ERTdesign Multisource module - User manual

Release 1.9.3

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Contents

CHAPTER 1

ERTdesign - Multisource module

The **multisource module of ERTdesign** (*ERTdesign_ms*) is a survey design tool for single and multi-transmitter deep resistivity/IP measurements, to be performed with Multisource devices (Multi-phase Technologies LLC).

Planning a survey with this tool requires a few simple steps.

1. Define the survey area by importing a polyline or a polygon from a Google Earth ™ **KMZ/KML** file or by using interface commands to specify a layout.
2. Specify the **total number** of boxes to be used and/or the **box electrode geometry**.
3. Set the **number of transmitting dipoles** to be combined in the two directions.
4. If needed, use the advanced options to configure any additional parameters, such as user-defined transmitter combinations or adding reciprocal measurements or other.

On the basis of the user defined configuration, the tool **automatically** derives the layout of the boxes and the sequence of multisource measurements to be acquired. Interactive plots and tables allow to easily monitor the main survey parameters:

- depth of investigation and maximum sensitivity for all combinations of (multi)TX/RX.
- Expected *Vmn signal* at the receivers by setting the user-defined background resistivity (ohm m) of the site and the input current intensity (mA) at transmitters.
- Geometric factors for n-poles.
- Automatic alerts in case of low Vmn potentials or risk of overload at receivers.

The set of generated Multisource boxes can be exported to *KML* file, displayed on Google Earth ™, modified to take into account for any restrictions on the arrangement of the sensors, imported back into ERTdesign_ms to allow for re-evaluation. Generated placeholders, divided by type (Multisource boxes, electrodes, survey area) can be transferred to data-loggers of the most common GPS devices and used for stakeout activities on site. ERTdesign_ms is compatible with the ViewLab3D and ERTLab64 softwares for modeling, inversion and visualization of 3D ERT multisource measurements: the project can be exported to *DATA* file and used on advanced modeling tasks for complex topography and three-dimensional distributions of subsoil resistivity and chargeability.

The project is exportable to *configuration file* format (CNFG) to be loaded on the Multisource controller software to acquire field data.

CHAPTER 2

Installing ERTdesign_ms

To install ERTdesign_ms run the *ERTdesign_ms_setup.exe* file, choose the language for the installation steps and follow the instructions. The software is installed in the default directory **C:\ERTdesign_ms**: this allows the user to work without the need to activate *administrator* permissions. At the end of the installation, run the ERTdesign_ms exe: a shortcut with the software icon has been added to the desktop.

Note: You need a valid license to work with ERTdesign_ms.

To get a valid ERTdesign_ms license send the **ertdesign_ms_id.txt** file, generated at first run and stored under the **license** directory of the installation folder, at ertdesign@fischanger.it. You will receive back an **ertdesign_ms_lic.txt** file to be copied into the same directory above, as shown in Fig. 2.1.

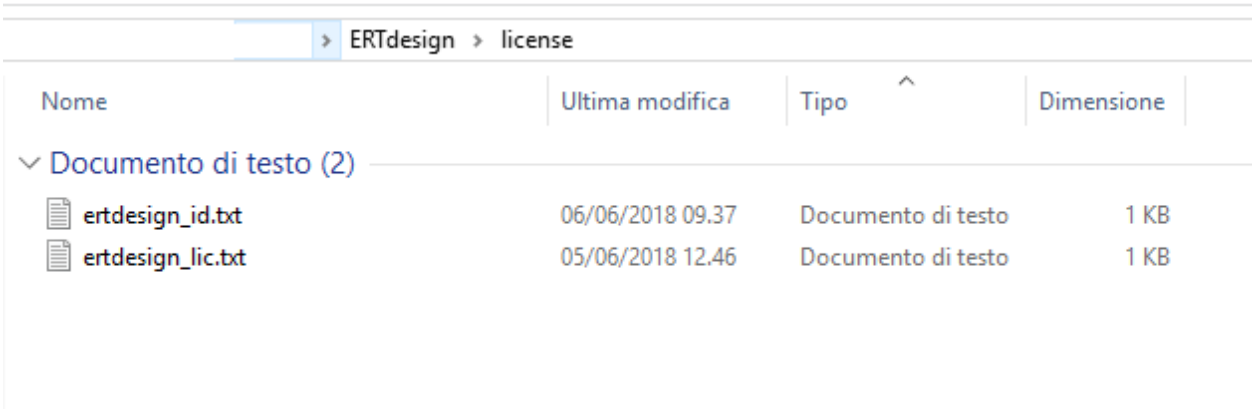


Fig. 2.1: Folder with user license files.

CHAPTER 3

Getting started

This short tutorial introduces to the basics of a complete ERTdesign project for multisource measurements through 3 quick steps.

3.1 Set the main survey parameters

The first thing to do to start an ERTdesign_ms project is to define the survey area. The most convenient way to do this is to draw a profile or an area - a polyline or polygon - in Google Earth ™ and then to import the related KMZ or KML file. Don't worry, however, if you miss a defined working area and you just need to perform a generic modeling task: ERTdesign_ms allows you to *define simple layouts from interface*.

Select the **Survey Design** icon of the Menu Bar to the left of the screen and set the configuration parameters in the corresponding panel.

- In the **Survey area** section select the **KML or KMZ file** containing the area for the design project. The layout of the area to be investigated will be shown on the map of the **Survey design summary tab** (Fig. 3.2).
- In the **Transceivers** section, set the total number of boxes and/or the spacing for the electrodes of the Multisource boxes. The geometry of the electrodes is defined for each box in a reference system local to the P2 electrode.
- In the **TX combinations** section specify the number of transmitting dipoles to be arranged in the two directions.
- In the **Run Generation** section click on the **Run** arrow to generate the project. Appropriate *advanced settings* allow to make more flexible the sensors generation.

3.2 Check and modify the survey project

You can explore the details of the design project through the three main tabs of the software.

The *Survey design summary* tab shows the details of the set of sensors: the total number of Multisource boxes needed to cover the survey area, the total number of electrodes, the total number of measurements. This information is accompanied by a figure with the map of the sensors, which can be easily zoomed, panned or saved to file.

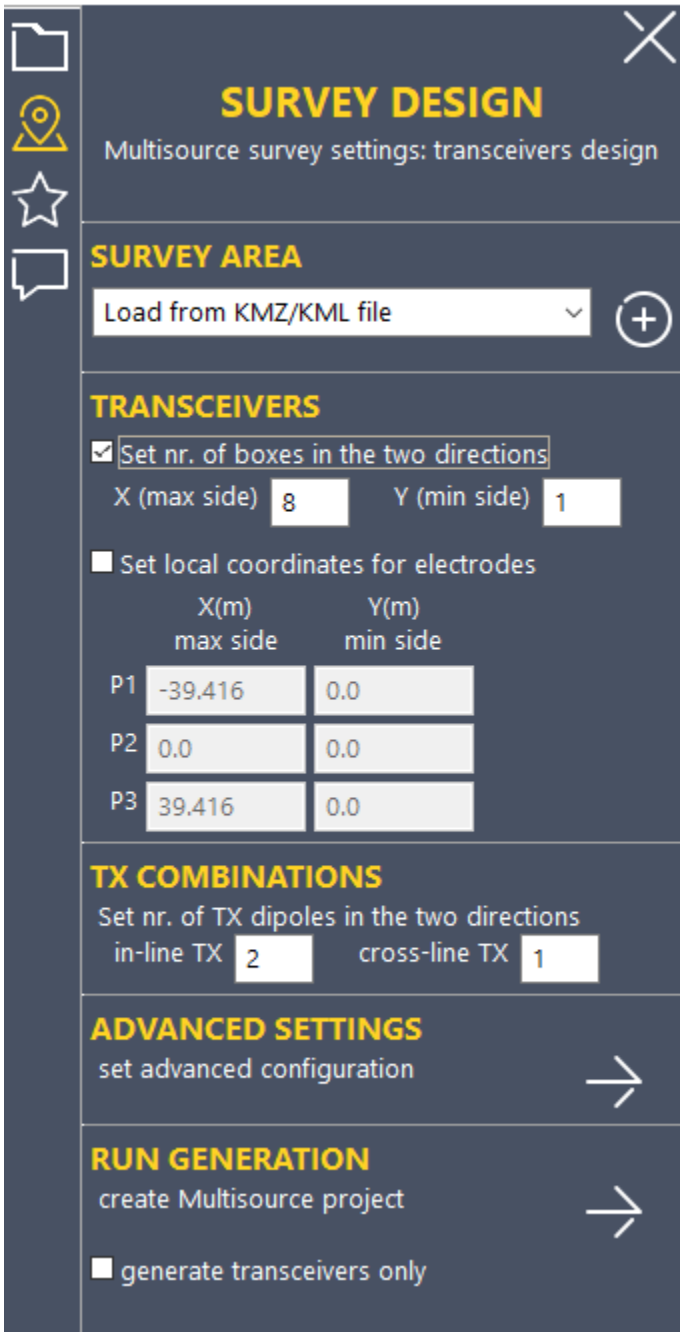


Fig. 3.1: Survey design panel.

