W, E, N, or S. At the end of this row two parameters indicate mode of data acquisition A-Auto Mode and it is followed by time increment in seconds, N-Manual Mode is followed by 0). Remaining fields correspond to the file original name, and date and time of survey line creation. The sample line header is shown below.

```
L   1.00     BV10  N A0.048 031008B    10/03/2008 08:59:25
```

The rows containing data start with the four character sequence (e.g. SV10), meaning of these characters is as follows:

1st S - reading and station,

R - reading, only when more than one reading was taken at one station,

N - start of new segment of the line,

C - comment, the text of comment follows this field.

2nd V - reading with Vertical dipole mode,
H - reading with Horizontal dipole mode.

3rd 0 - no fiducial marker,
1 - fiducial marker pressed at this station (only in Auto Mode),

4th 1 - EM38-MK2 reading,
0 - EM38-MK2-1 reading (only some versions).

Above 4 character field is followed by station number [user units], Conductivity 1m, Inphase 1 m, Conductivity 0.5 m, Inphase 0.5 m, Temperature 1 m, Temperature 0.5 m, and Time Stamp. All columns are separeted by comma. Conductivity 1m represents conductivity taken for 1 m coil separation. If EM38-MK2 is used then fields for 0.5 m coil separations are filled by zeros.

Eaxmple of a line containing EM38-MK2 reading is given below:

```
SV01,  1.000,  117.678, -95.008, 338.521, 0.323, 17.568, 9.176,08:59:26.707
```

All fields (columns) in DAT38MK2 data file are comma delimited.

File may also contain lines started with with **C** that contain field comment (maximum 15 characters).

Reading containing GPS data starts with character $. This character is followed by a standard NMEA GPS messages. For more informations regarding GPS parameters refer to Appendix A of the EM38MK2 manual.

The DAT38MK2 data file can be easily edited using any text editor, however care should be taken on preserving proper placement of all parameters.

