

RTM 31

Version 1.17

User's Manual

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Introduction

1

The Geomar RTmap31 Data Logging System consists of a data logging program RTmap31 and associated PC computer program RTM31. The program RTmap31 is designed for the Windows CE based Allegro CX field computer.

The program RTM31 is used to process data files recorded under the control of program RTmap31. It recognizes data file formats created with various versions of RTmap31 automatically.

1.1 About the RTM31

The program RTM31 is a Windows based program for IBM PC compatible computers operating under MS Windows 10/7/XP and Windows 2000. The program RTM31 is designed to process data collected by a field computer under the control of programs RTmap31. The program can be used to position EM31-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 EM31-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 EM31-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 EM31-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 RTmap31: 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 RTM31 also allows you to correct the collected GPS positions with post-processed GPS files.

The RTM31 uses data files in RTmap31 format which have extension name T31. 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 RTmap31 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 RTM31.

One sample RTmap31 data file, 031722B.T31, and one external (postprocessed) GPS file Trext04.txt are included on the program disk. They allow the user to become familiar with running the RTM31 program.

1.2 Contents of RTM31 Distribution Disk

Program RTmap31 software is supplied on one CD disk or USB memory stick. Disk contains following files and directories:

- Setup31R** - setup program for RTM31
- SetupRTmap31** - installation for data acquisition program RTmap31 Windows 10 version (can be also RTmap31wm for Windows Mobile version)
- RTM31.pdf** - manual for RTM31 in pdf format
- RTmap31.pdf** - manual for data acquisition program RTmap31
- Documentation** - directory containing all RTmap31 and RTM31 available RTmap31 manuals, and other Geomar manuals in PDF format.

The Software can be supplied on a CD disk or USB memory stick, or by download from provided link. While downloading files are often named showing their version number, for example Setup31R.exe can be posted as Setup31R_V117.exe to indicate that the setup program contains program RTM31 version 1.17.

1.3 RTM31 Software Installation

RTmap31 software uses a setup program to load files necessary for data processing onto your computer. The following section describes the installation process. To install RTM31: Insert the RTmap31 CD disk or USB stick into computer CD drive (or USB memory drive to USB connector). Alternatively use the SetpRTM31R file in Windows Explorer if the software was downloaded. Exit all Windows applications before installing the program. From the Windows File Manager, select **Run** from the **Windows System** menu (or simply press key Windows + R). The Run dialog box opens (Figure 1.1).

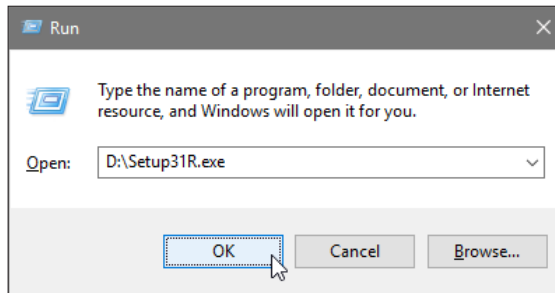


Figure 1.1: Run Dialog window

Alternatively, browse for the file SetupR.exe in the CD disk, USB disk, or Windows folder. Double 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 License Agreement window will be displayed (Figure 1.3).

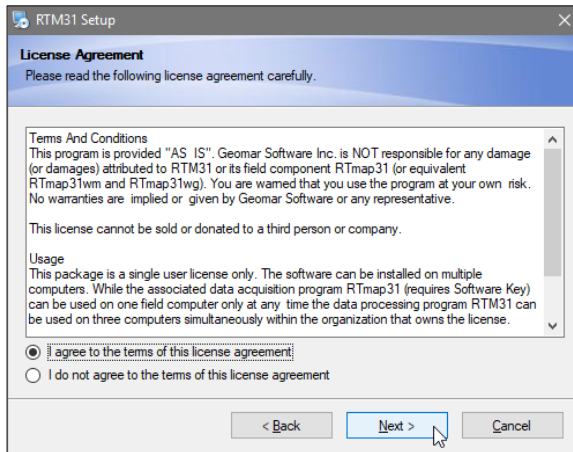


Figure 1.3: License Agreement window

Read the text and click the **Next** button. The Serial Number window will be displayed (Figure 1.4).

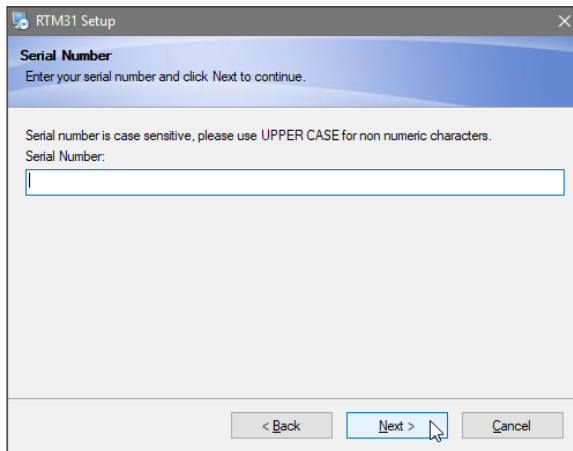


Figure 1.4: Serial Number window

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 1.5).

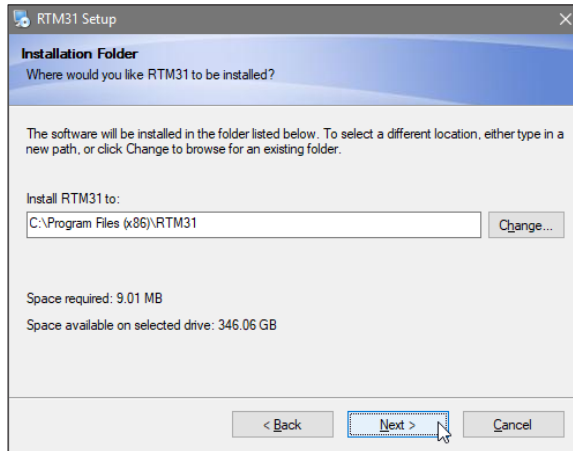


Figure 1.5: *Installation Directory window*

The default directory is C:\Program Files\RTM31. Click the **Next** button to install the program to this directory. If you wish to install RTM31 to another directory, click the **Change** button, and the Select Installation Directory window will open. 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 Shortcut Folder window opens (Figure 1.6).

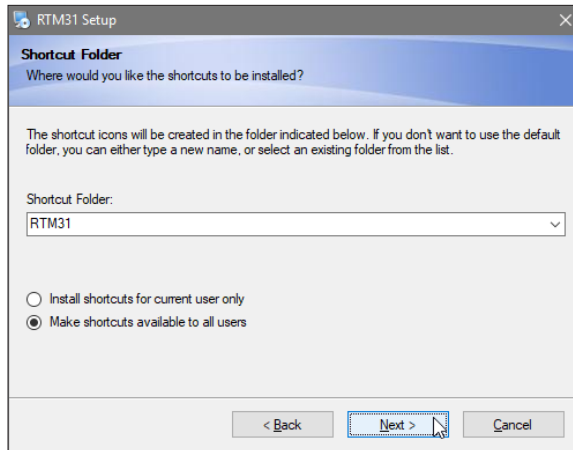


Figure 1.6: *Select Shortcut Folder window*

The setup program will create a RTM31 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).

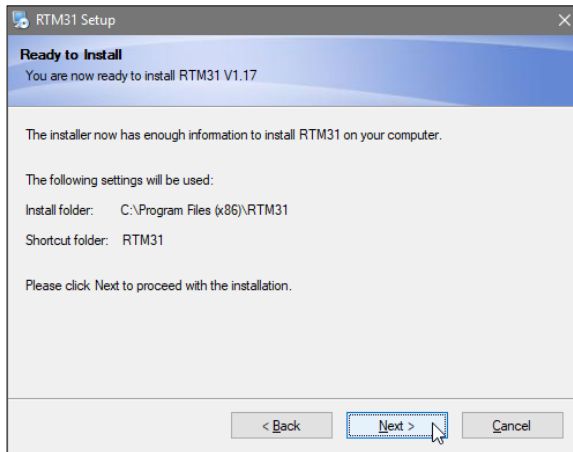


Figure 1.7: Ready to Install window

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. The Installing Files window with a progress bar displays the percentage of the installation completed. When finished, the following window will appear (Figure 1.8).

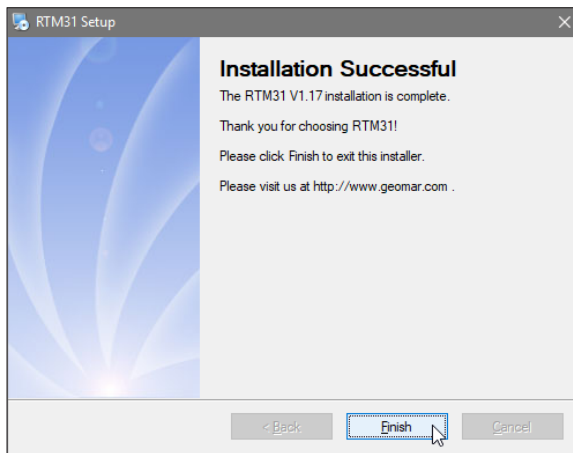


Figure 1.8: Finished window

Click **Finish** to end installation. Setup31R creates a RTM31 program group and places **RTM31** and **Uninstall** icons into it. The setup program creates also a **RTM31** 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.

1.4 Program Overview

Start the RTM31 by double clicking the RTM31 icon in the **Start | Programs** menu, in Windows Explorer, or on the desktop if a shortcut was created. At the start, RTM31 displays the following screen (Figure 1.9):

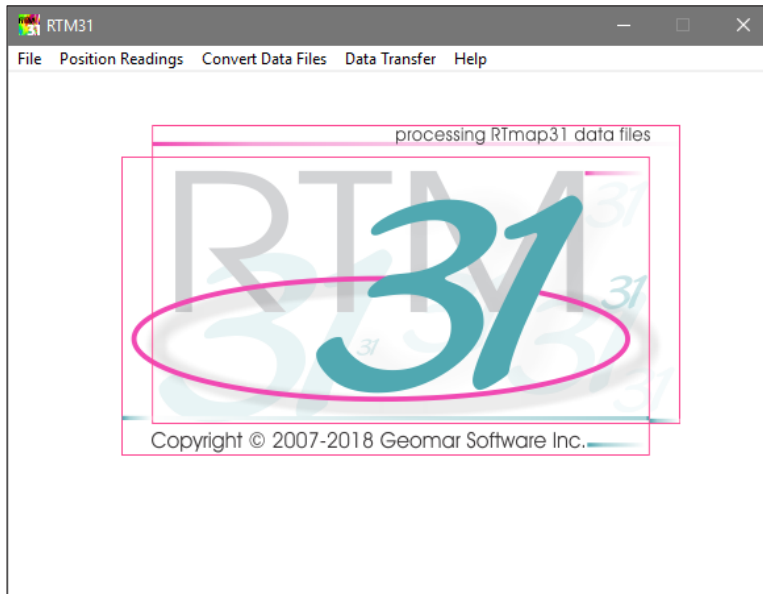


Figure 1.9: RTM31 Main Screen

The RTM31 is a menu driven program. Most of menu 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 1.10. 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.

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 1.11. At the same time remaining items in the File menu are enabled.

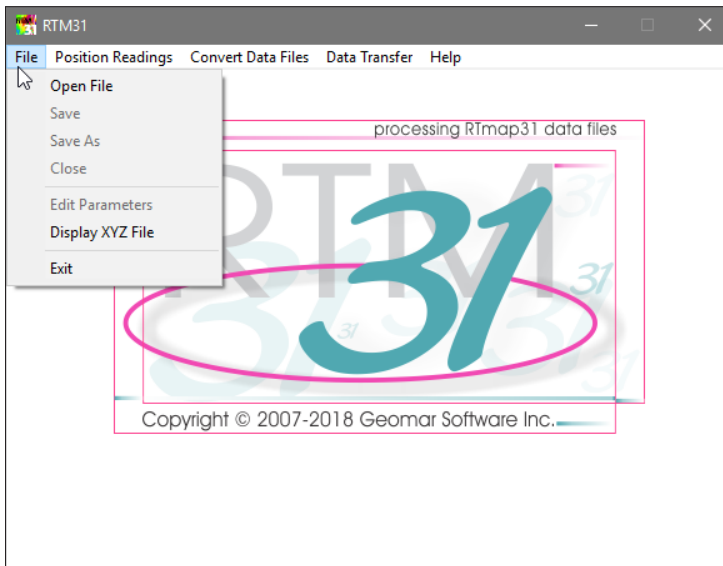


Figure 1.10: RTM31 File menu

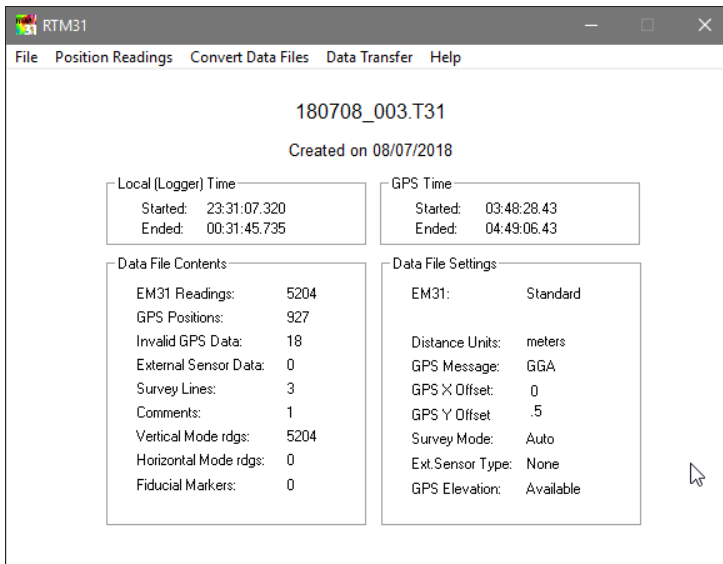


Figure 1.11: RTM31 Main Screen after Loading data file

RTM31 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

other than 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 06/02/2018 as 180602_004.T31".