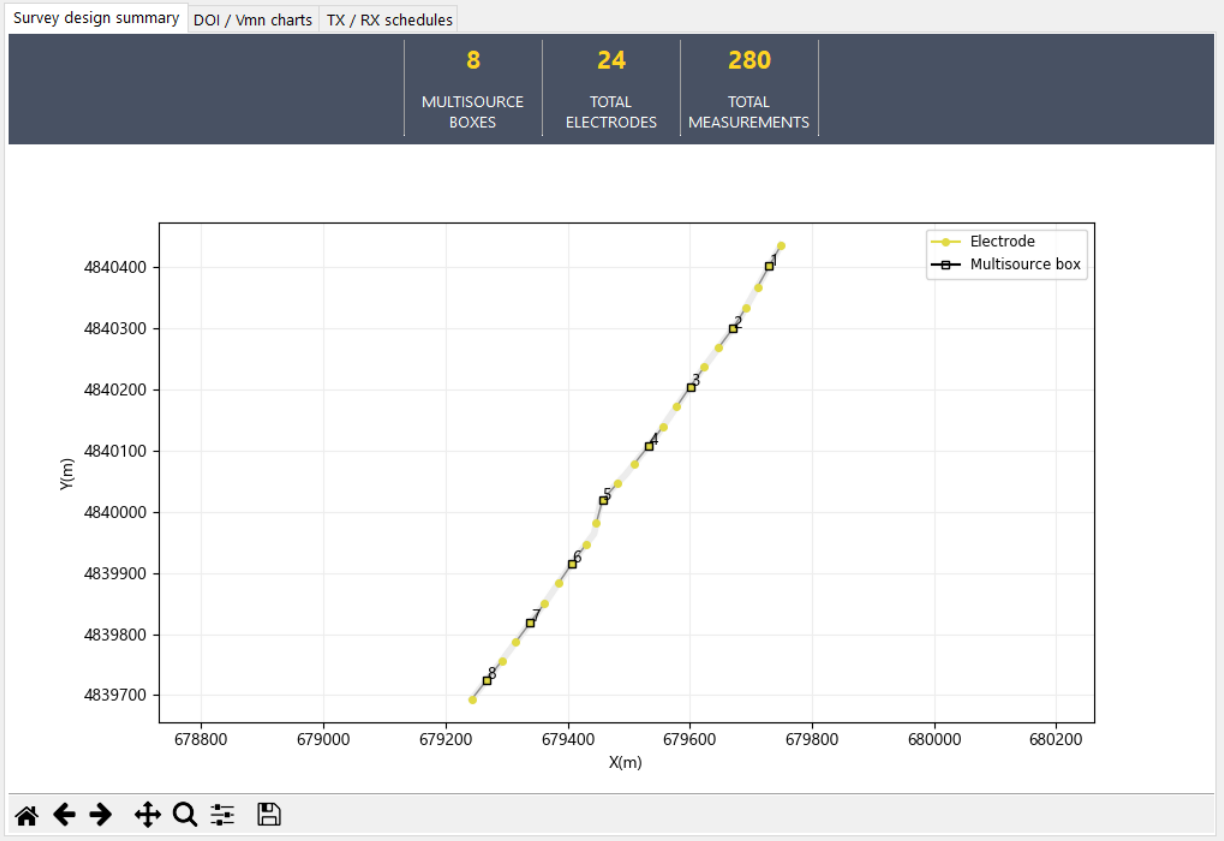


Fig. 3.2: Survey design summary tab.

The *DOI/Vmn charts* tab allows to display plots of the maximum sensitivity and depth of investigation for different combinations of receiving dipoles/transmitting multi-poles (left in Fig. 3.3) and to check how the Vmn signal changes when the background resistivity or the input current is modified (right section in Fig. 3.3).

Fig. 3.3: Plots with maximum sensitivity, depth of investigation and expected Vmn signal.

The *TX/RX schedules* tab displays the sheets with the coordinates of the electrodes of transceivers and with the details on n-poles measurements. In the bottom part of the tab you find the graphs with the measurements pseudo-plot and sensitivity plot for each n-pole.

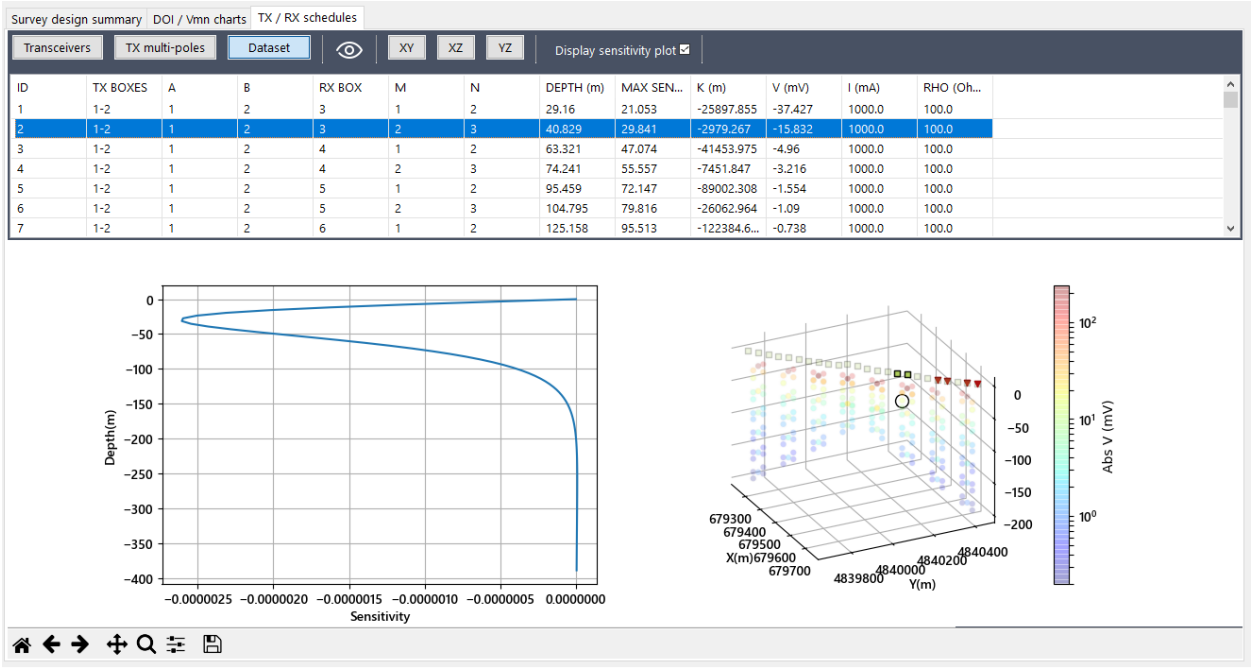
The analysis of the above parameters allows you to eventually redesign the survey, by modifying one or more parameters of the design panel, and to re-evaluate the project.

3.3 Save the project

Select the **Load and save** icon of the Menu Bar to the left of the screen to access the panel with the saving functions.