Example of DAT38MK2 File

```
EM38-MK2 V1.15 032619A
L   3.00     BV10  N A0.100 032619A    26/03/2008 19:52:21
SV01,     -649.000,    -86.016,     55.430,    302.266,    983.125,     17.568,     18.211,19:52:22.788
SV00,     -648.000,    -85.664,     55.508,    304.102,    984.180,     17.568,     18.211,19:52:22.928
SV00,     -647.000,    -84.180,     56.445,    305.820,    985.664,     17.568,     18.211,19:52:22.997
SV00,     -646.000,    -82.969,     57.227,    308.125,    987.266,     17.568,     18.211,19:52:23.075
SV00,     -645.000,    -81.406,     58.633,    311.523,    989.688,     17.568,     18.211,19:52:23.201
SV00,     -644.000,    -80.430,     60.313,    315.664,    993.125,     17.568,     18.211,19:52:23.278
$GPGGA,023555.00,4336.59339,N,07936.64566,W,2,7,1,140.54,M,-35,M,6,119*54,                 19:52:23.269
SV00,     -643.000,    -77.148,     62.109,    322.422,    998.008,     17.568,     18.211,19:52:23.383
$GPGSA,A,3,,31,29,,16,23,20,,13,06,,,02.5,01.4,02.0*0B,                                    19:52:23.383
SV00,     -642.000,    -74.453,     63.516,    326.914,   1001.484,     17.568,     18.211,19:52:23.464
SV00,     -641.000,    -71.328,     65.000,    334.063,   1007.461,     17.568,     18.211,19:52:23.564
SV01,     -640.000,    -66.719,     68.516,    343.516,   1016.016,     17.568,     18.211,19:52:23.664
SV01,     -639.000,    -62.813,     72.422,    355.039,   1026.602,     17.568,     18.211,19:52:23.751
SV01,     -638.000,    -55.586,     76.328,    367.813,   1037.266,     17.568,     18.211,19:52:23.854
SV01,     -637.000,    -50.508,     80.430,    381.641,   1050.039,     17.568,     18.211,19:52:23.930
SV01,     -636.000,    -41.016,     85.664,    396.563,   1062.617,     17.568,     18.211,19:52:24.031
SV01,     -635.000,    -33.203,     92.148,    413.125,   1078.789,     17.568,     18.211,19:52:24.114
SV01,     -634.000,    -22.148,     99.844,    430.820,   1096.406,     17.568,     18.211,19:52:24.241
$GPGGA,023556.00,4336.59333,N,07936.64579,W,2,7,1,140.09,M,-35,M,4,119*59,                 19:52:24.269
$GPGSA,A,3,,31,29,,16,23,20,,13,06,,,02.5,01.4,02.0*0B,                                    19:52:24.269
SV01,     -633.000,    -12.617,    107.305,    449.766,   1114.336,     17.568,     18.211,19:52:24.363
SV01,     -632.000,     -0.391,    115.352,    468.750,   1132.539,     17.568,     18.211,19:52:24.421
SV01,     -631.000,     11.172,    123.789,    487.461,   1150.977,     17.568,     18.211,19:52:24.529
SV01,     -630.000,     23.281,    133.164,    506.289,   1169.648,     17.568,     18.211,19:52:24.589
SV01,     -629.000,     35.156,    141.953,    524.414,   1188.516,     17.568,     18.211,19:52:24.725
SV01,     -628.000,     46.055,    151.367,    541.406,   1207.617,     17.568,     18.211,19:52:24.792
SV01,     -627.000,     58.242,    160.039,    556.914,   1226.484,     17.568,     18.211,19:52:24.899
SV01,     -626.000,     69.648,    168.711,    571.836,   1243.281,     17.568,     18.211,19:52:25.033
SV01,     -625.000,     78.516,    176.914,    585.430,   1260.859,     17.568,     18.211,19:52:25.081
SV01,     -624.000,     88.438,    185.547,    597.461,   1275.977,     17.568,     18.211,19:52:25.185
$GPGGA,023557.00,4336.59332,N,07936.64580,W,2,7,1,140.28,M,-35,M,4,119*5C,                 19:52:25.267