The information displayed by the RTM31 contains Local and UTC time, number and type of EM31-MK2 data points and GPS positions, number of survey lines, specified distance units and GPS antenna offsets, etc. (see Figure 1.11). Four parameters: Instrument Type, Distance Units, GPS X and Y offsets can be adjusted using the Edit Parameters item (see Figure 1.12).

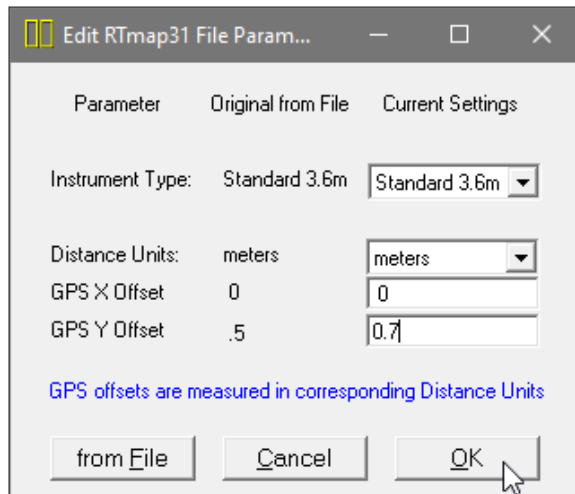


Figure 1.12: Edit Parameters window

Position Readings Menu

The Position Readings menu represents the main function of the program: positioning of the EM31-MK2 (or EM31 RT modified unit) sensor based on the system geometry and GPS positioning (Figure 1.13).

The first item of the menu, Position Sensors using RTmap31 Data File allows you to position sensors based on Real Time GPS data embedded in RTmap31 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 latter requires that the GPS data is collected in the field computer running RTmap31 program as well as in

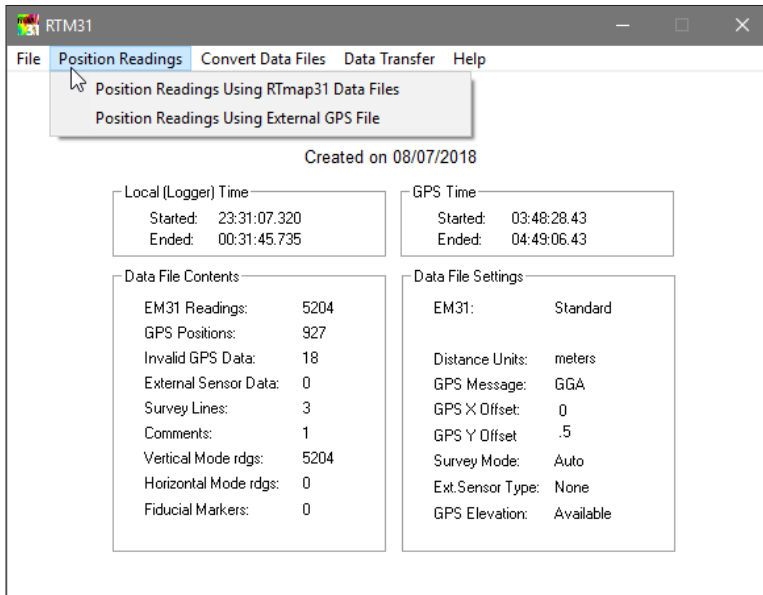


Figure 1.13: RTM31 Position Sensors menu

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 such coordinates are available from GPS manufacturer software (while not available in other employed data processing or mapping software).

Convert Data Files Menu

The Convert Data menu has five functions available. The menu is shown in Figure 1.14.

The first item, RTmap31 Files to Geonics G31 Format allows you to convert RTmap31 data files to files that can be loaded to and processed by the Geonics DAT31W program.

The second item, RTmap31 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.

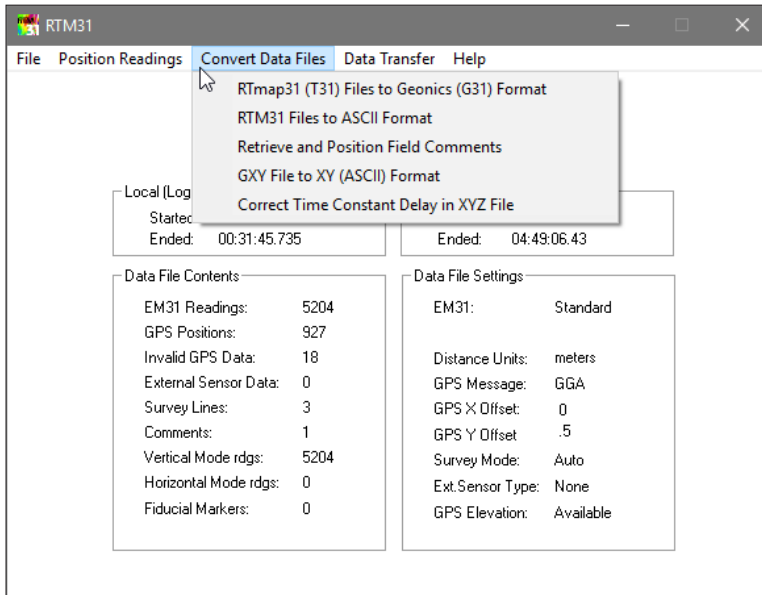


Figure 1.14: RTM31 Convert Data menu

In case when the RTmap31 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 (local time) of each position 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 RTmap31 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 EM31-MK2 and GPS receiver) time constant delay in two dimensional XYZ files generated during positioning EM31-MK2 data.

Data Transfer Menu

This menu has one item only providing information how to download data files. It applies mainly to older field computers (Windows CE and Windows Mobile devices). All data files collected with Windows 7 or Windows 10 computer can be copied and pasted using standard Windows procedures. The menu is shown in Figure 1.15.

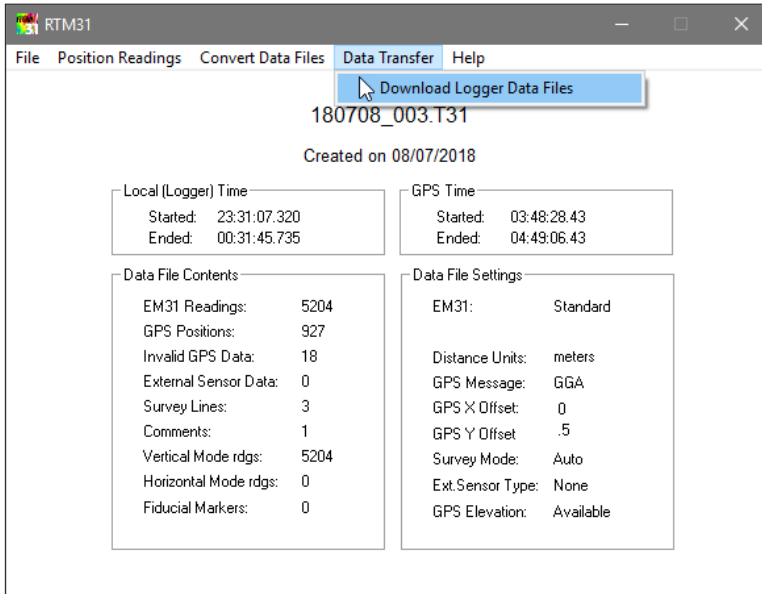


Figure 1.15: RTM31 Data Transfer menu

Windows CE: Transfer of data 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 1.16). Optionally, data files and program files can be transferred between Allegro CX and other computers by using PC memory card.

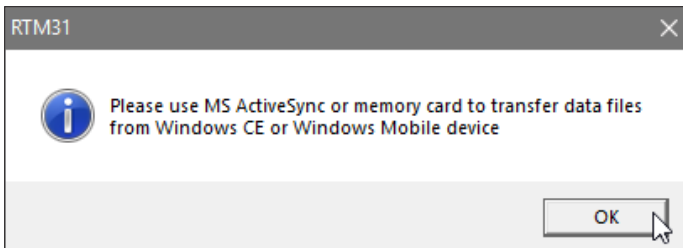


Figure 1.16: Allegro CX data transfer info

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

Windows Mobile: Data files from Archer2 (or similar devices) can be transferred using memory card SD or microSD, or by USB mamory stick (if USB connector iis available).

Help Menu

Item "About" is the only available option in this menu (Figure 1.17). It displays name and version of the program, as shown in Figure 1.18. A dedicated Help function is not available in this version of the RTM31.

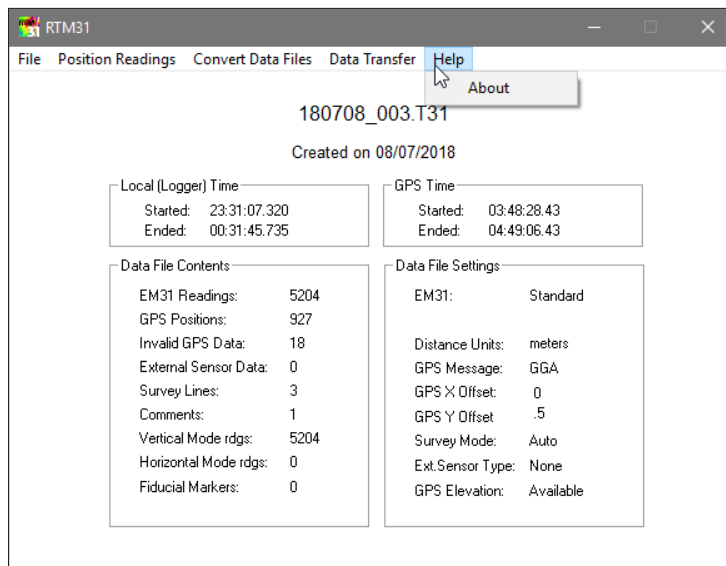


Figure 1.17: RTM31 Help menu

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

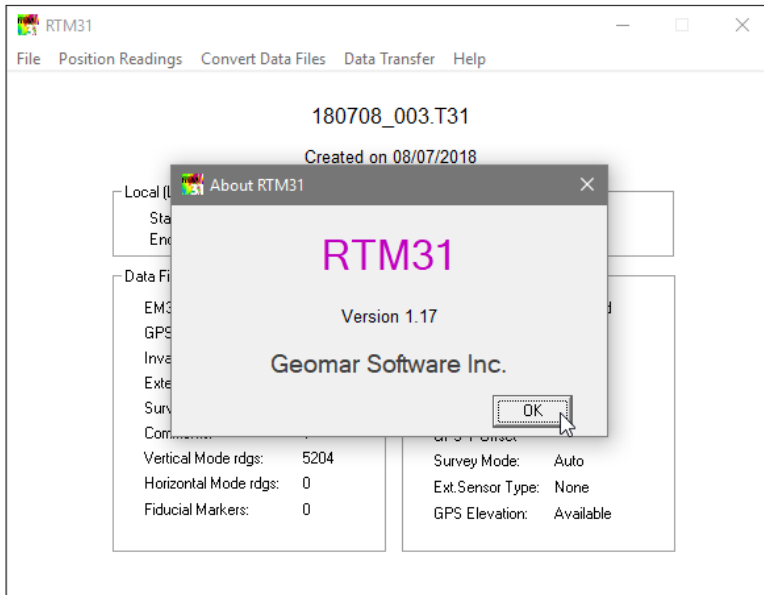


Figure 1.17: About RTM31 window

File Menu

2

File menu of RTM31 program is shown in Figure 2.1. There are several items associated with the File menu:

- Open File (loads RTmap31 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 RTM31 program).

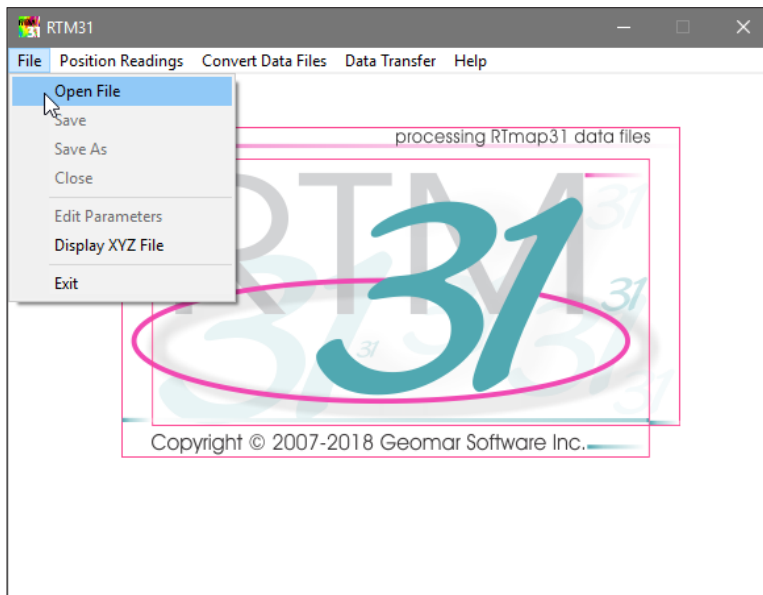


Figure 2.1: RTM31 File menu

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 RTM31 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 RTmap31 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 RTmap31 Input File window will be displayed in the centre of the screen, Figure 2.2.