The **Save Project** command allows you to save three files with the project details:

- the *KML* file contains the locations of all sensors (Multisource boxes, electrodes, survey area). You can open this file in Google Earth ™ , edit it and import it again into ERTdesign_ms using the command **Load project** to check how signals and sensitivities change with the new geometry of the electrodes.
- The *DATA* file contains the complete list of electrodes and n-poles. You can use this file to perform modeling tasks within the ERTLab64 ™ and ViewLab3D tools.
- The *TXT* file contains the full configuration used to generate the project. You can open this file to reload the settings for a new survey design.



ID	TX BOXES	A	B	RX BOX	M	N	DEPTH (m)	MAX SEN...	K (m)	V (mV)	I (mA)	RHO (Oh...
1	1-2	1	2	3	1	2	29.16	21.053	-25897.855	-37.427	1000.0	100.0
2	1-2	1	2	3	2	3	40.829	29.841	-2979.267	-15.832	1000.0	100.0
3	1-2	1	2	4	1	2	63.321	47.074	-41453.975	-4.96	1000.0	100.0
4	1-2	1	2	4	2	3	74.241	55.557	-7451.847	-3.216	1000.0	100.0
5	1-2	1	2	5	1	2	95.459	72.147	-89002.308	-1.554	1000.0	100.0
6	1-2	1	2	5	2	3	104.795	79.816	-26062.964	-1.09	1000.0	100.0
7	1-2	1	2	6	1	2	125.158	95.513	-122384.6...	-0.738	1000.0	100.0

Fig. 3.4: Tab with sensors schedules and pseudo-plots.

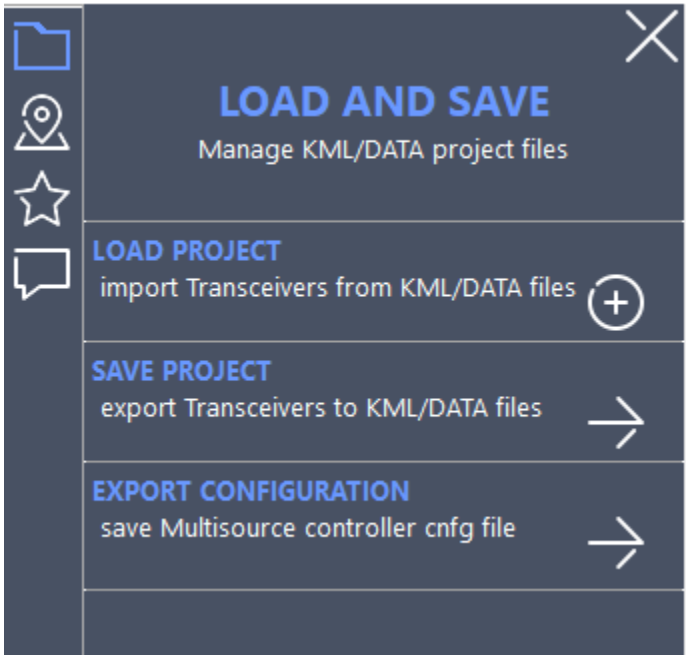


Fig. 3.5: Load and save panel.

The **Export configuration** command allows you to save a *CNFG* file to load on the Multisource controller software to acquire field data.

CHAPTER 4

A look at the application interface

The user interface of the ERTdesign *multisource* module consists of four components.

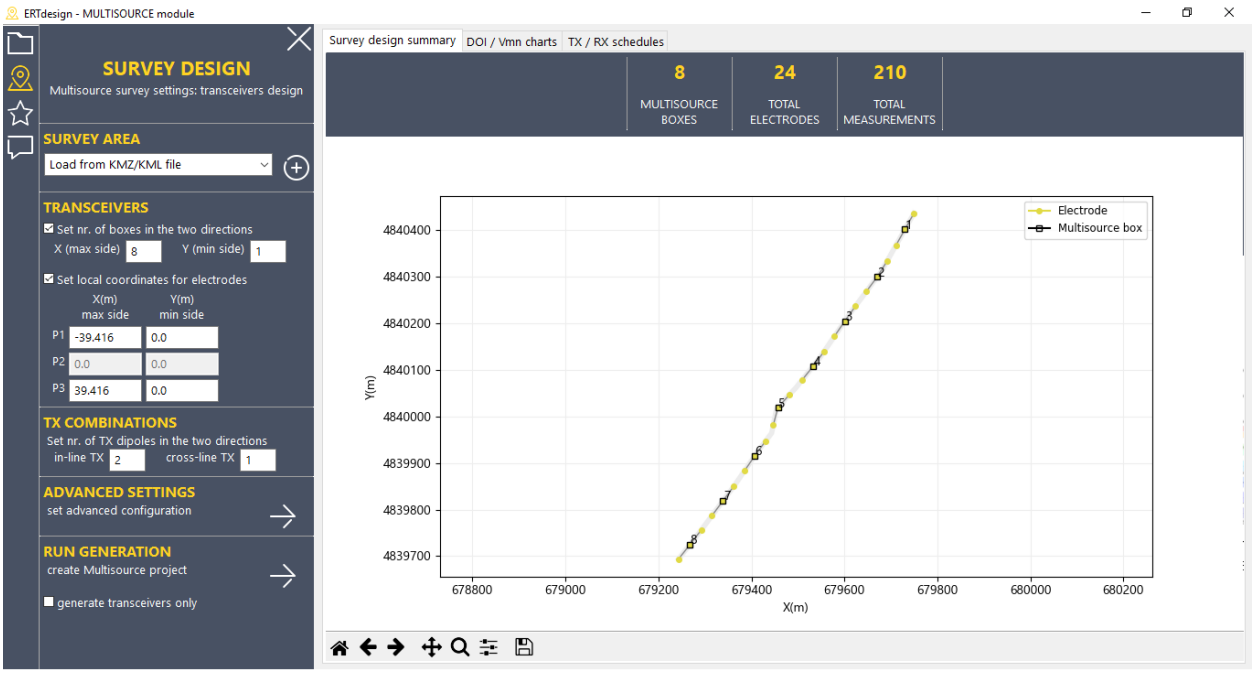


Fig. 4.1: Application interface.

1. One **Menu Bar** on the left of the screen with command-icons to show/hide the *Side Panels* for accessing the application functionalities.
2. Four **Side panels** on the left of the screen, which are accessed by each one of the *Menu Bar* commands.
3. Three **Project tabs** with project details and analysis tools.

4. One **Graphical toolbar** at the bottom of tabs for managing the properties of plots.

4.1 Menu bar

Shows/hides the *Side Panels* with functions for opening/saving project files, survey design, user preferences settings and access to documentation.

Fig. 4.2: Menu Bar.

4.2 Side panels

- The *Load and save* panel allows to open and save project files.
- The *Survey design* panel contains the configuration commands for the survey project: properties of the area to be investigated, receivers and transmitters settings.
- The *Preferences* panel allows for setting the application defaults.
- The *Info and documentation* panel gives access to the documentation.

4.3 Project tabs

- The *Survey design summary* tab contains the details of the generated set of sensors.
- The *DOI/Vmn charts* allows to analyze sensitivity, depth of investigation and expected Vmn signal for TX/RX combinations.
- The *TX/RX schedules* contains sheets with coordinates of the generated electrodes, with details on n-poles and with measurements pseudo-plots.

4.4 Graphic toolbar

The graphic toolbar allows to perform the most common operations on properties of the graphs present in each project tab.

Looking at the bar controls from left to right we find:

Fig. 4.3: Graphic toolbar.

- **Home, Back, Forward**. These commands are similar to *home, forward and back* of a web browser. The *Forward* and *Back* commands are used to navigate back and forth between previously defined views. The *Home* command takes back to the default data view.
- **Pan/Zoom**. This command has two modes: **pan and zoom**. Press the left mouse button and hold it to pan the figure, dragging it to a new position. By pressing the "x" or "y" keys while panning, the motion will be constrained respectively on the x or y axis. Pressing the *right mouse button* zooms in. The x axis will be zoomed in proportionately to the rightward movement and zoomed out proportionately to the leftward movement. The same is true for the y axis and up/down motions.
- **Zoom on rectangular area**. Define a rectangular region by dragging the mouse while holding the button to a new location. When using the left mouse button, the axes view limits will be zoomed to the defined region. When using the right mouse button, the axes view limits will be zoomed out, placing the original axes in the defined region.
- **Configuration of subplots**. Using this tool will configure the appearance of the subplot: you can stretch or compress the left, right, top, or bottom side of the subplot, or the space between the rows or space between the columns.
- **Save**. Save files with the following extensions: png, ps, eps, svg and pdf.