SV01,     -623.000,     96.289,    192.773,    608.203,   1279.922,     17.568,     18.211,19:52:25.271
$GPGSA,A,3,,31,29,,16,23,20,,13,06,,,02.5,01.4,02.0*0B,                                    19:52:25.271
SV01,     -622.000,    105.938,    199.453,    617.266,   1279.922,     17.568,     18.211,19:52:25.370
SV01,     -621.000,    111.602,    205.430,    624.219,   1279.922,     17.568,     18.211,19:52:25.453
SV01,     -620.000,    116.875,    210.469,    629.102,   1279.922,     17.568,     18.211,19:52:25.565
SV01,     -619.000,    121.289,    215.078,    631.680,   1279.922,     17.568,     18.211,19:52:25.645
SV01,     -618.000,    125.938,    218.984,    633.711,   1279.922,     17.568,     18.211,19:52:25.748
SV01,     -617.000,    128.750,    222.422,    634.297,   1279.922,     17.568,     18.211,19:52:25.857
SV01,     -616.000,    130.078,    225.273,    635.273,   1279.922,     17.568,     18.211,19:52:25.933
SV01,     -615.000,    132.578,    227.305,    635.664,   1279.922,     17.568,     18.211,19:52:26.010
SV01,     -614.000,    133.359,    228.320,    637.578,   1279.922,     17.568,     18.211,19:52:26.135
SV01,     -613.000,    135.664,    228.555,    640.586,   1279.922,     17.568,     18.211,19:52:26.222
$GPGGA,023558.00,4336.59337,N,07936.64580,W,2,7,1,140.35,M,-35,M,5,119*5B,                 19:52:26.267
SV01,     -612.000,    134.063,    227.383,    643.359,   1279.922,     17.568,     18.211,19:52:26.309
$GPGSA,A,3,,31,29,,16,23,20,,13,06,,,02.5,01.4,02.0*0B,                                    19:52:26.309
SV01,     -611.000,    133.203,    224.961,    645.859,   1279.922,     17.568,     18.211,19:52:26.423
SV01,     -610.000,    131.055,    221.680,    646.367,   1279.922,     17.568,     18.211,19:52:26.535
SV01,     -609.000,    128.359,    216.914,    644.531,   1279.922,     17.568,     18.211,19:52:26.593
SV01,     -608.000,    121.992,    211.875,    641.406,   1279.922,     17.568,     18.211,19:52:26.722
SV01,     -607.000,    116.016,    206.875,    635.859,   1279.922,     17.568,     18.211,19:52:26.792
SV01,     -606.000,    109.570,    201.484,    629.258,   1279.922,     17.568,     18.211,19:52:26.877
SV01,     -605.000,    103.125,    196.211,    622.852,   1279.922,     17.568,     18.211,19:52:26.961
SV01,     -604.000,     98.281,    190.352,    616.445,   1279.922,     17.568,     18.211,19:52:27.066
SV01,     -603.000,     93.516,    186.094,    612.266,   1279.922,     17.568,     18.211,19:52:27.203
SV01,     -602.000,     90.430,    184.023,    613.086,   1279.922,     17.568,     18.211,19:52:27.263
$GPGGA,023559.00,4336.59333,N,07936.64571,W,2,7,1,140.29,M,-35,M,4,119*5C,                 19:52:27.288
$GPGSA,A,3,,31,29,,16,23,20,,13,06,,,02.5,01.4,02.0*0B,                                    19:52:27.288
SV01,     -601.000,     89.883,    182.852,    615.352,   1279.922,     17.568,     18.211,19:52:27.355
SV01,     -600.000,     90.664,    181.992,    616.641,   1279.922,     17.568,     18.211,19:52:27.461
SV01,     -599.000,     90.234,    182.539,    620.938,   1279.922,     17.568,     18.211,19:52:27.544
SV01,     -598.000,     91.953,    184.141,    624.805,   1279.922,     17.568,     18.211,19:52:27.625
SV01,     -597.000,     93.984,    184.492,    625.625,   1279.922,     17.568,     18.211,19:52:27.722
SV01,     -596.000,     94.141,    185.430,    625.938,   1279.922,     17.568,     18.211,19:52:27.854
```