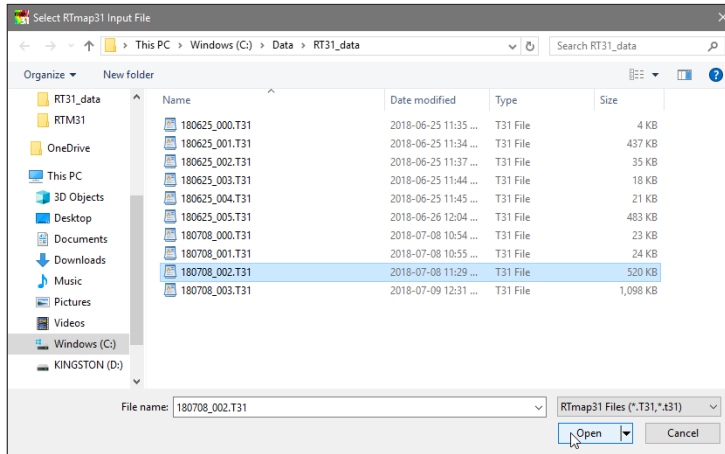


Figure 2.2: Select RTmap31 Input File window

The window lists files with extension name T31. Select a file name and click the **Open** button. The Select RTmap31 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 RTM31 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 EM31 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 EM31 Type (Short or Standard), type of used GPS NMEA message, GPS X and Y offsets (in Distance Units).



Figure 2.3: Progress bar indicating loading the Rmap31 file

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

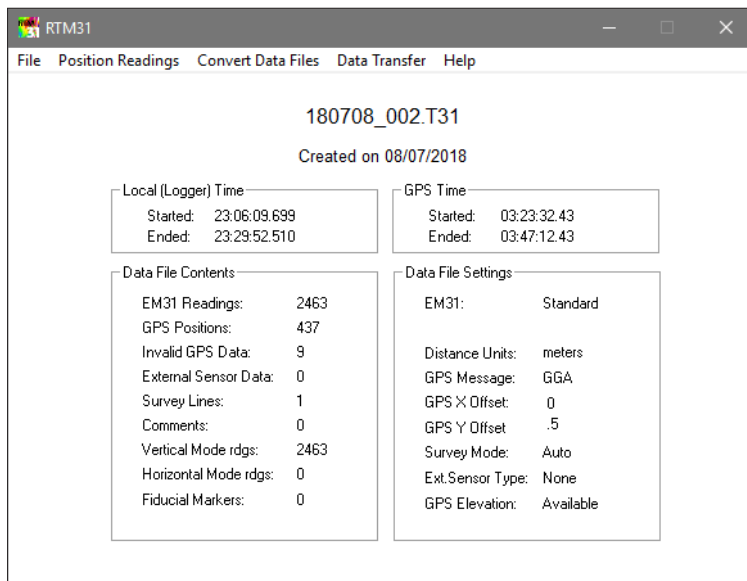


Figure 2.4: RTM31 Main Screen after data file is loaded

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.T31 (Figure 2.5). Otherwise this label would provide only date of the created file (see Figure 2.6).

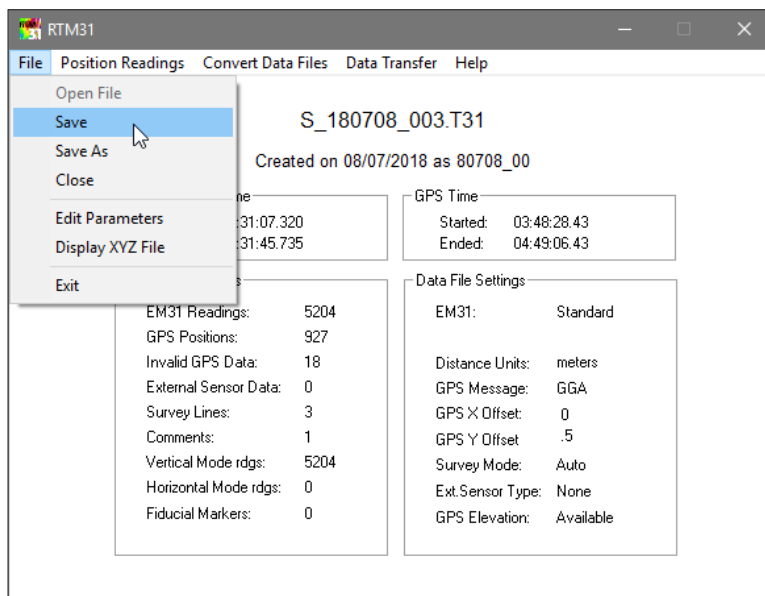


Figure 2.5: RTM31 Main Screen with item Save enabled after not original file was loaded

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, the Save As RTmap31 Input File window will be displayed in the centre of the screen, Figure 2.7.

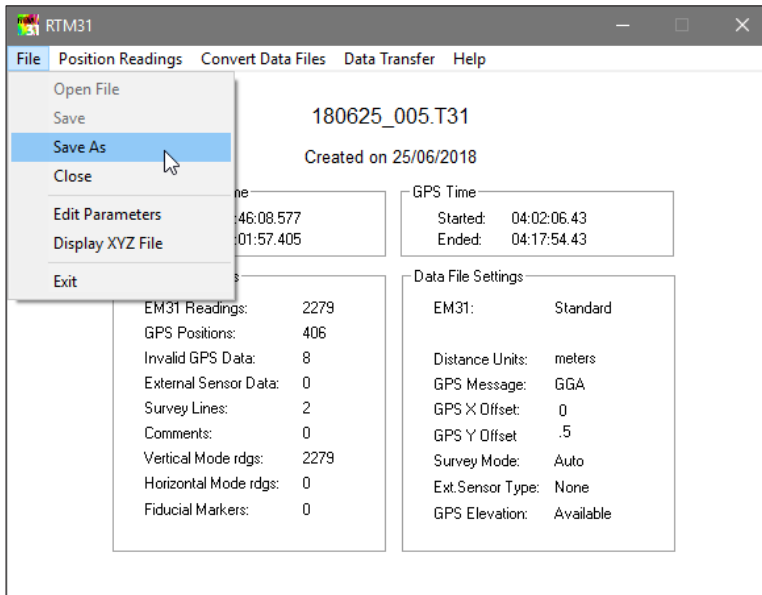


Figure 2.6: RTM31 Screen with loaded original data file, disabled Save option, and selected Save As item

This option is especially useful when data files are loaded several times. Data files created in Windows systems (especially Windows CE and Windows Mobile) may be not

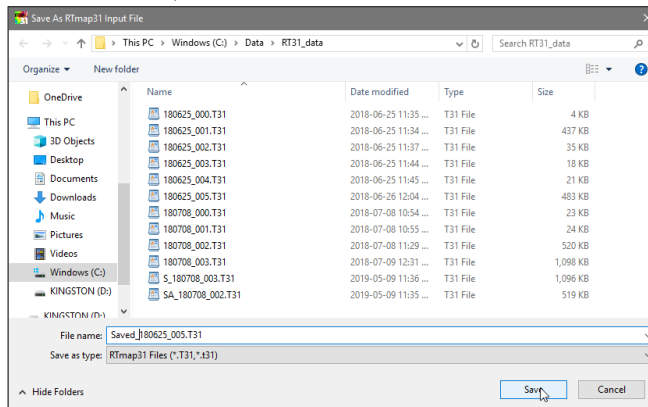


Figure 2.7: Save As RTmap31 Input File window

organized according to time stamp sequence in several places. When such file is loaded, first it is sorted by the program. The option Save As will save data in organized format and additionally checks GPS records integrity, 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 RTM31 will be updated, and file name will be 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).

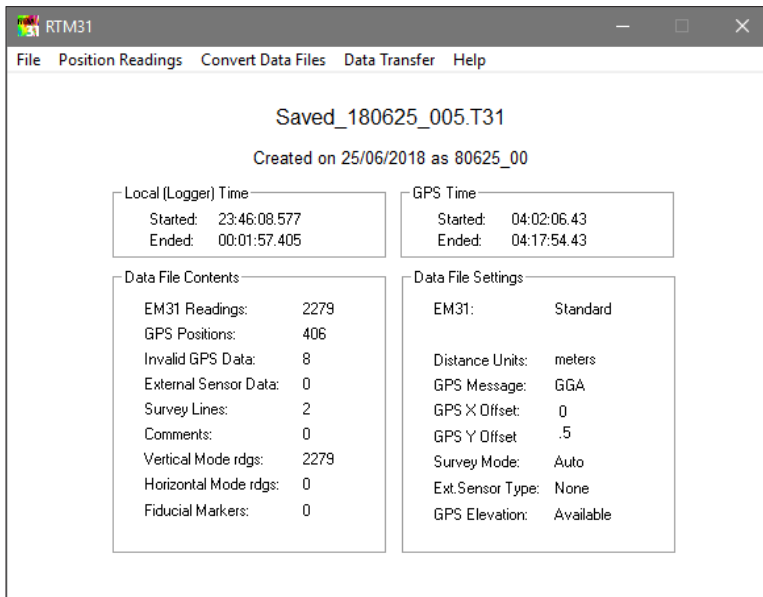


Figure 2.8: RTM31 Main Screen after completed Save As option

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 RTmap31 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 RTmap31 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: EM31-MK2 Type (Short or Standard), 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 Y offsets must be

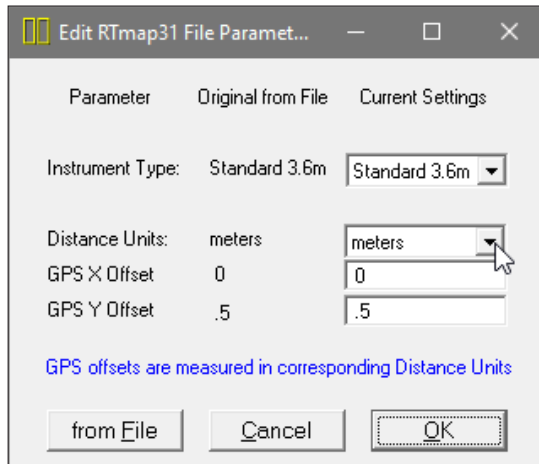


Figure 2.9: *Edit RTmap31 File Parameters window*

entered in appropriate text boxes. Example of RTmap31 File Info window with modified parameters is shown in Figure 2.10.

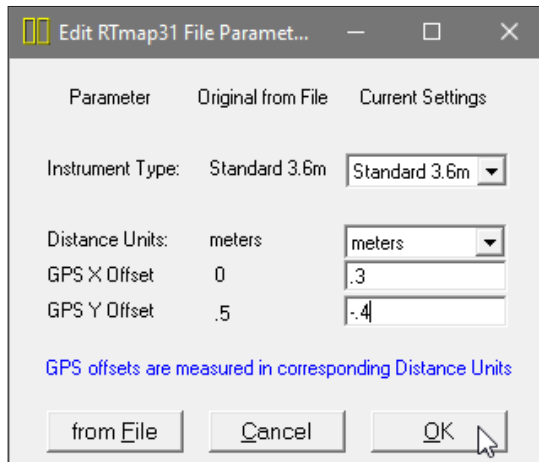


Figure 2.10: *Modified parameters in Edit Parameters window*

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 RTmap31 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.

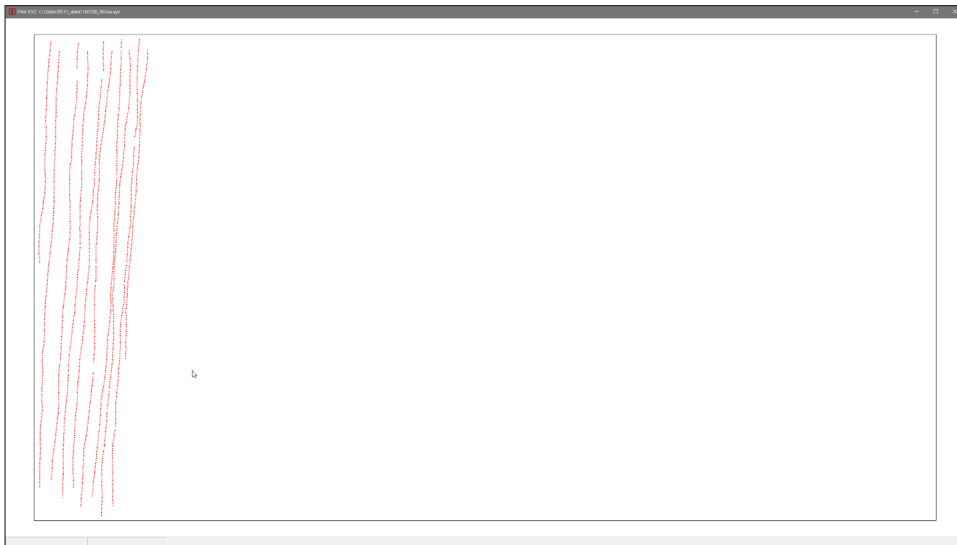


Figure 2.11: Two dimensional layout of stations in XYZ File

Positioning of the Geonics EM31-MK2 sensor is the main function of the RTM31. 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 RTM31: Position Sensors using RTmap31 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 RTmap31 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 RTmap31 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 available in other GPS system (and it cannot be obtained in employed data processing or mapping software).

Description of functions involved in positioning the EM31-MK2 is preceded by a short description of the system geometry.

3.1 The RTmap31 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 EM31-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 EM31-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 EM31-MK2 antenna to the center of the GPS antenna, while facing direction of the movement, see Figure 3.1.