CHAPTER 5

“Load and save” panel

The “Load and save” panel (Fig. 5.1) allows to manage project files for a *multisource* survey design activity.

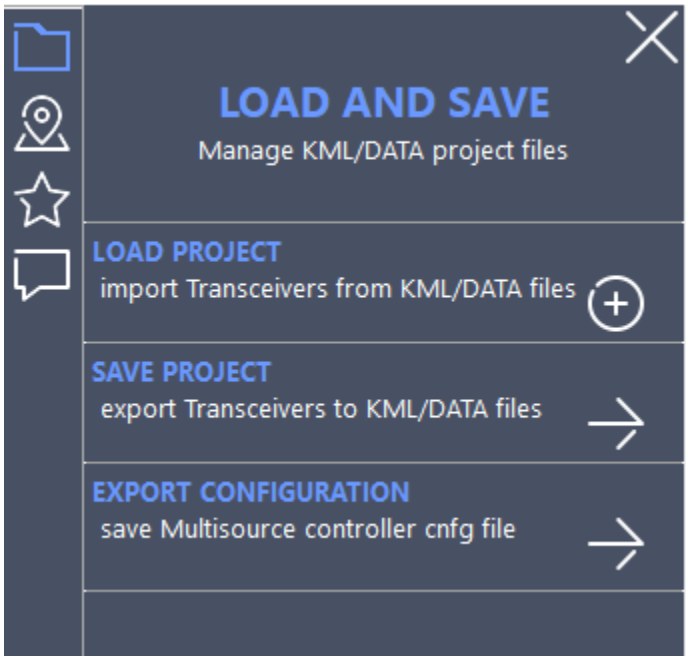


Fig. 5.1: Load and save panel.

5.1 Load project

Loads a previously saved ERTdesign_ms project and redraws the graphs to display the project properties.

The behavior of this command is different depending on the number and type of files that are being loaded. In general, **a complete ERTdesign project consists of 3 files with the same name and with extensions .KML, .DATA and .TXT**.

- **In the presence of all three files**, the application uses the KML file to determine the position of the electrodes of transceivers and to load the polygon or polyline with survey area. The DATA file is used exclusively for reloading the sequence of measurements (if consistent with the information on box names, otherwise the n-poles are not loaded). The TXT file reloads the design settings used to generate the project.
- **When the DATA file is missing** or when the DATA file does not contain information consistent with the KML file (different sensor names or missing sensors or other) the application uses the KML file to determine the position of the electrodes of the boxes.
- **When the KML file is missing** the application uses the DATA file to both derive the position of the electrodes of transceivers (which in this case will not be referenced in latitude and longitude) and to load the n-poles.
- **In the presence of the TXT** file only, the program uses the file to reload the design settings stored in the file.

5.2 Save project

Saves the three files with project information:

- the *KML* file with the position of the sensors (Multisource boxes, electrodes, survey area). You can open this file in Google Earth ™ , edit it and import it again into ERTdesign_ms using the command *Load project* to check how signals and sensitivities change with the new geometry of electrodes.
- the *DATA* file is a text file that contains the complete list of electrodes and n-poles. The file can be used to perform modeling tasks within the ERTLab64 ™ and ViewLab3D softwares.
- The *TXT* file contains the complete configuration used to generate the project. This file can be used for reloading the design settings.

Note: In case **the area is not referenced**, when saving the project, only the DATA file will be generated with the complete list of electrodes and n-poles. Of course, **it is not possible to produce the KML** file with the export of the sensors to be displayed on Google Earth ™ .

5.3 Save configuration

Allows to save the CNFG file to be used for the acquisition of field measurements inside the Moultisource software that remotly controls the boxes. This operation requires that in the Transceiver section of the *Preferences* area the **user has previously specified his own list of boxes** with the properties on box ID/names to be used in the field.

CHAPTER 6

"Survey Design" panel

The "Survey Design" panel (Fig. 6.1) allows to manage the *multisource* survey project, by defining the survey area, the configuration of transceivers and the combinations of transmitters.

The panel is made of five sections and the configuration parameters are usually specified following a top-to-bottom order.

6.1 "Survey area" section

Contains the commands to define the layout of the area or profile to be investigated. In the drop-down menu you can choose between two options.

6.1.1 1. Load from KMZ/KML file

Opens the dialog to select a **KML or KMZ** file with the area (polygon) or the profile (polyline) for the project design. If multiple graphic objects are stored into the file, only the first occurrence will be taken into account. The layout of the survey area will be shown on the map of the *Project summary* tab. The map makes use of UTM coordinates, with conversion based on the ellipsoid defined in the *Preferences* panel (default is WGS84).

6.1.2 2. Define the survey area geometry

When a KMZ or KML file is missing, use this command to access the *Define survey area* panel to generate simple linear or rectangular survey geometries.

6.2 "Transceivers" section

In this section it's possible to specify the **total number of boxes to arrange in the two directions and/or the spacing of the electrodes for each device.**

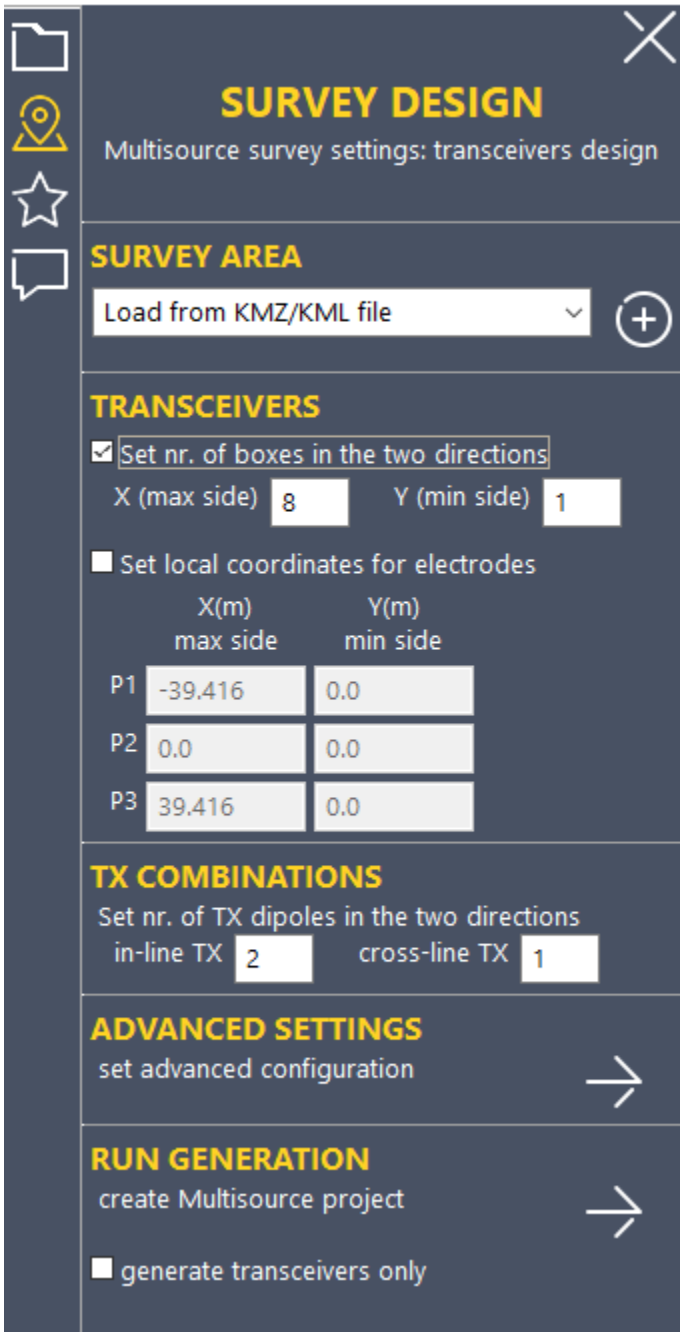


Fig. 6.1: Survey design panel.