B.2 Description of RTmap38MK2 File in ASCII Format

The RTmap38MK2 data file converted to ASCII format is similar to file in DAT38MK2 however it contains additional information related to some parameters that are not supported by DAT38MK2 format. The format of the file is self explanatory.

The file starts with a header block, which starts with the line **RTM38MK2 File Header** and it ends with line **End of file header**. The file header includes: RTmap38MK2 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: S or R. These reading indicators are described in section B.1 of this Appendix. Reading identifier is floowed Dipole Mode (Vertical or Horizontal), and then by six columns: station number, Conductivity for 1.0 m, Inphase for 1.0 m, Conductivity for 0.5 m, Inphase for 0.5 m, 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 originaly recorder NMEA GPS messages or two lines starting with GP and GQ, depending on selection in Convert RTmap38MK2 Data to ASCII Format. 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 RTmap38MK2 File to ASCII Format window.

Examples of RTmap38MK2 files in ASCII format

```
RTM38MK2 File Header  Version W1.04
Positioning: GPS          Distance units: meters
Sensor Type: EM38-MK2  Survey Mode: Auto
External Sensor: None
Data File  : 050215A.TM8
GPS Message   : GGA/GSA
GPS Antenna Position
      GPS X offset: 0.00
      GPS Y offset: 0.00
End of file header

Calibration
    Conductivity  1.0 m:      0.000
    Conductivity  0.5 m:      0.000
    Inphase Vert  1.0 m:      0.000
    Inphase Vert  0.5 m:      0.000
    Inphase Horiz 1.0 m:      0.000
    Inphase Horiz 0.5 m:      0.000
Calibration End

Survey Line      : 0
Start Station    : 0.00
Station Increment: 1.000
Date: 02/05/2008  Time: 15:43:24
S Vertical         0.000    44.727    27.461    25.156    26.484 15:43:26.216
S Vertical         1.000    44.883    16.953    65.273    27.539 15:43:26.325
S Vertical         2.000    55.078    26.719    54.961    27.969 15:43:26.433
S Vertical         3.000    54.883    17.695    45.078    38.047 15:43:26.541
S Vertical         4.000    65.039    18.125    44.961    37.695 15:43:26.650
$GPGGA,171215.00,4336.59410,N,07936.64504,W,2,9,1,141.99,M,-35,M,6,119*56    15:43:26.662
$GPGSA,A,3,29,,26,24,21,18,,15,10,08,06,,02.2,01.3,01.8*01                    15:43:26.662
S Vertical         5.000    44.688    37.422    35.078    27.461 15:43:26.759
S Vertical         6.000    44.766    36.875    55.313    36.641 15:43:26.867
S Vertical         7.000    44.883    27.031    65.156    37.227 15:43:26.975
S Vertical         8.000    35.000    16.992    64.961    27.656 15:43:27.083
S Vertical         9.000    45.078    37.148    45.313    16.875 15:43:27.191
S Vertical        10.000    24.727    37.500    15.234    37.656 15:43:27.299
S Vertical        11.000    44.883    37.031    65.000    18.359 15:43:27.408
S Vertical        12.000    34.844    17.891    15.078    28.281 15:43:27.518
S Vertical        13.000    44.727    17.188    24.844    26.641 15:43:27.627
$GPGGA,171216.00,4336.59462,N,07936.64493,W,2,9,1,141.99,M,-35,M,6,119*56    15:43:27.688
$GPGSA,A,3,29,,26,24,21,18,,15,10,08,06,,02.2,01.3,01.8*01                    15:43:27.688
S Vertical        14.000    34.766    28.008    75.195    36.563 15:43:27.735
S Vertical        15.000    54.805    38.008    35.352    28.359 15:43:27.843
806
$GPGGA,171220.00,4336.59684,N,07936.64452,W,2,9,1,141.99,M,-35,M,6,119*56    15:43:31.816
$GPGSA,A,3,29,,26,24,21,18,,15,10,08,06,,02.2,01.3,01.8*01                    15:43:31.816
S Vertical        52.000   155.625    56.797   115.195    47.891 15:43:31.914
S Vertical        53.000   155.508    48.125   125.352    46.992 15:43:32.023
S Vertical        54.000   165.703    48.008   115.156    37.148 15:43:32.132
S Vertical        55.000   205.781    47.070   115.117    37.344 15:43:32.241
S Vertical        56.000   155.703    47.813   124.805    57.578 15:43:32.350
S Vertical        57.000   175.664    57.461   104.961    37.422 15:43:32.460
S Vertical        58.000   165.547    37.969   115.195    46.914 15:43:32.570
S Vertical        59.000   165.820    57.891   145.078    47.500 15:43:32.680
S Vertical        60.000   195.625    47.031   125.352    37.656 15:43:32.789
```