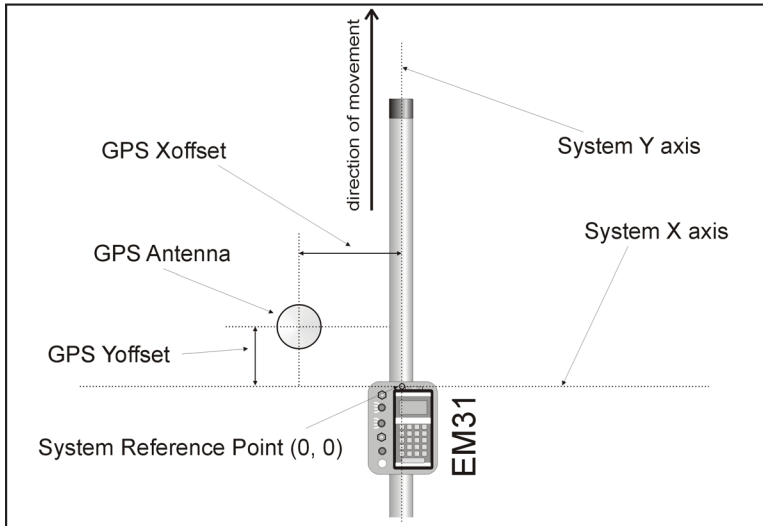


Figure 3.1: The EM31-MK2 and GPS antenna geometry

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 set. Therefore, the operator cannot 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 EM31-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 and the GPS antenna is located on the same trailer or on the towin vehicle (Figure 3.2). It is always advised to make the GPS Y offset as small as possible to achieve better positioning accuracy. The RTM31 calculates positions using advanced interpolation based on time stamps, neighbouring GPS positions, as well as projected EM31 positions along curved lines to achieve positioning as accurate as possible. However, as it was mentioned earlier, the highest accuracy is achieved when the GPS antenna is located above the center of the EM31-MK2 sensor. In case where the GPS antenna is located in front of the

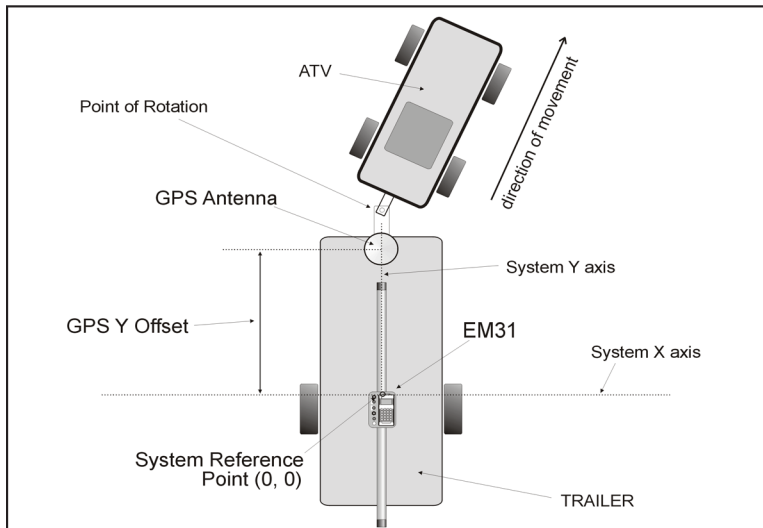


Figure 3.2: Geometry of the EM31-MK2 sensor and GPS antenna during towing

electromagnetic sensor the GPS Y Offset is positive, and if the GPS antenna is located behind the instrument the GPS Y Offset is negative.

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 RTM31.

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 including neighbouring points, instant heading, and projection of neighbouring calculated sensor positions. 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. Pausing readings while the system is stopped will save time during data processing and will result in better data presentation.

3.2 Positioning Readings Using RTmap31 Data File

After a data file is loaded the RTM31 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 EM31-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.

The Position Readings Using RTmap31 Data option allows you to position EM31-MK2 stations based on Real Time GPS data which were recorded in RTmap31 data file during the survey. Select **Position Sensors | Position Readings Using RTmap31 Data Files** from the main program menu, as shown in Figure 3.3.

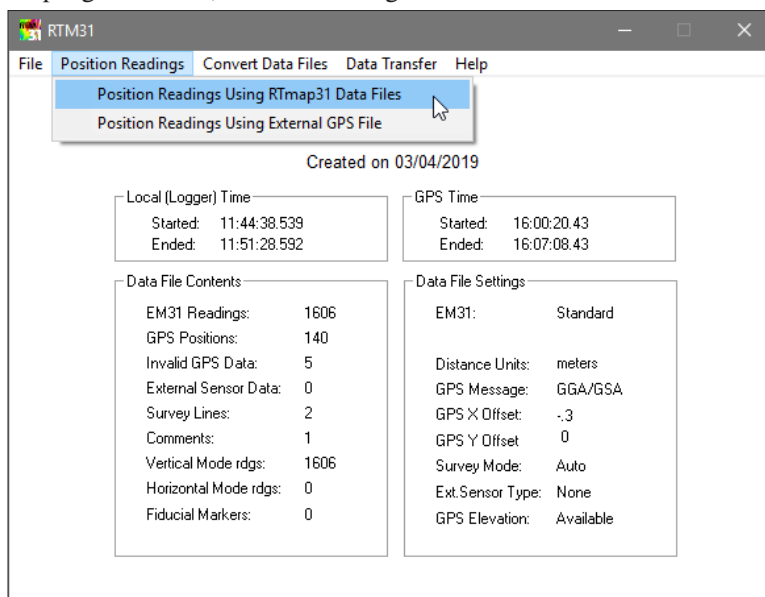


Figure 3.3: Position Readings menu

After the selected menu item is clicked the Position EM31-MK2 Readings Using RTmap31 Data File window will be displayed in the centre of the computer screen, Figure 3.4.

Parameters in Positioning Readings Using RTmap31 Data File Window

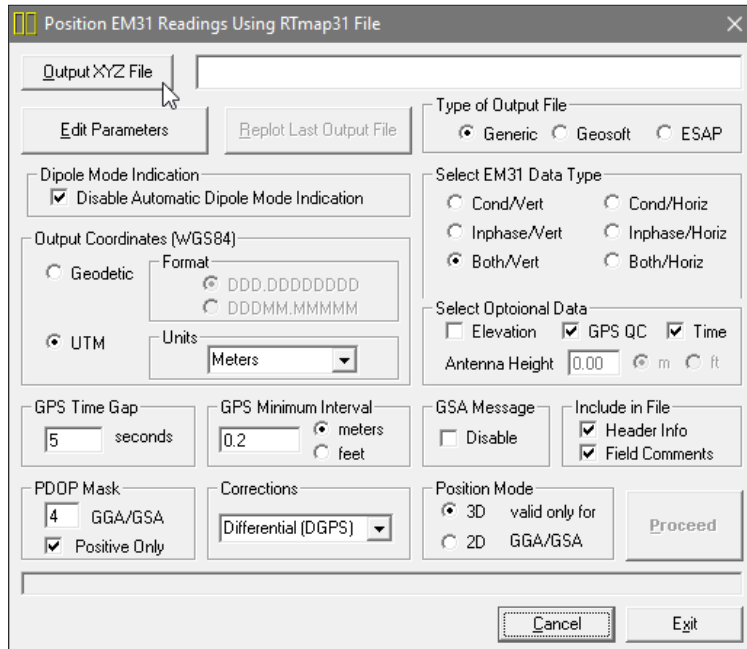


Figure 3.4: Position EM31-MK2 Readings Using RTmap31 Data File window

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 RTM31 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 RTM31 main screen). Click on the **Edit Parameters** button and Edit RTmap31 File Parameters window will appear (Figure 3.5).

The window displays parameters that the user can edit. These are: the EM31-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

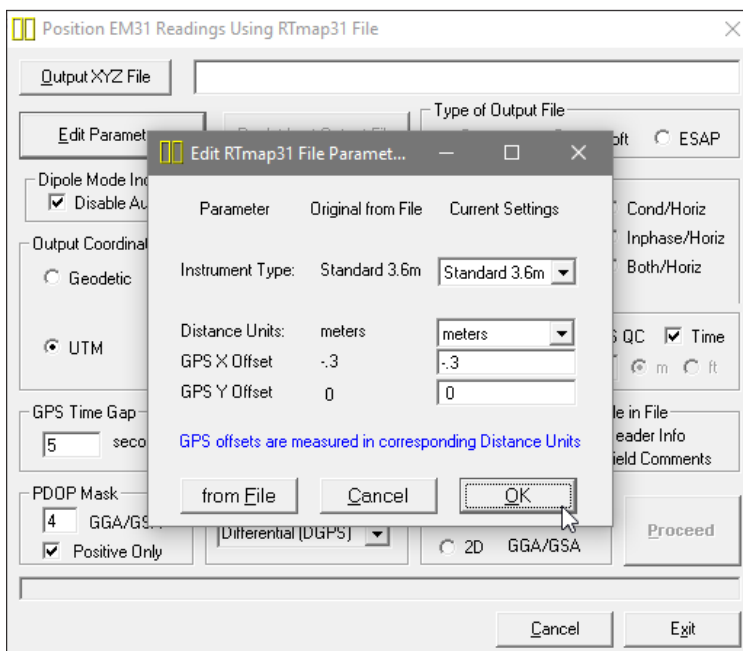


Figure 3.5: Edit RTmap31 File Parameters window

these entries. In case some of the parameters require modification they can be entered in appropriate text boxes located under label Current Settings. EM31-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 RTmap31 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 RTmap31 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.

Output File

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

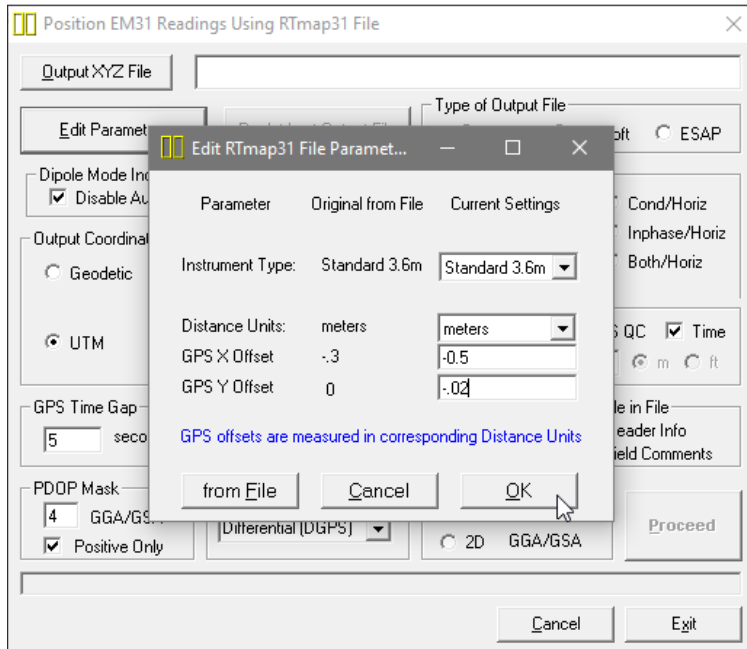


Figure 3.6: Modified parameters in Edit Parameters window

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 EM31-MK2 Readings Using RTmap31 File window.

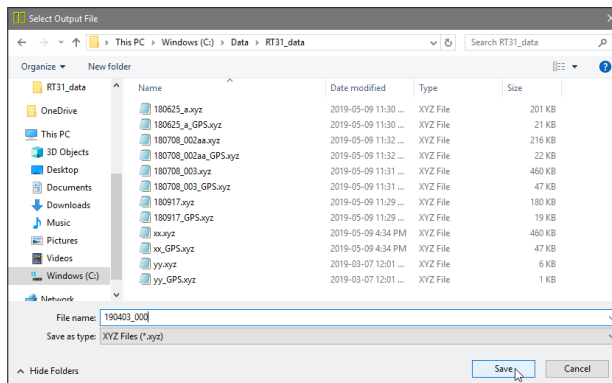


Figure 3.7: Select Output File window

When Output file is specified the **Proceed** button in the Position EM31-MK2 Readings Using RTmap31 File becomes active (Figure 3.8).

EM31-MK2 Data (Both Components) (Select EM31-MK2 Data Type)

To select a data type (component and dipole mode) click on desired radio buttons labeled **Cond/Vert**, **Inphase/Vert**, **Both/Vert** for vertical dipole mode, and similarly for Horizontal dipole mode **Cond/Horiz**, **Inphase/Horiz**, **Both/Horiz**. Data is always placed in the created XYZ file in the following order: X coordinate (Easting or Longitude), Y coordinate (Northing or Latitude), and selected component for selected dipole mode. If data type containing separation "Both" was selected (Both/Vert or Both/Horiz) then the order is Conductivity and Inphase for selected dipole mode. 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 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 EM31-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 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.

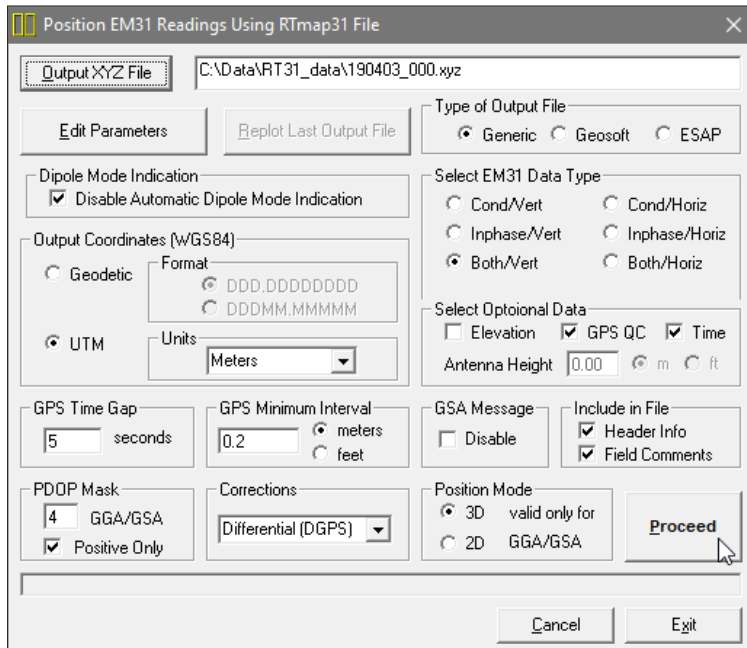


Figure 3.8: Position EM31-MK2 Readings Using RTmap31 Data File window

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), EM31-MK2 data type (as selected, 1 or 2 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 RTM31 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.DDDDDDDDD 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.