- If only the total number of boxes is specified, the electrode spacing is automatically derived and vice versa.
- If both parameters are defined, the tool stops the sensors generation when reaching the specified number of boxes, which can lead to cover only partially the survey area.

Use the **X (max side)** textbox to specify the number of boxes in the direction of the survey area with the **major** extension. Use the **Y (min side)** textbox to specify the number of boxes in the direction of the survey area with the **minor** extension.

The geometry of the electrodes is defined for each box in a **reference system local to the P2 electrode**, which has always (0.0, 0.0) coordinates. The logic of the P1-P3 electrodes arrangement is based on the following convention:

- **the x axis of the local reference system** is aligned along the direction of the survey area with the **major** extension;
- **the y axis of the local reference system** is aligned along the direction of the survey area with the **minor** extension.

For example, setting P1 coordinates to (-15.0, 0.0) and P3 to (15.0, 0.0) will arrange the three electrodes along the direction of the survey area with the larger extension, as displayed in Fig. 6.2.

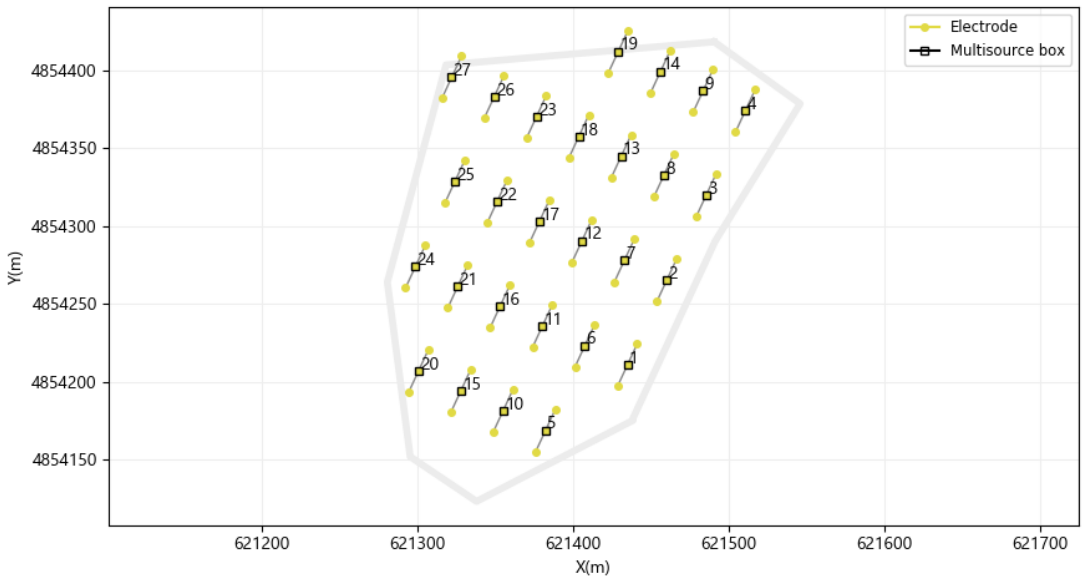


Fig. 6.2: Transceiver geometry aligned along the larger area dimension: P1(- 15.0, 0.0) and P3(15.0, 0.0).

Setting P1 coordinates to (0.0, -15.0) and P3 to (0.0, 15.0) will arrange the three electrodes along the direction of the survey area with the minor extension, as displayed in Fig. 6.3.

Similarly, setting P1 coordinates to (15.0, 0.0) and P3 to (0.0, 15.0) will arrange the three electrodes according to an "L-shaped" geometry, with alignment of P1-P2 along the direction of the survey area with the larger extension, as displayed in Fig. 6.4.

Any other combination of coordinates is allowed in order to create dipolar geometries of any kind.

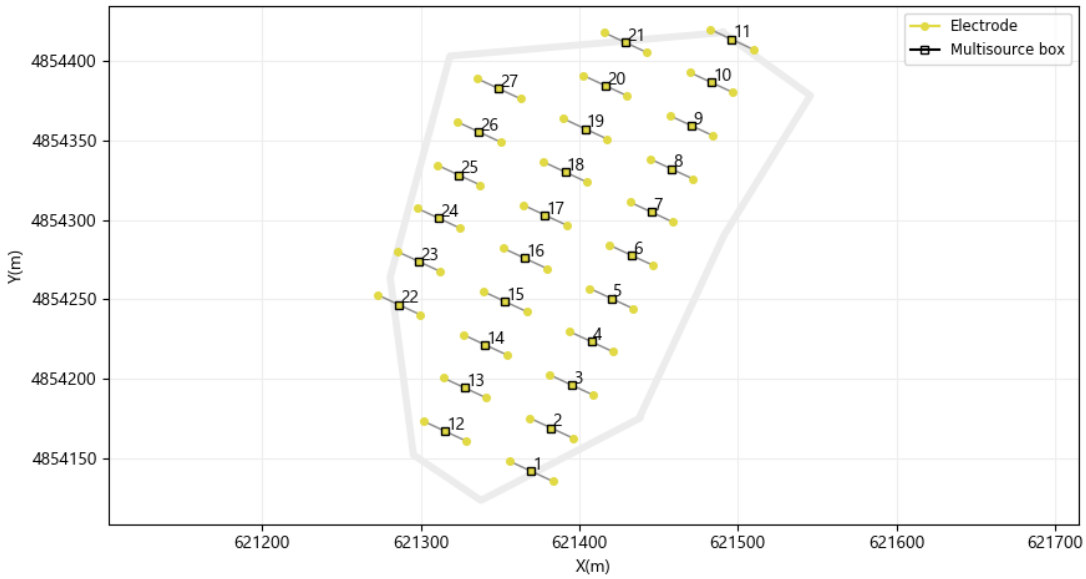


Fig. 6.3: Transcriber geometry aligned along the smaller area dimension: P1(0.0, -15.0) and P3(0.0, 15.0).

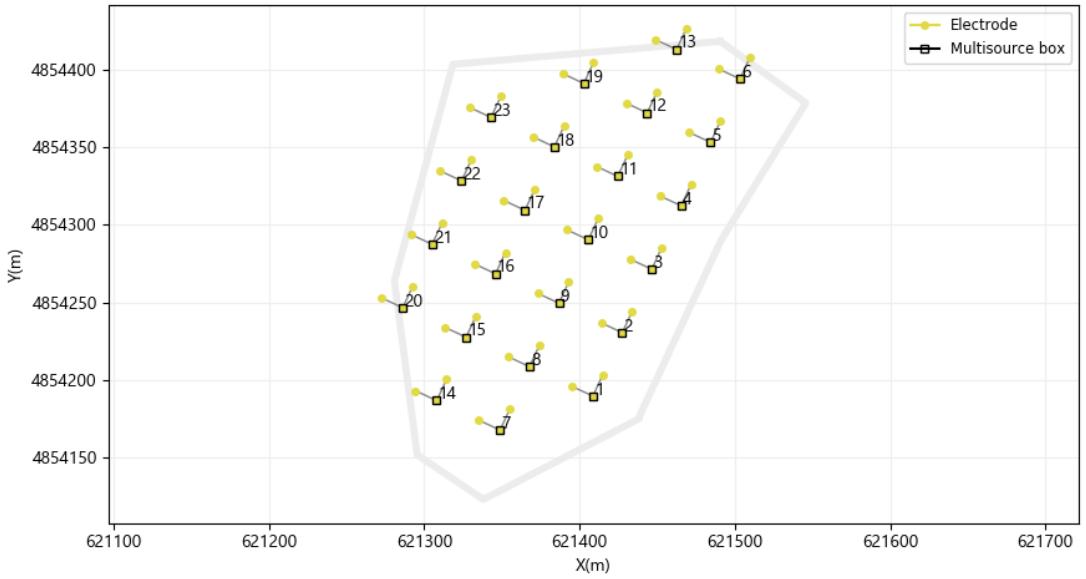


Fig. 6.4: “L-shaped” geometry for transceivers with P1(15.0, 0.0) and P3(0.0, 15.0).