B.3 RTmap38MK2 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 RTmap38MK2 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 RTM38MK2 (Geosoft Format)

```
// UTM zone = 17, Datum: WGS1984
//Easting[USft],Northing [USft],Q[mS/m]V1.0,I[ppt]V1.0,Q[mS/m]V0.5,I[ppt]V0.5, Elev.[m],Quality, Sat., PDOP,  Time
Line 0
    2008226.774   15844731.470     231.88     -46.14     985.89     -57.63   141.833   2   7   2.20    22:08:56.435
    2008226.794   15844731.601     232.23     -47.12     986.04     -57.78   141.834   2   7   2.20    22:08:56.477
    2008226.817   15844731.752     231.26     -46.96     985.18     -57.24   141.835   2   7   2.20    22:08:56.525
    2008226.837   15844731.900     230.51     -46.81     984.91     -56.14   141.836   2   7   2.20    22:08:56.572
    2008226.860   15844732.051     231.18     -47.04     986.08     -55.67   141.836   2   7   2.20    22:08:56.620
    2008226.882   15844732.202     231.73     -47.51     987.06     -55.52   141.837   2   7   2.20    22:08:56.667
    2008226.905   15844732.353     231.02     -47.90     986.36     -56.81   141.838   2   7   2.20    22:08:56.715
    2008226.925   15844732.500     230.32     -48.06     986.63     -56.42   141.839   2   7   2.20    22:08:56.762
    2008226.948   15844732.648     230.67     -48.41     986.32     -56.22   141.840   2   7   2.20    22:08:56.809
    2008226.971   15844732.799     231.14     -48.14     985.85     -55.79   141.841   2   7   2.20    22:08:56.857
    2008226.991   15844732.950     230.48     -48.45     986.75     -55.48   141.842   2   7   2.20    22:08:56.905
    2008227.014   15844733.101     230.83     -48.41     987.10     -56.45   141.843   2   7   2.20    22:08:56.952
    2008227.037   15844733.248     231.02     -47.39     986.51     -56.45   141.844   2   7   2.20    22:08:56.999
    2008227.060   15844733.399     232.43     -47.16     986.63     -53.95   141.845   2   7   2.20    22:08:57.047
    2008227.079   15844733.547     230.59     -47.47     987.53     -54.77   141.846   2   7   2.20    22:08:57.094
    2008227.102   15844733.698     231.84     -47.55     986.55     -55.44   141.847   2   7   2.20    22:08:57.142
    2008227.125   15844733.845     231.30     -47.16     986.01     -53.99   141.848   2   7   2.20    22:08:57.189
    2008227.145   15844733.996     231.45     -47.47     986.59     -53.88   141.849   2   7   2.20    22:08:57.237
    2008227.168   15844734.147     232.04     -47.63     987.49     -55.75   141.849   2   7   2.20    22:08:57.284
    2008227.191   15844734.298     232.04     -47.20     987.49     -54.23   141.850   2   7   2.20    22:08:57.332
    2008227.214   15844734.154     231.45     -47.20     989.56     -53.99   141.852   2   7   2.20    22:08:57.419
    2008227.220   15844734.570     231.37     -47.24     988.39     -54.11   141.831   2   7   2.20    22:08:57.437
    2008227.234   15844734.685     231.61     -47.31     987.53     -56.96   141.825   2   7   2.20    22:08:57.474
    2008227.250   15844734.836     232.08     -47.31     986.98     -55.95   141.818   2   7   2.20    22:08:57.522
    2008227.270   15844734.984     231.49     -47.51     988.39     -54.50   141.811   2   7   2.20    22:08:57.569
    2008227.286   15844735.131     232.12     -47.24     987.10     -55.59   141.803   2   7   2.20    22:08:57.616
    2008227.302   15844735.282     232.19     -46.73     987.41     -53.45   141.796   2   7   2.20    22:08:57.664
    2008227.322   15844735.430     229.85     -47.59     986.51     -53.49   141.789   2   7   2.20    22:08:57.711
    2008227.339   15844735.581     234.81     -47.86     985.50     -54.46   141.782   2   7   2.20    22:08:57.759
    2008227.355   15844735.729     230.48     -47.55     984.44     -54.38   141.774   2   7   2.20    22:08:57.806
    2008227.375   15844735.879     230.67     -47.86     985.03     -53.88   141.767   2   7   2.20    22:08:57.854
    2008227.391   15844736.027     230.98     -47.63     984.13     -53.52   141.760   2   7   2.20    22:08:57.901
    2008227.407   15844736.178     230.44     -47.63     984.17     -53.95   141.753   2   7   2.20    22:08:57.949
    2008227.427   15844736.326     230.63     -47.78     984.64     -53.29   141.745   2   7   2.20    22:08:57.996
    2008227.444   15844736.477     231.45     -47.63     984.36     -53.99   141.738   2   7   2.20    22:08:58.044
    2008227.460   15844736.624     231.96     -47.86     984.40     -53.45   141.731   2   7   2.20    22:08:58.091
    2008227.480   15844736.775     231.53     -47.71     985.18     -54.42   141.724   2   7   2.20    22:08:58.139
    2008227.496   15844736.923     232.12     -47.78     984.87     -54.07   141.716   2   7   2.20    22:08:58.186
    2008227.512   15844737.070     230.55     -48.41     984.13     -54.81   141.709   2   7   2.20    22:08:58.234
    2008227.532   15844737.218     231.57     -47.16     984.29     -55.63   141.702   2   7   2.20    22:08:58.281
    2008227.571   15844737.546     230.36     -47.98     985.15     -54.38   141.689   2   7   2.20    22:08:58.367
    2008227.604   15844737.782     231.30     -47.78     983.15     -54.58   141.694   2   7   2.20    22:08:58.436
    2008227.614   15844737.835     229.89     -47.90     983.11     -54.77   141.695   2   7   2.20    22:08:58.451
    2008227.624   15844737.907     230.75     -47.35     984.60     -56.38   141.696   2   7   2.20    22:08:58.471
    2008227.647   15844738.068     231.18     -47.00     984.33     -55.83   141.698   2   7   2.20    22:08:58.518
    2008227.670   15844738.235     231.34     -47.47     984.05     -56.26   141.701   2   7   2.20    22:08:58.566
    2008227.696   15844738.399     230.09     -47.47     983.47     -56.42   141.703   2   7   2.20    22:08:58.613
    2008227.719   15844738.566     231.18     -47.67     983.31     -55.79   141.706   2   7   2.20    22:08:58.661
    2008227.742   15844738.730     230.63     -47.28     982.76     -54.85   141.708   2   7   2.20    22:08:58.708
    2008227.765   15844738.898     230.91     -47.71     984.21     -55.28   141.711   2   7   2.20    22:08:58.756
    2008227.791   15844739.062     230.83     -47.43     984.25     -56.06   141.714   2   7   2.20    22:08:58.803
    2008227.814   15844739.226     230.55     -47.94     984.76     -54.85   141.716   2   7   2.20    22:08:58.851
    2008227.837   15844739.390     230.71     -47.63     985.07     -55.17   141.719   2   7   2.20    22:08:58.898
    2008227.860   15844739.557     231.34     -47.82     984.60     -54.31   141.721   2   7   2.20    22:08:58.946
    2008227.886   15844739.721     231.84     -47.35     985.93     -55.36   141.724   2   7   2.20    22:08:58.993
    2008227.909   15844739.889     234.34     -48.06     985.58     -54.62   141.726   2   7   2.20    22:08:59.041
    2008227.932   15844740.053     230.20     -48.21     985.18     -54.70   141.729   2   7   2.20    22:08:59.088
    2008227.959   15844740.220     231.14     -48.29     984.68     -55.87   141.731   2   7   2.20    22:08:59.136
    2008227.982   15844740.381     231.49     -48.02     984.83     -55.83   141.734   2   7   2.20    22:08:59.183
    2008228.005   15844740.545     231.37     -48.60     983.11     -55.24   141.736   2   7   2.20    22:08:59.230
```