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 RTM31 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 EM31-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 5 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. 999 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 EM31-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 RTM31 will calculate positions of sensor in case offset values (GPS X and/or GPS Y Offsets) are different than zero, positions of the EM31-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 (RTmap31) that the GPS Message will be pair GGA/GSA and for any reason message GSA was not recorded. In such case the RTM31 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. Recent versions of the program detect presence of GSA statement automatically.

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 GSK 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 EM31-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 so on till **Differential (RTK 9)**. All but two first types of corrections RTK (real time kinematic) are available in higher end of GPS receivers and differently named depending on manufacturer, however in NMEA specifications they indicate Quality Parameter 3, 4, 5, and so on. When **Raw** is selected, both differentially corrected and raw GPS data are used to calculate positions of EM31-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 RTM31.

Creating XYZ Files With Positioned Readings

When all parameter are set and output file name is specified, the **Proceed** button is activated in the Position Readings Using RTmap31 File window. After you click the **Proceed** button, the program begins to filter loaded data, calculates EM31-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).

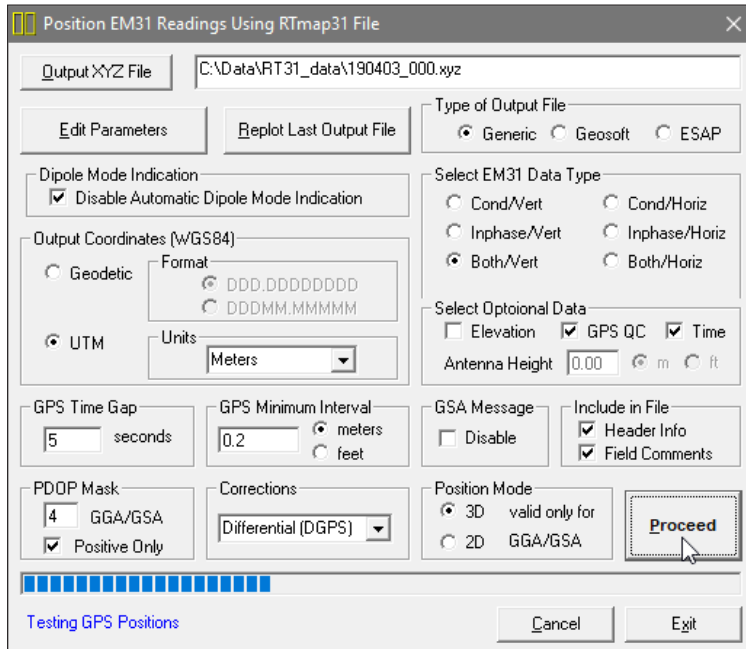


Figure 3.9: Position EM31-MK2 Readings Using RTmap31 File window during creating XYZ file

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 EM31-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).

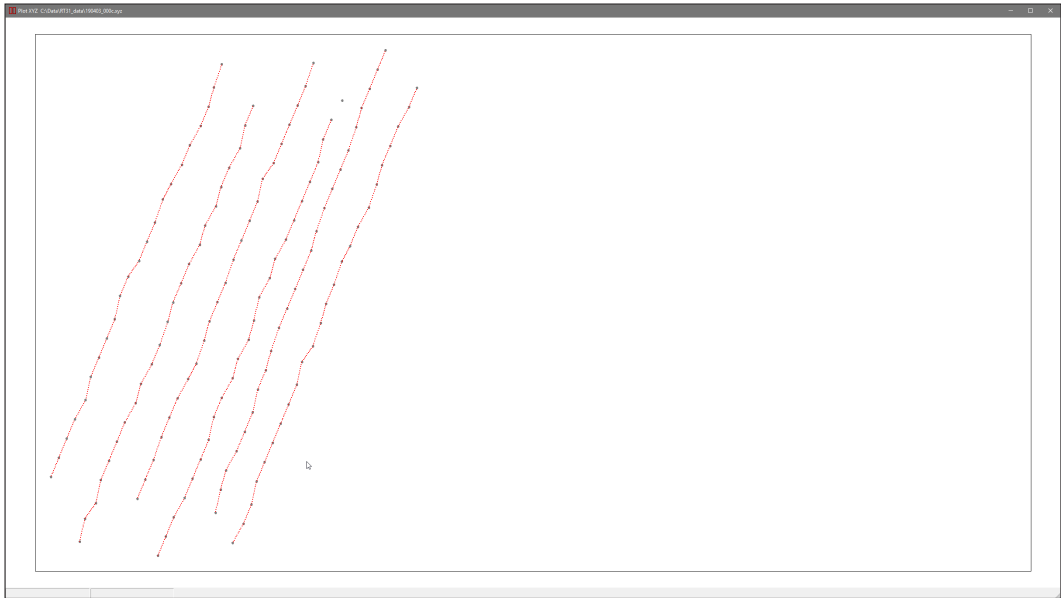


Figure 3.10: Two dimensional layout of stations taken with the Geonics EM31-MK2. The GPS X and Y offsets were set to zero (GPS antenna was located above the center of the EM31-MK2 sensor).

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 RTmap31 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.

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

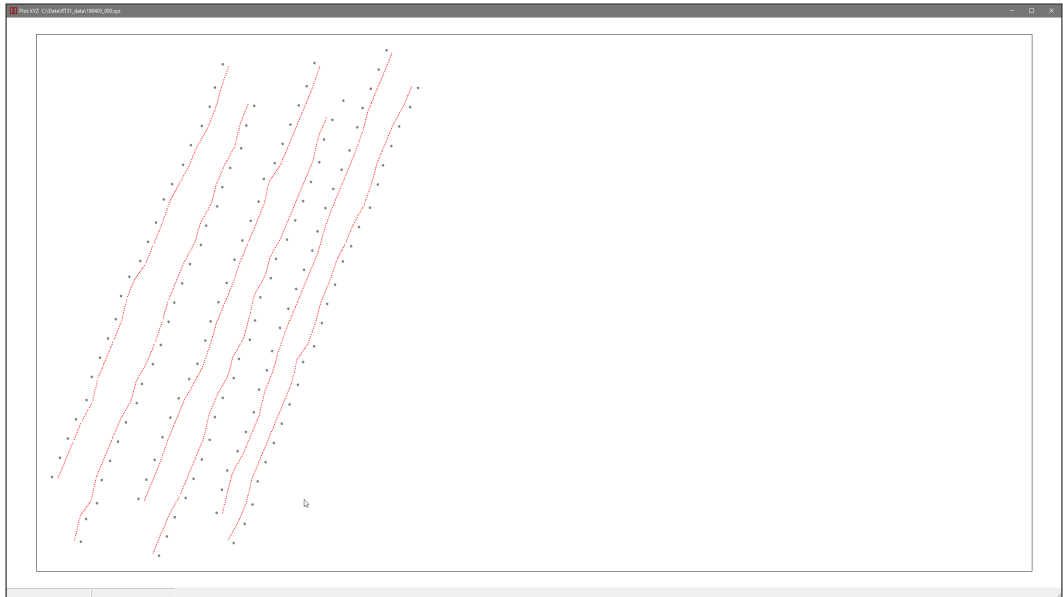


Figure 3.11: Two dimensional layout of stations taken with the EM31-MK2. The GPS antenna location: GPS X Offset = -0.6 m and GPS Y Offset = 0.00 m (the first W line was surveyed in N direction).

(check Disable GSA Message), raw positions only when Differential button is checked, too small value specified in GPS Time Gap section, not existing EM31-MK2 channels specified in Select Data section, etc..

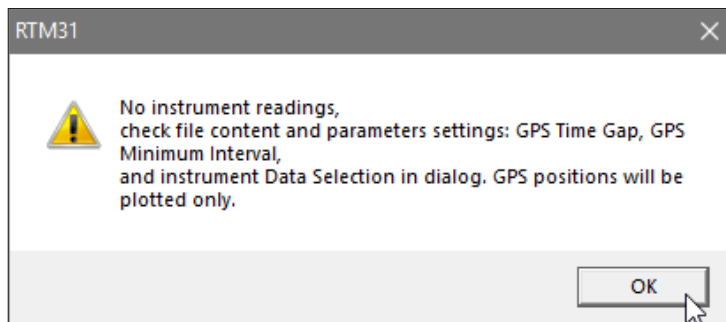


Figure 3.12: Warning window

3.3 Positioning Readings Using External GPS File

After a data file is loaded the RTM31 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 EM31-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 EM31-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 RTmap31 program during the survey. Select **Position Sensors | Position Readings Using External GPS File** from the main program menu, as shown in Figure 3.13.

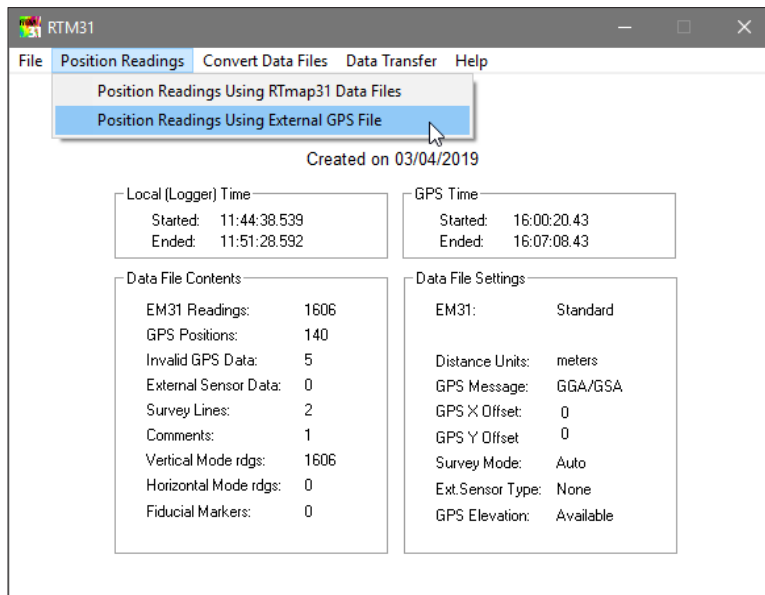


Figure 3.13: Position Readings menu

After the selected menu item is clicked the Position EM31-MK2 Readings Using External GPS File window will be displayed in the centre of the screen, Figure 3.14.

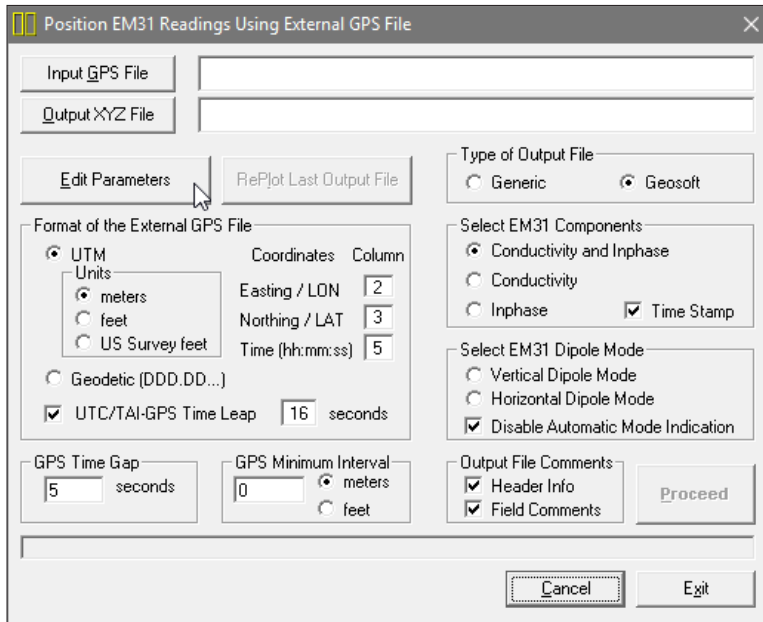


Figure 3.14: Position EM31-MK2 Readings Using External GPS File window

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 RTM31 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 RTM31 main screen). Click on the **Edit Parameters** button and Edit RTmap31 File Parameters window will appear (Figure 3.15).

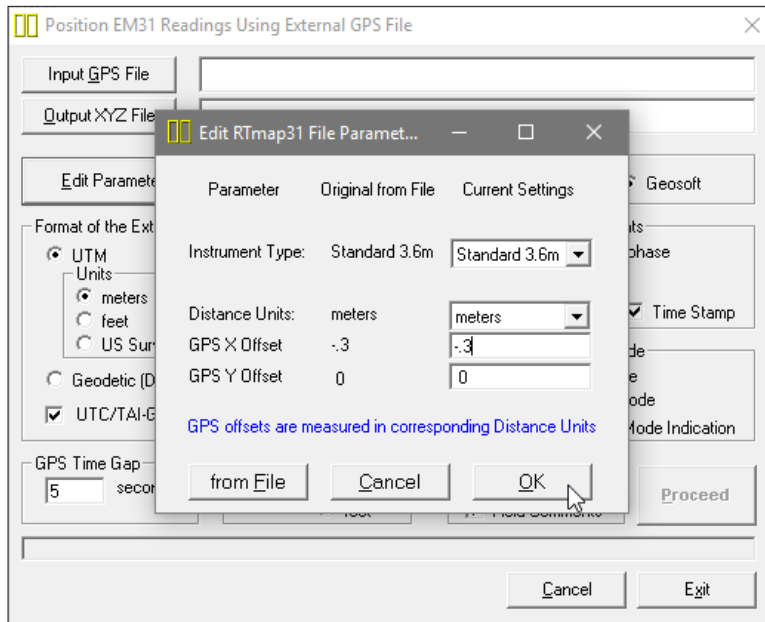


Figure 3.15: Edit RTmap31 File Parameters window

The window displays parameters that the user can edit. These are: the EM31-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 RTmap31 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 RTmap31 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.