6.3 "TX combinations" section

In this section you can define how many transmission dipoles you want to use, based on two distribution modes: **alignment** of the dipoles along a given direction or **parallel arrangement** (side-by-side spread of TX dipoles).

- Insert in the **TX in-line** textbox the number of **aligned** TX dipoles to be used.
- Insert in the **TX cross-line** textbox the number of TX dipoles to arrange **parallel between adjacent lines**. This option is only available if the *multisource* boxes are distributed over areal geometries.

6.4 "Advanced Settings" section

The specific section with the *advanced settings* allows to perform more flexible generations, by modifying configuration parameters of both transceivers and transmitter combinations.

6.5 Run generation

Once the survey configuration parameters have been defined, it is possible to proceed to project generation **by clicking on the "Run"** arrow icon of this section.

The **generate transceivers only** checkbox performs the simple generation of sensors and skips the n-poles sequence generation.

Note: The **"generate transceivers only" option is strongly recommended at the first generation of the project**, in order to quickly check the distribution of the transceivers on the survey area and compare the design results with the area coverage needs and with the total number of Multisource boxes available in the field.

Once a satisfactory distribution of the transceivers has been defined, it will be possible to proceed to a **new generation** that excludes the "generate transceivers only" option and produces the global set of measurements to be acquired.

CHAPTER 7

“Define survey area” panel

When a KMZ/KML file is missing, it is possible to define a survey profile or rectangular area through the controls of this panel.

The panel consists of the following commands.

- **L1(m) and L2(m)**: represent the **dimensions in meters of the two sides of the rectangular area**. To define a survey profile, one of the two dimensions can be set equal to 0.
- **Longitude (degrees), Latitude (degrees), Azimuth (degrees)**: parameters for georeferencing the survey area. Latitude and longitude specify the geographic coordinates of the vertex at the bottom left of the rectangle. The azimuth defines the orientation of the L1 side relative to North. These parameters can also be left at 0 if the user has no need of georeferencing the area.

Note: In case **the area is not referenced**, when saving the project, the DATA file only will be generated with the complete list of electrodes and n-poles. Of course, **it is not possible to produce the KML** file storing the sensors to be displayed on Google Earth ™.

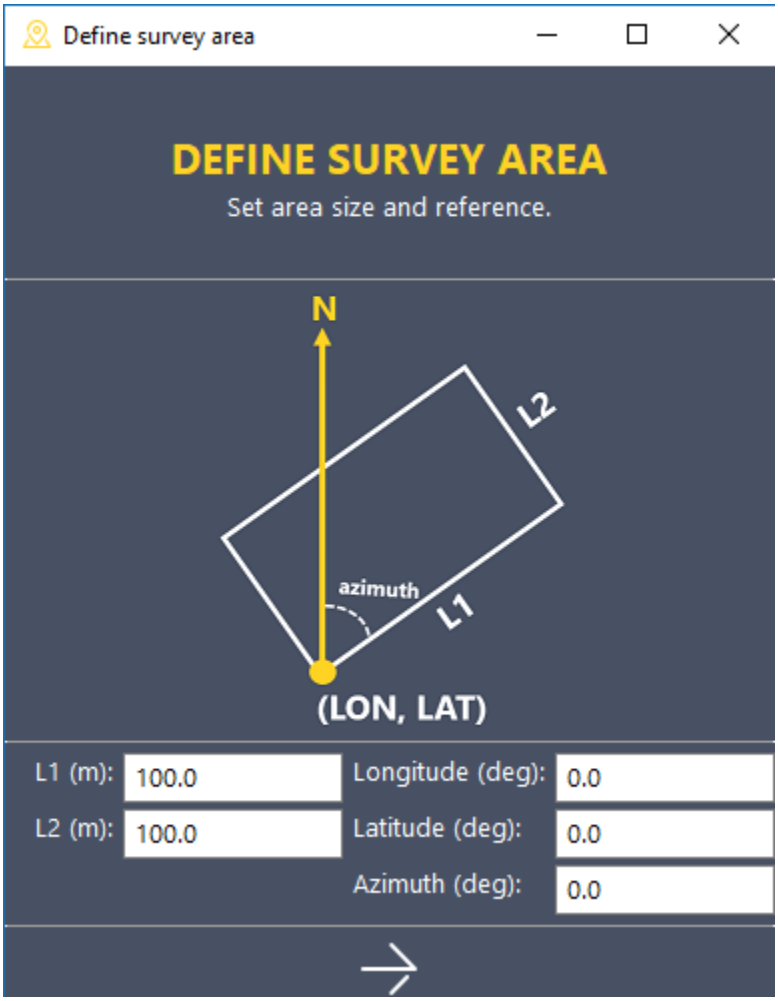


Fig. 7.1: Panel for the definition of the survey area.

CHAPTER 8

“Advanced Settings” panel

The advanced settings panel allows the user to define some **custom parameters** to refine the survey design. Settings are divided into two sections, one for transceivers features and one for the TX combinations.

In order to make the modifications persistent, click on the arrow-button **Apply** at the bottom of the panel, which implements the changes e leads back to the main design window.

8.1 Transceivers

The transceivers section contains two configuration parameters.

8.1.1 Box sensor spacing

The value in the text box represents the distance between **successive electrodes of two adjacent transceiving boxes**, as shown in figure Fig. 8.2.

When the **auto** checkbox is selected, the software automatically finds the spacing between the transceivers, based on the geometry of the electrodes: the distance will be equal to the width of the largest transceiver dipole.

8.1.2 In/Out area tolerance

Defines the **tolerance radius** in meters for arranging the *multisource* boxes within the survey area and is useful to make the generation of transceivers more flexible in case of complex geometries of the survey area. In the example of figure Fig. 8.3 the modification of the tolerance from 5 meters (**a**) to 20 meters (**b**) causes the insertion of five extra transceivers to the project, with an extended coverage of the boundaries of the survey area.

When the **auto** checkbox is selected, the software automatically calculates a tolerance equal to 10% of the width of the largest transceiver dipole.

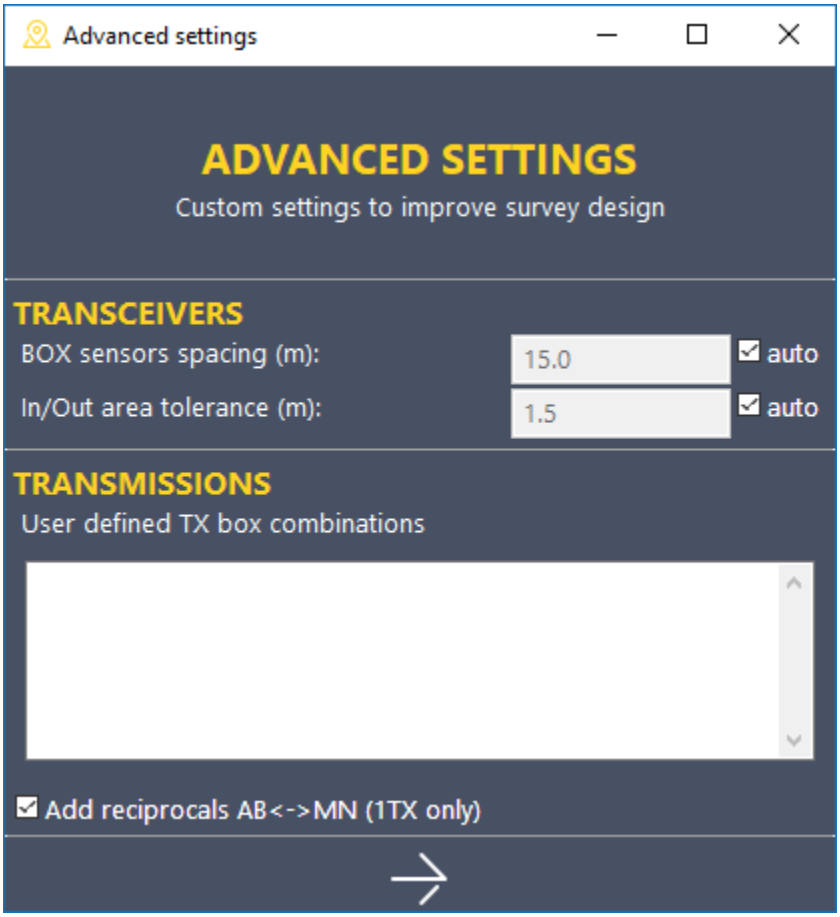


Fig. 8.1: Advanced settings panel.