Example of XYZ file created by RTM38MK2 (ESAP Format)

1	2008228.72	15844731.18	231.88	985.89
2	2008228.74	15844731.31	232.23	986.04
3	2008228.76	15844731.47	231.26	985.18
4	2008228.78	15844731.61	230.51	984.91
5	2008228.81	15844731.76	231.18	986.08
6	2008228.83	15844731.91	231.73	987.06
7	2008228.85	15844732.06	231.02	986.36
8	2008228.87	15844732.21	230.32	986.63
9	2008228.90	15844732.36	230.67	986.32
10	2008228.92	15844732.51	231.14	985.85
11	2008228.94	15844732.66	230.48	986.75
12	2008228.96	15844732.81	230.83	987.10
13	2008228.98	15844732.96	231.02	986.51
14	2008229.01	15844733.11	232.43	986.63
15	2008229.03	15844733.26	230.59	987.53
16	2008229.05	15844733.41	231.84	986.55
17	2008229.07	15844733.56	231.30	986.01
18	2008229.09	15844733.71	231.45	986.59
19	2008229.12	15844733.86	232.04	987.49
20	2008229.14	15844734.01	232.04	987.49
21	2008229.18	15844734.28	231.45	989.56
22	2008229.17	15844734.34	231.37	988.39
23	2008229.19	15844734.46	231.61	987.53
24	2008229.21	15844734.61	232.08	986.98
25	2008229.22	15844734.75	231.49	988.39
26	2008229.24	15844734.90	232.12	987.10
27	2008229.26	15844735.05	232.19	987.41
28	2008229.28	15844735.20	229.85	986.51
29	2008229.29	15844735.35	234.81	985.50
30	2008229.31	15844735.50	230.48	984.44
31	2008229.33	15844735.65	230.67	985.03
32	2008229.35	15844735.80	230.98	984.13
33	2008229.36	15844735.95	230.44	984.17
34	2008229.38	15844736.09	230.63	984.64
35	2008229.40	15844736.25	231.45	984.36
36	2008229.42	15844736.39	231.96	984.40
37	2008229.43	15844736.54	231.53	985.18
38	2008229.45	15844736.69	232.12	984.87
39	2008229.47	15844736.84	230.55	984.13
40	2008229.49	15844736.99	231.57	984.29
41	2008229.52	15844737.26	230.36	985.15
42	2008229.55	15844737.50	231.30	983.15
43	2008229.56	15844737.55	229.89	983.11

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 RTM38MK2 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 RTM38MK2. The user must specify where parameters needed by RTM38MK2 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 RTM38MK2.

```
-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