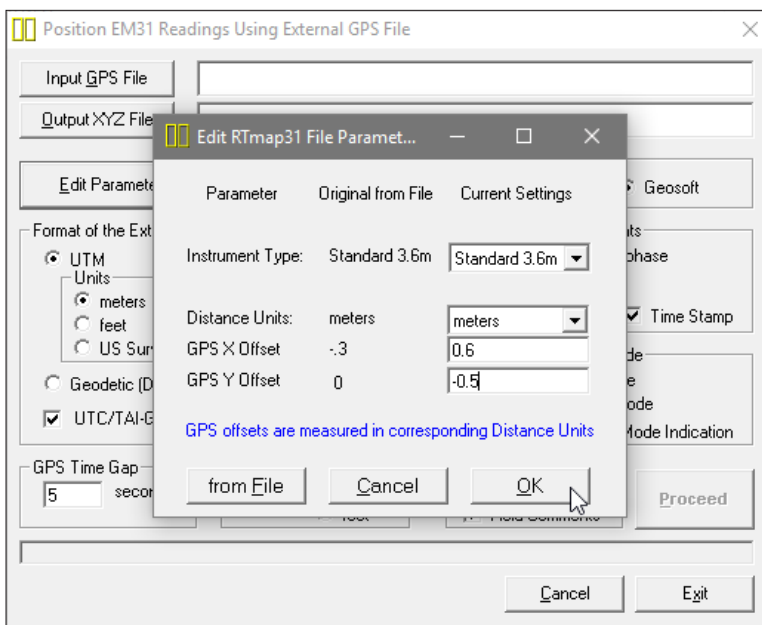


Figure 3.16: Modified parameters in Edit Parameters window

Input GPS File

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

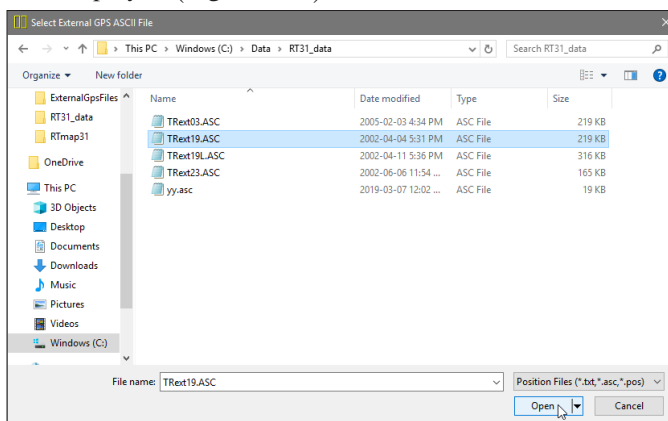


Figure 3.17: Select External GPS File window

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).

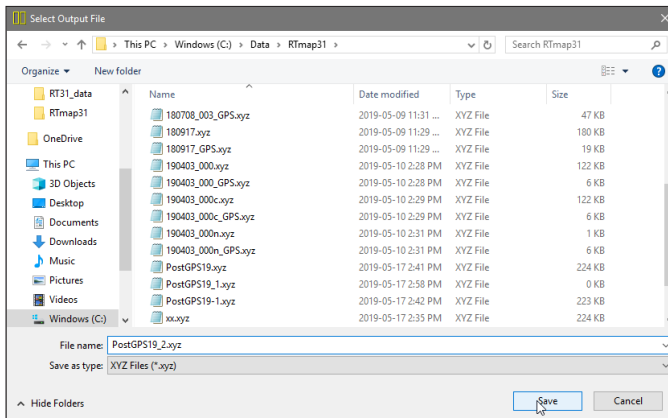


Figure 3.18: Select Output File window

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 RTmap31, Input GPS and Output files are specified the **Proceed** button in the Position EM31-MK2 Readings Using External GPS File becomes active (Figure 3.19).

Select EM31 Components and Select EM31 Dipole Mode

To select a data type (component and dipole mode) click on desired radio buttons labeled **Conductivity and Inphase**, **Conductivity**, or **Inphase** in the Select EM31 Component section and click on one of the radio buttons labeled **Vertical Dipole Mode** or **Horizontal Dipole Mode** in the section Select EM31 Dipole Mode section. Both components Conductivity and Inphase are given as a 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 selected component. If data type containing both components was selected (**Conductivity and Inphase** in the Select EM31 Components section) then the order is as follows: coordinates (as above), and Conductivity and Inphase for se-

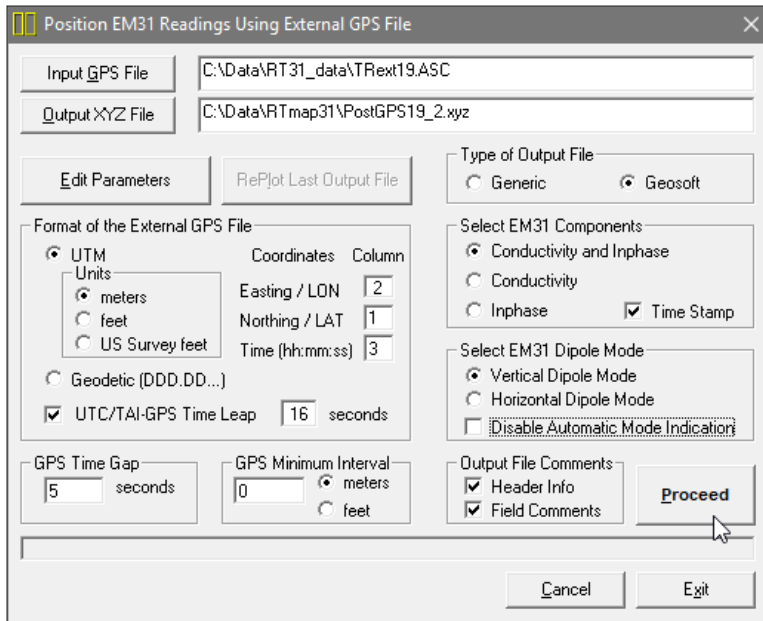


Figure 3.19: Position EM31-MK2 Readings Using External GPS File window

lected dipole mode. This data may be followed by one more columns containing Time Stamp if this option is selected (checkbox button located in the EM31-MK2 Separations section).

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 EM31-MK2 Dipole Mode section the program will ignore reading dipole mode tags and it will write all data (within selected components) in XYZ file, regardless dipole mode selection in the Select EM31-MK2 Dipole Mode 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 RTM31 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 EM31-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 3 to 5 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. 900 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 EM31-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 RTM31 will calculate positions of sensor in case offset values (GPS X and/or GPS Y Offsets) are

different than zero, positions of the EM31-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 RTM31 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 3.19). 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 RTM31. 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 3.19). 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 must be checked and value in seconds (default is 16s) specified if your GPS software is using Satellite Time to time stamp positions. NMEA messages, and therefore RTmap31 data file contains UTC time as a time of GPS reading. In most cases, if GPS logger is used to save data the Satellite Time is used. Please refer to your GPS software manual. Currently difference between UTC and Satellite clocks is 16 seconds.

Creating XYZ Files With Positioned Readings

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 EM31-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 procedure.

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 3.20).

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 EM31-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).

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 RTmap31 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 3.21 where GPS antenna location was changed as compared to case shown in Figure 3.20.

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.

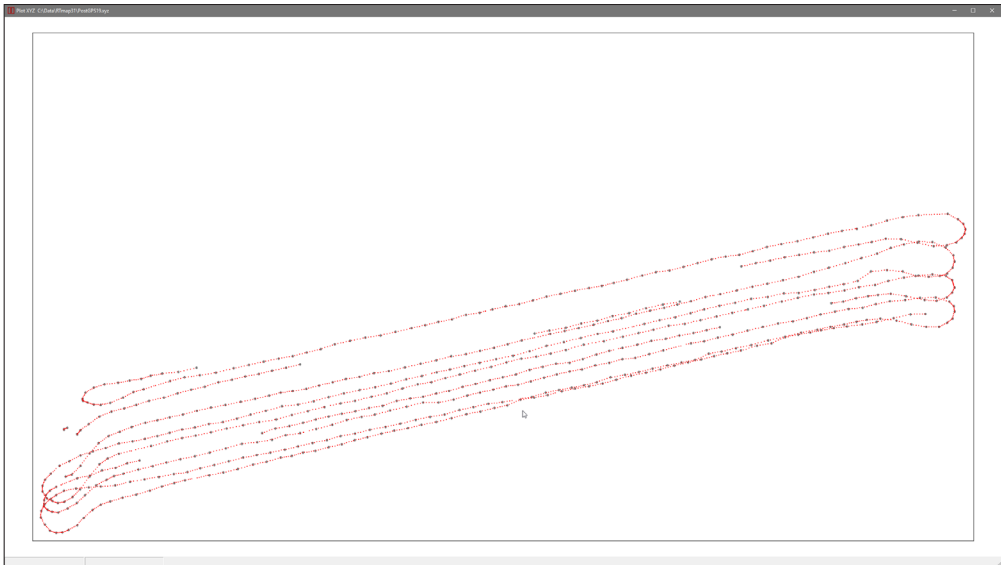


Figure 3.20: Two dimensional layout of stations taken with the Geonics EM31-MK2 and GPS. The GPS antenna was located above the center of the EM31-MK2 sensor (GPS X and Y offsets are set to zero).

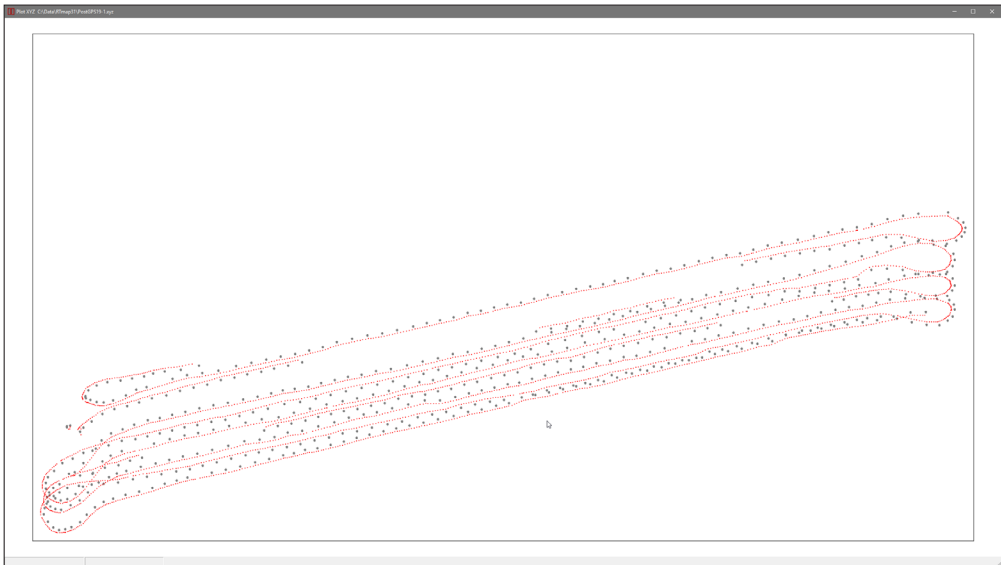


Figure 3.21: Two dimensional layout of stations taken with the Geonics EM31-MK2 and GPS. The GPS antenna was located off the center of the EM31-MK2 sensor (GPS X offset = 1.0 m and GPS Y offset = 0).

Convert Data Files

4

Convert menu of RTM31 program allows you to convert the RTmap31 binary file to other formats. There are five items associated with the Convert menu (Figure 4.1):

- convert RTmap31 file to Geonics DAT31W (.G31) format,
- convert RTmap31 file to general format ASCII file,
- retrieve and position field comments from RTmap31,
- convert GXY file to ASCII file containing positions,
- correct system time constant delay in XYZ files.

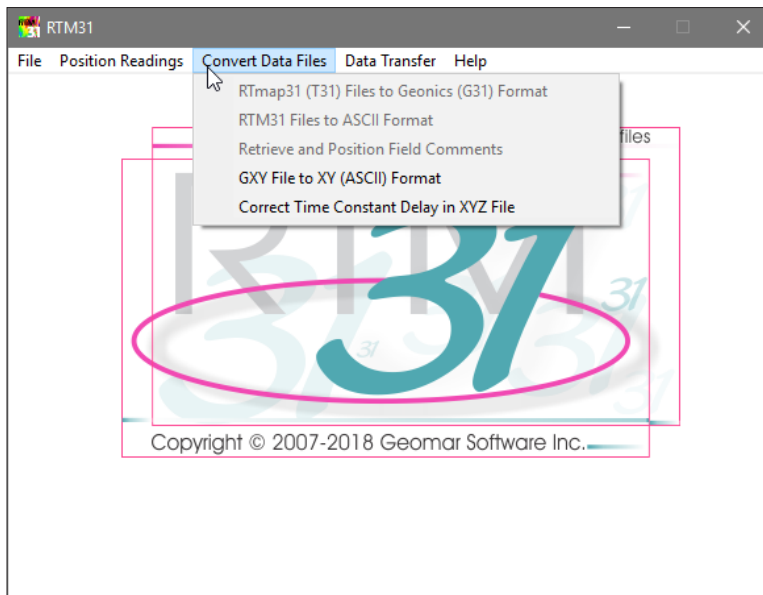


Figure 4.1: Convert Data Files menu

Files converted to Geonics G31 format can be further processed by the Geonics DAT31W program, while files converted to general ASCII format can be easily reformatted and used by other software. While retrieving comments from RTmap31 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 RTmap31 data file is loaded in File menu (Figure 4.2).