Fig. 8.2: Spacing between the transceivers.

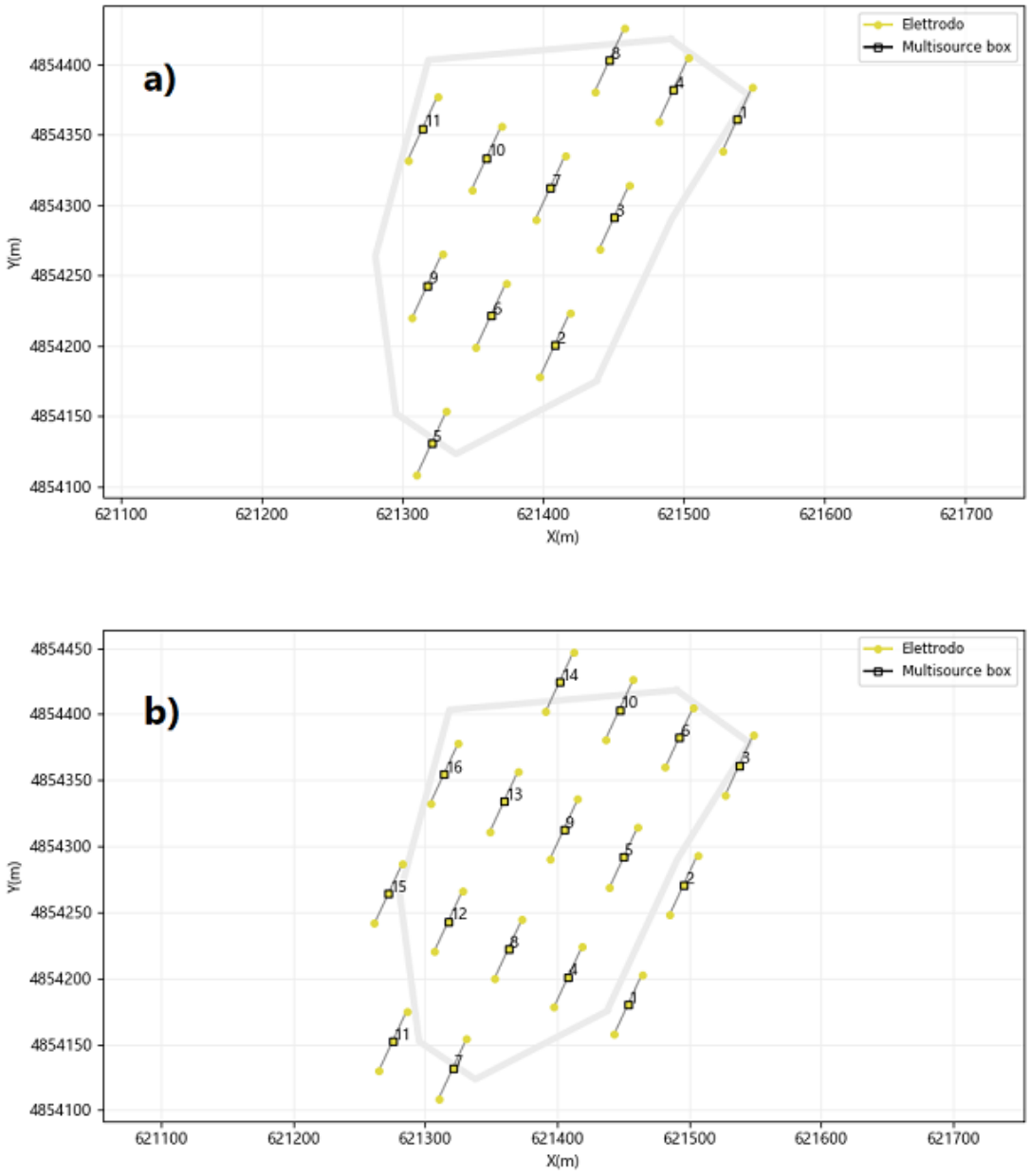


Fig. 8.3: Example of generation of transceivers for different inside/outside tolerances: a) 5 m; b) 20m.

8.2 Transmissions

Settings in this section allows to modify the properties of transmissions.

8.2.1 User-defined TX box combinations

In this textbox it's possible to define the box combinations to be used as transmitters. This option allows the user to choose **which boxes to use or combine in the transmissions**. To do this, simply add a line in the textbox for each desidered TX combination. For example, specifying the line *1 2 4* means generating a set of n-poles measurements where boxes 1, 2 and 4 transmit simultaneously and the remaining boxes act as receivers.

Since the automatic generation of transmitter combinations is governed by a box-proximity logic, this option allows for combining distant boxes in the transmission. It can also be useful to select a *subset* of boxes to be used as transmitters: those not specified in the list will always behave only by receivers.

Note: In the list of combinations **it is not possible to define mixed combinations of transmitters**, i.e. rows with a different number of transmission dipoles. The generation of n-poles measurements in ERTdesign_ms always consists of a fixed number of transmitters.

8.2.2 Add reciprocals AB<->MN (1TX only)

This option allows for **adding reciprocal quadrupoles** in the sequence generation for single transmitter measurements. If the option is not checked, only the quadrupoles where the transmitter has a box number lower than the receiver box number will be generated.

CHAPTER 9

“Preferences” panel

The **User Preferences** panel permits to **change the default settings** of the application, allowing the user to preset the most frequently used design parameters. The parameters are grouped in six sections: General, Georeferencing, Survey area, Transceivers, Transmissions and Field parameters.

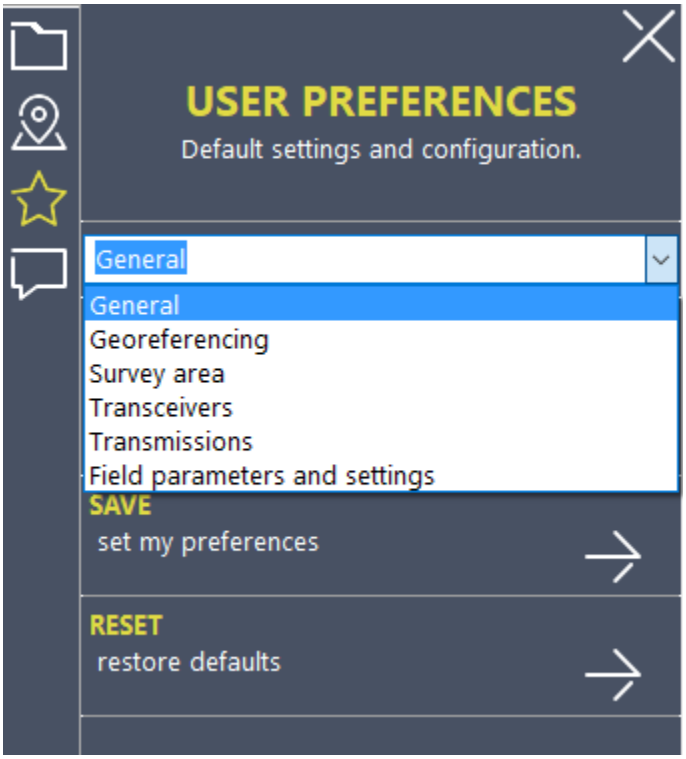


Fig. 9.1: Preferences panel.

Changes made by the user can be made permanent through the **Save** command and will be **active at software restart**.

To restore the *factory parameters* select the **Reset** command. User preferences are saved inside a text file (*ertdesign_ms_config.ini*) in the *preferences* folder of the software installation directory.