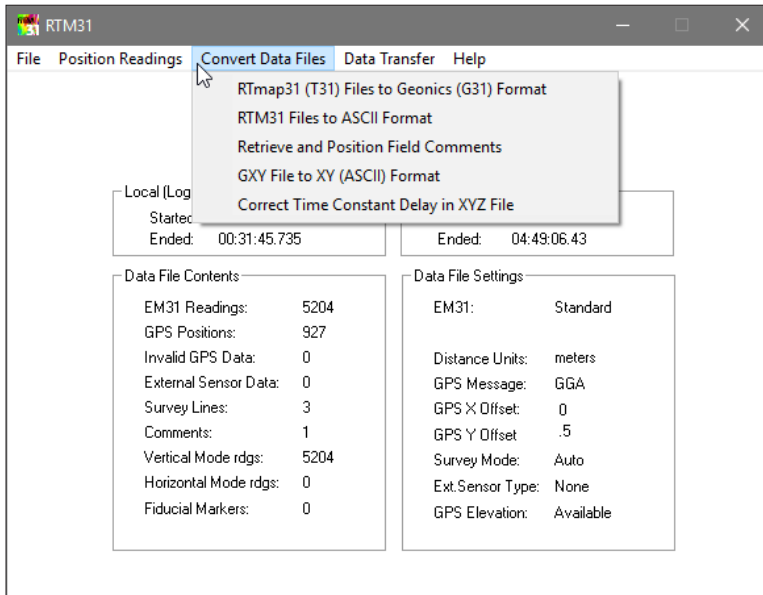


Figure 4.2: Convert Data Files menu after RTmap31 file is loaded to the program

Selected examples of file formats created by RTM31 are given in Appendix B of this manual.

4.1 Convert RTmap31 Data to Geonics DAT31W (G31) Format

The Convert RTmap31 to Geonics G31 Format option allows you to convert RTmap31 files to Geonics DAT31W format. Select **Convert | RTmap31 to Geonics G31 Format** from the main program menu, as shown in Figure 4.2.

After the selected menu item is clicked the Convert RTmap31 Files (T31) to Geonics G31 Format window will be displayed in the centre of the screen, Figure 4.3.

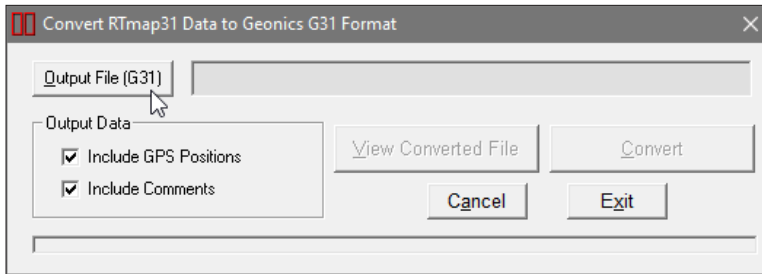


Figure 4.3: Convert RTmap31 Files to Geonics G31 Format

Parameters in Convert RTmap31 Data to Geonics G31 Format Window

Several parameters which affect the contents and format of the created output (G31) 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 (G31)

Click on the **Output File (G31)** button. The Select Output File window is displayed (Figure 4.4).

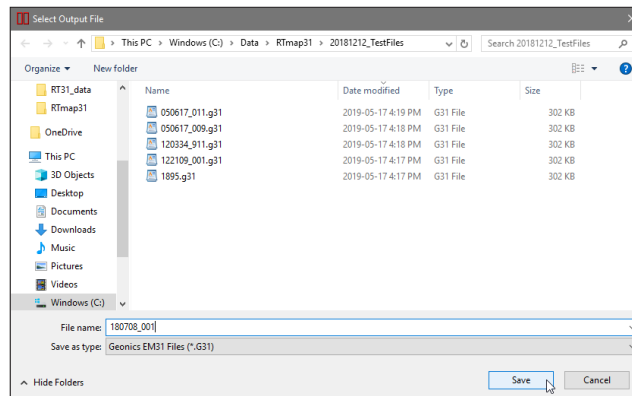


Figure 4.4: Select Output File window

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 (G31)** button in the Convert RTmap31 to Geonics G31 Format window.

When Output file is specified the **Convert** button in the Convert RTmap31 to Geonics G31 Format window becomes active.

Output Data

RTM31 can generate a file with EM31-MK2 data as recorded by RTmap31 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 DAT31W format regardless which GPS message was used during the survey.

Converting RTmap31 Data to Geonics DAT31W (G31) Format

When all parameters are set and input and output file names are specified, the **Convert** button is activated in the Convert RTmap31 File to Geonics G31 Format window. After you click the **Convert** button, the program begins to read the input file, converts data to DAT31W 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).

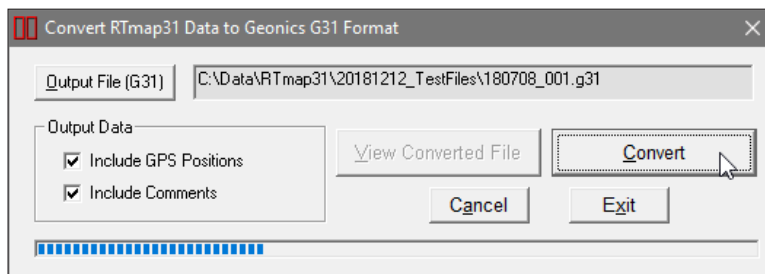


Figure 4.5: Convert RTmap31 Files (T31) to Geonics G31 Format window during data processing

The speed of this operation depends on the size of the input file. After the output (G31) 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 DAT31W 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 (G31)** button. Click on **Exit** button to close the Convert RTmap31 Files (T31) to Geonics G31 Format window.

An example of data file in Geonics DAT31W (G31) format is given in Appendix B.

4.2 Convert RTmap31 Data to ASCII Format

The Convert RTmap31 Data to ASCII Format option allows you to convert RTmap31 binary files to ASCII format, which can be viewed with any text editor and then easily converted to the other format. Select **Convert | RTmap31 to ASCII Format** from the main program menu, as shown in Figure 4.2.

After the selected menu item is clicked the Convert RTmap31 Files to ASCII Format window will be displayed in the centre of the screen, Figure 4.6.

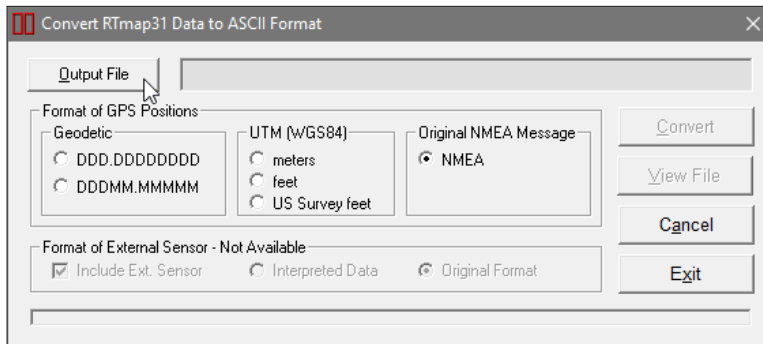


Figure 4.6: Convert RTmap31 Files to ASCII Format window

Parameters in Convert RTmap31 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 RTmap31 Files to ASCII Format window.

When Output file is specified the **Convert** button in the Convert RTmap31 Data to ASCII Format window becomes active.

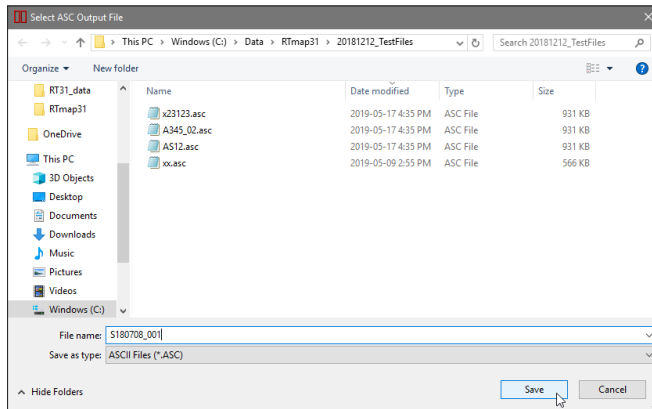


Figure 4.7: Select ASC Output File window

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 RTmap31 Data to ASCII Format

When all parameter are set and output file name is specified, the **Convert** button is activated in the Convert RTmap31 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).

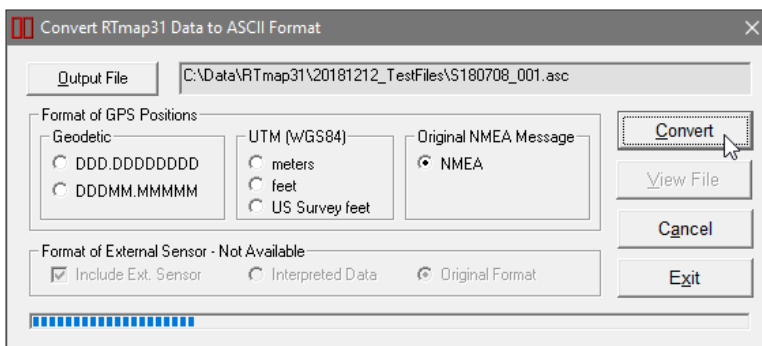


Figure 4.8: Convert RTmap31 Files to ASCII Format window during data processing

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 EM31-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 RTmap31 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 RTmap31 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 RTmap31 File window will be displayed in the centre of the screen, Figure 4.9.

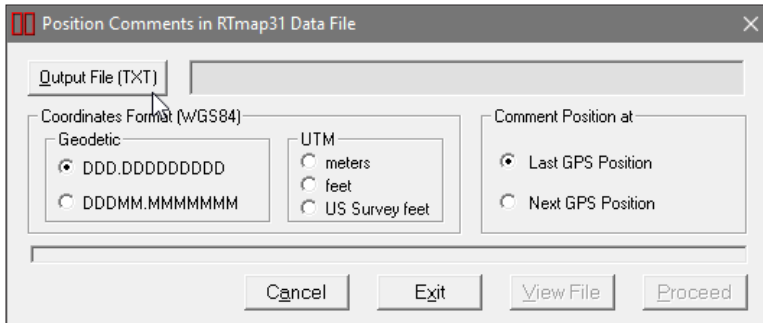


Figure 4.9: Position Comments in RTmap31 Data window

Parameters in Position Comments Recorded in RTmap31 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).

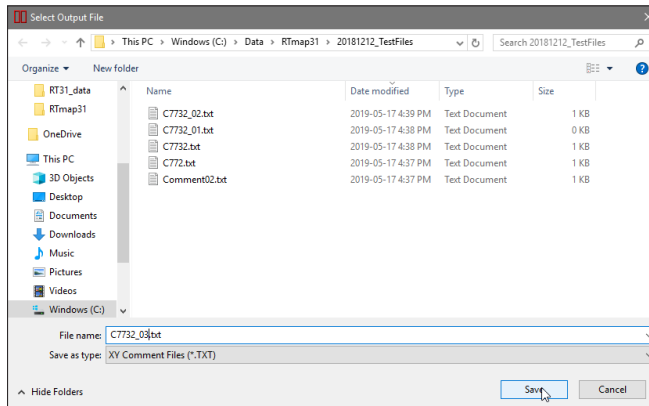


Figure 4.10: Select Output File window

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 RTmap31 File window.

When both, Input and Output files are specified the **Proceed** button in the Position Comments Recorded in RTmap31 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 RTmap31 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 RTmap31 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 RTmap31 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).

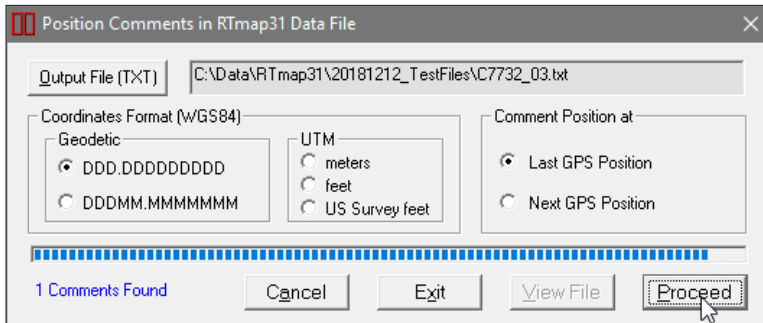


Figure 4.11: Position Comments Recorded in RTmap31 File during data processing

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 (T31)** and **Output File (TXT)** buttons. Click on **Exit** button to close the Position Comments Recorded in RTmap31 File window.

4.4 Convert GXY Files to XY (ASCII) Format

Files GXY are created by the RTmap31 when only GPS data are collected (EM31-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 RTM31.

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.

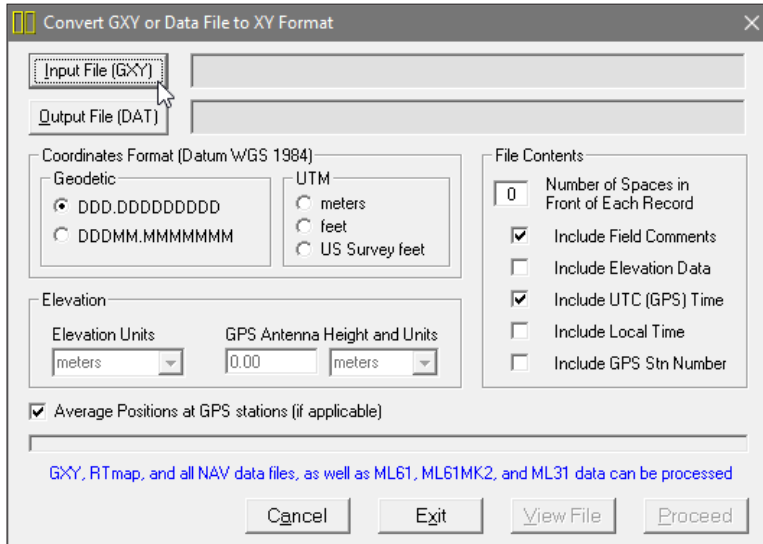


Figure 4.12: Convert GXY Files to XY Format window

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.

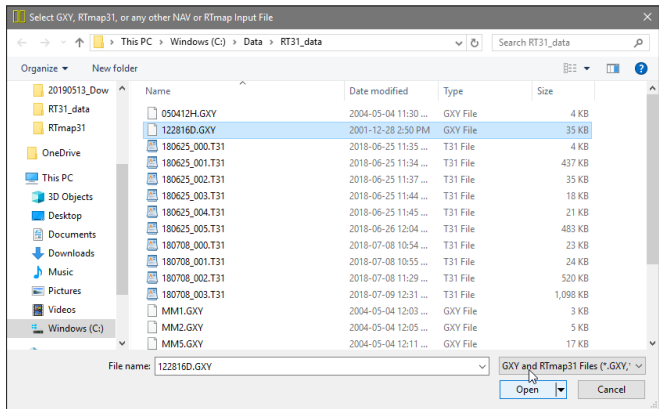


Figure 4.13: Select GXY Input File window

Output File (DAT)

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

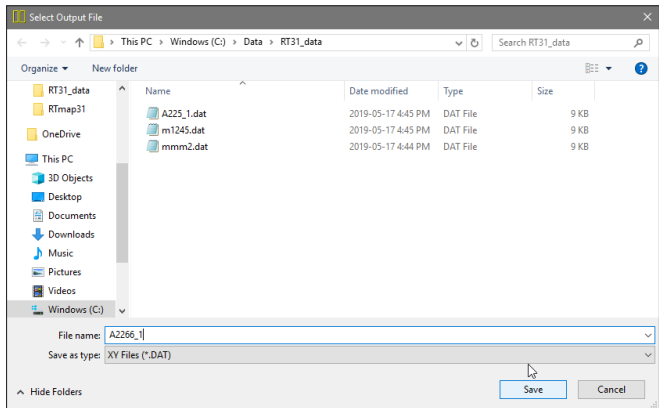


Figure 4.14: Select Output File window

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 RTmap31. 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).

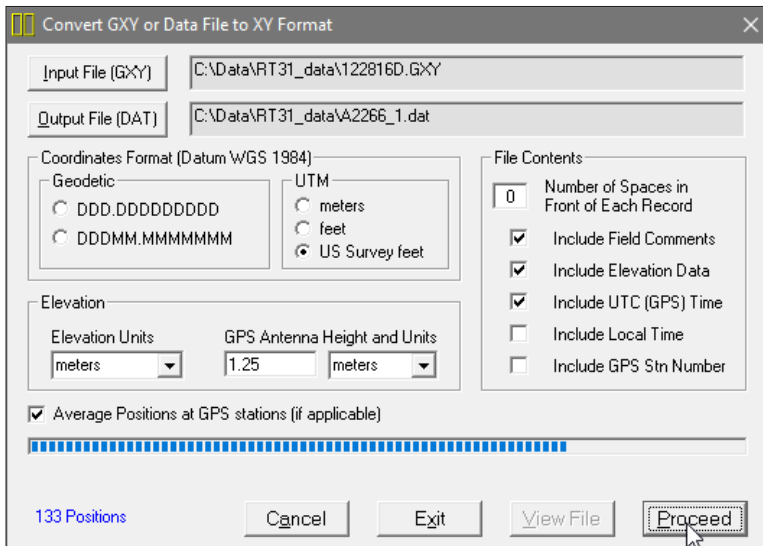


Figure 4.15: Convert GXY Data Files to XY Format window during data processing

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 EM31-MK2 time constant is known (approximately 0.5 s) the time constant of the combined EM31-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 gridding) the procedure can be time consuming, however it only needs to be done once for a given GPS receiver and EM31-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).

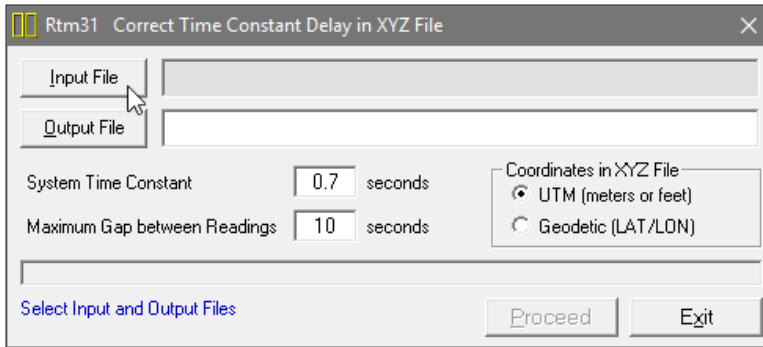


Figure 4.16: Correct Time Constant Delay in XYZ File window

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).

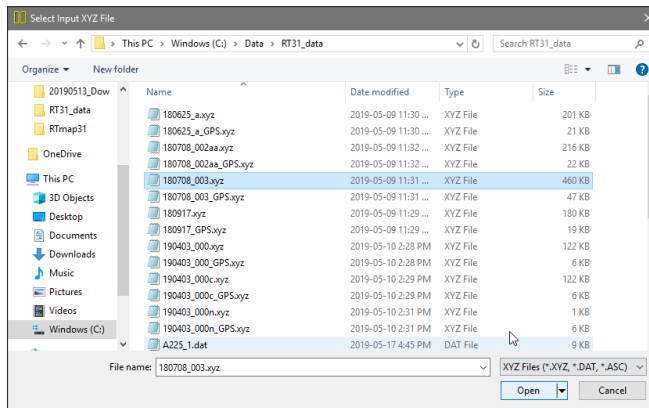


Figure 4.17: Select Input XYZ File window

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).

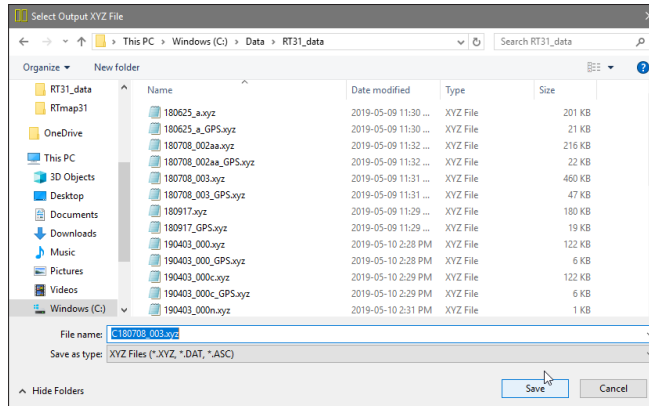


Figure 4.18: Select Output XYZ File window

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 0.7 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 EM31-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).

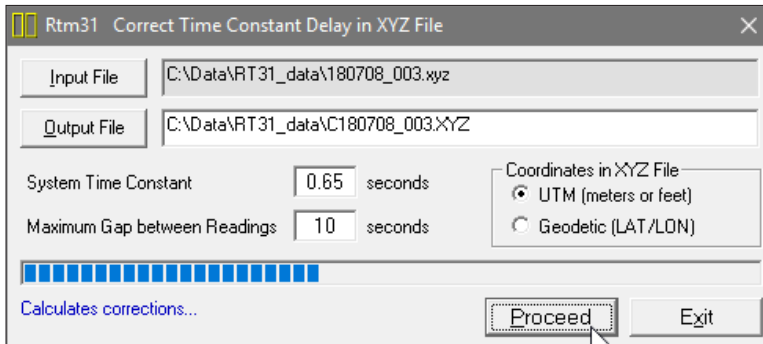


Figure 4.19: Correct Time Constant Delay in the XYZ File window during data processing

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.

RTmap31 Data File



A.1 Description of RTmap31 Data File Format (T31)

Each record created by the RTmap31 for MS Windows 10/7 program contains 27 characters, including line feed at the end of each record.

Header of the file contains 5 records starting with characters R, H, and then three records starting with G.

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	1				W	2	0	0	Survey Type	UT	ID	IM	IC	ST			LT				svid	10	
H																										
H																										
G																										
G																										
G																										
G																										

- RTM31 - identification of program file, if rTM31 (lower case r) is present later in the file, it indicates start of appended file header
- W200 - version number (V2.00)
- Survey Type - GPS (if GPS Input Enabled) or GRD (grid)
- UT - unit type (0 = meters, 1 = ft, 2 = US Survey ft)
- ID - EM31 Dipole Mode (selected by operator) (0 = Vertical, 1 = Horizontal, 2 = Both)
- IM - EM31 survey mode (0 = Auto, 2 = Manual)
- IC - EM31 component (=0 Both, =1 Inphase)
- ST - EM31 type (0 = Standard 3.66 m, 1 = Short 2 m)
- LT - computer type (fixed =1 MS Windows)
- svid - logger/software type id (not used)
- Data File Name - file name, maximum 10 characters
- Time/Samples - this field depends on EM31 survey mode
 Auto Mode - Time Increment in seconds
 Manual Mode - Samples/Reading

- TG - File tag (space=original, 1=Saved As / edited)
- 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 = RTS pseudo-GGA)
- GS - GPS state (0=disabled, 1=Enabled, >1 indicates averaging number for GXY files)
- GR - GPS update rate (= 0, fixed, not used)
- Initial Easting - survey start coordinate (program internal use only)
- ZN - UTM Zone (program internal use only)
- Initial Northing - survey start coordinate (program internal use only)
- 10 - Line Feed character

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

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	
L	Line Name - 8 characters																								10		
B	Start Station (Format F11.2)																										10
A	Dir							Station Increment (Format F11.3)															10				
Z	D	D	M	M	Y	Y	Y	Y		H	H	:	M	M	:	S	S	.	h	h							10

- 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)																										10
																	Time Stamp in ms (10 digits)										

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	Reading 1					Reading 2										Time Stamp in ms (10 digits)					10				

- I - indicator T or 2
- T - first reading at the EM31 station (default for Auto mode)
- 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	1	<i>not used</i>
6	64	Marker	= 1 <i>trigger pressed</i> = 0 <i>otherwise</i>
5	32	Mode	= 1 <i>Vertical</i> <i>Horizontal</i>
4	16	0	<i>not used</i>
3	8	0	<i>not used</i>
2	4	Range 3	
1	2	Range 2	
0	1	0	<i>not used</i>

Range 3 and Range 2 represent sensitivity (gain) as follows

Both Components (OPER mode)

Sensitivity	Range 2	Range 3	Multiplication Factors	
1000	1	1	Conductivity	-0.25
100	0	1	Conductivity	-0.025
10	1	0	Conductivity	-0.0025

Multiplication factor for Inphase is the same for all ranges: =0.025

Both Components (COMP mode)

Sensitivity	Range 2	Range 3	Multiplication Factors	
1000	1	1	Inphase	-0.0625
100	0	1	Inphase	-0.00625
10	1	0	Inphase	-0.000625

Conductivity is not recorded in COMP mode.

Multiply Reading by above factors to obtain result in mS/m or ppt.

- Reading 1** - five character field containing instrument output. Conductivity if Both components, Inphase if Inphase was selected includes sign (+ or -) and four digits
- Reading 2** - five character field containing instrument output. Inphase if Both components, not used if Inphase was selected includes sign (+ or -) and four digits
- Time Stamp** - 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

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					

Internal Readings

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
{	a	Internal Position of an Element (Format 14.3)														Time Stamp in ms (10 digits)										10

These records (curly brackets) are used only internally during data collection to speed up map re-drawing in real time.

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 RTmap31 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 RTmap31 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 RTmap31 Data File

The RTmap31 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.

```
RTM31    W200GPS00000 1
H180625 002 0.200      0
G 0.000 0.500 7 11 101
G 610730.497 17      B2E
G 4829891.531
L1
B          0.00
AE          1.000
Z25062018 23:36:14
*23:36:14.004 1073216906
X$STARTED 1073218531
@$GPGGA,035214,4336.8268,N
#,07937.6649,W,8,08,2.0,19
#0.0,M,-35.4,M,*7
!000001p 1073219453
{0 0.0001073219453
@$GPGSA,A,3,10,13,15,20,21
#,24,27,32,,,,,3.6,2.0,3.0
#*3
!000001 1073219609
T#-2108-2112 1073221000
T#-2108-2112 1073221375
@$GPGGA,035216,4336.8274,N
#,07937.6647,W,8,08,2.0,19
#0.0,M,-35.4,M,*7
!000002p 1073221453
{a 610730.1091073221453
{b 4829892.1911073221453
{c 610731.0931073221453
{d 4829892.0171073221453
{e 610730.2971073221453
{f 4829893.2581073221453
{g 610731.2821073221453
{h 4829893.0841073221453
@$GPGSA,A,3,10,13,15,20,21
#,24,27,32,,,,,3.6,2.0,3.0
#*3
!000002 1073221609
T#-2109-2112 1073221734
T#-2108-2112 1073222093
T#-2108-2112 1073222453
T#-2109-2112 1073222812
T#-2108-2112 1073223187
T#-2108-2112 1073223546
@$GPGGA,035218,4336.8280,N
#,07937.6646,W,8,08,2.0,19
#0.0,M,-35.4,M,*7
!000003p 1073223453
{e 610730.4841073223453
{f 4829894.3241073223453
{g 610731.4701073223453
{h 4829894.1531073223453
@$GPGSA,A,3,10,13,15,20,21
#,24,27,32,,,,,3.6,2.0,3.0
#*3
!000003 1073223609
T#-2108-2112 1073223906
T#-2108-2112 1073224265
T#-2108-2112 1073224625
T#-2108-2112 1073224984
.....
```

A.3 Format of GXY Data File

The RTmap31 data file with extension GXY contains GPS records. The structure of this file is identical to the standard RTmap31 (T31) file. The difference is that it does not contain any EM31-MK2 records. This file is created by RTmap31 when the EM31-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 RTmap31 data file, as well as GXY and data files created by other Geomar data acquisition programs (RTmap38MK2, NAV31, NAV61MK2, ML61MK2xpn, 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.