9.1 General

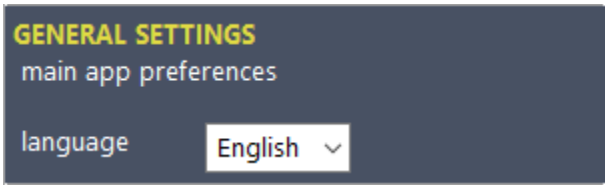


Fig. 9.2: General Preferences.

Use this section to set the **language** option for the user interface, choosing between English and Italian.

9.2 Georeferencing

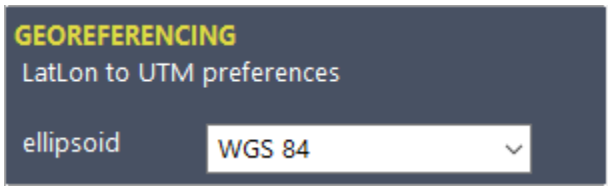


Fig. 9.3: Georeferencing preferences.

The section allows to preset the **ellipsoid** for the conversion of the geographic coordinates (Latitude and Longitude) to the **UTM** projection plane. You can choose from 23 different ellipsoids. The *default* uses WGS84.

9.3 Survey area

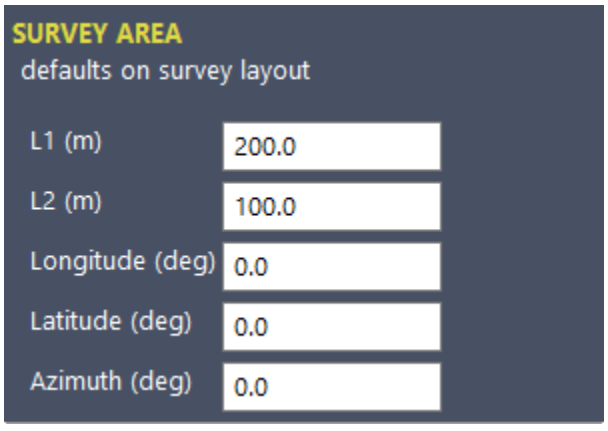


Fig. 9.4: Survey area preferences.

Find in this section the defaults on the geometry of the survey area, to be generated as an alternative to the import from KMZ/KML files. The parameters present are the same as described in the section related to *"Define survey area"* panel of this manual.

9.4 Transceivers

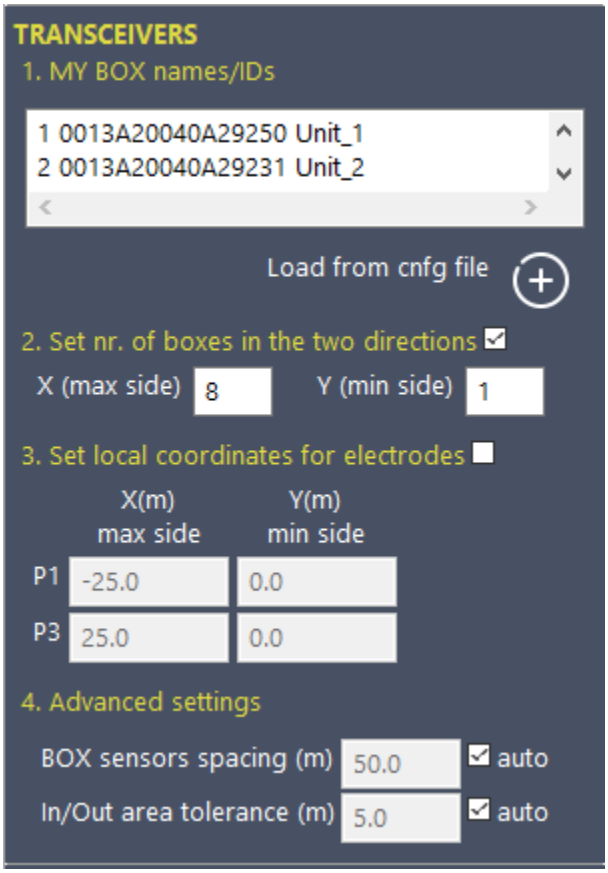


Fig. 9.5: Transceivers preferences.

9.4.1 My BOX names/IDs

This parameter allows to store a **list of strings with the parameters identifying the multisource boxes** for the field operations. **This option is fundamental to save the configuration file for the Multisource software that remotly controls the acquisition.** Each line in the list identifies a box and consists of 3 elements:

- Number of the box unit.
- Serial of the box unt.
- Id of the the box unit.

E.g.: 1 0013A27840A29250 Unit_ERTdesign

The list of box names/IDs can be manually edited or imported from a configuration or .wdat file through the command **Load from cnfg file**.

9.4.2 Nr. of boxes in the two directions

The parameters present here are the same as described in *"Transceivers" section* of *Survey design* panel.

9.4.3 Local coordinates for electrodes

The parameters present here are the same as described in *"Transceivers" section* of *Survey design* panel.

9.4.4 Advanced settings

The parameters present here are the same described in the section related to *Transceivers* of *Advanced Settings* panel.

9.5 Transmissions

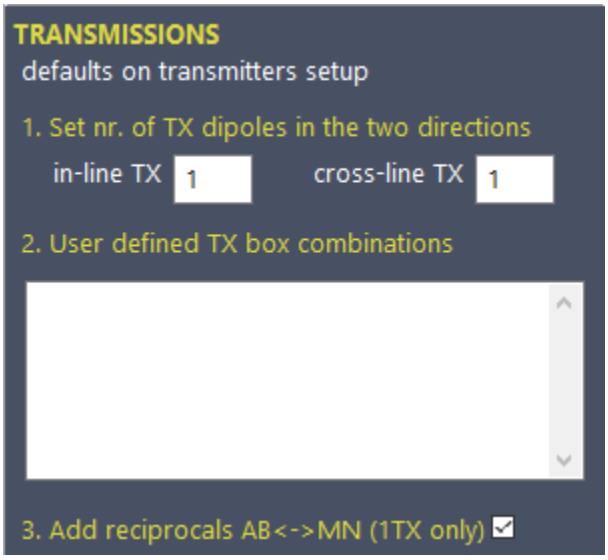


Fig. 9.6: Transmitters preferences.

The parameters present here are the same described in the *Survey Design* panel and in the section related to *Transmissions* of *Advanced Settings*.

9.6 Field parameters

The parameters here store presets related to the fieldwork scenario:

- **Background Rho**: this is the value (in Ohm m) of the site background resistivity.
- **Injected current**: this is the value (in mA) the user supposes will be able to inject into the ground at the transmitting dipoles.

The parameters **Alert on Vmn MIN and MAX** allow to preset the alarm thresholds (in mV) to alert the user in case of too low potentials or in case of risk of *overload* at receivers.

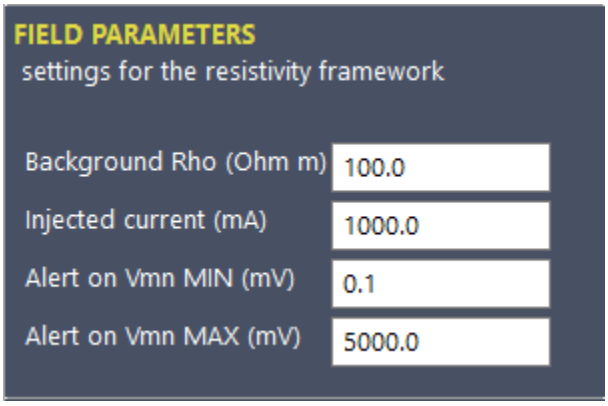


Fig. 9.7: Field parameters preferences.

CHAPTER 10

“Info and documentation” panel

The **Info and documentation** panel gives access to the *release* information of the application and to the documentation.

Fig. 10.1: Info and documentation panel.

- The **About** command returns to online resources about the software project.
- The **License** opens the ERTdesign license.
- The **Docs** section gives access to manuals and tutorials.

CHAPTER 11

“Survey design summary” tab

The **Survey design summary** tab describes the details of the generated set of sensors.

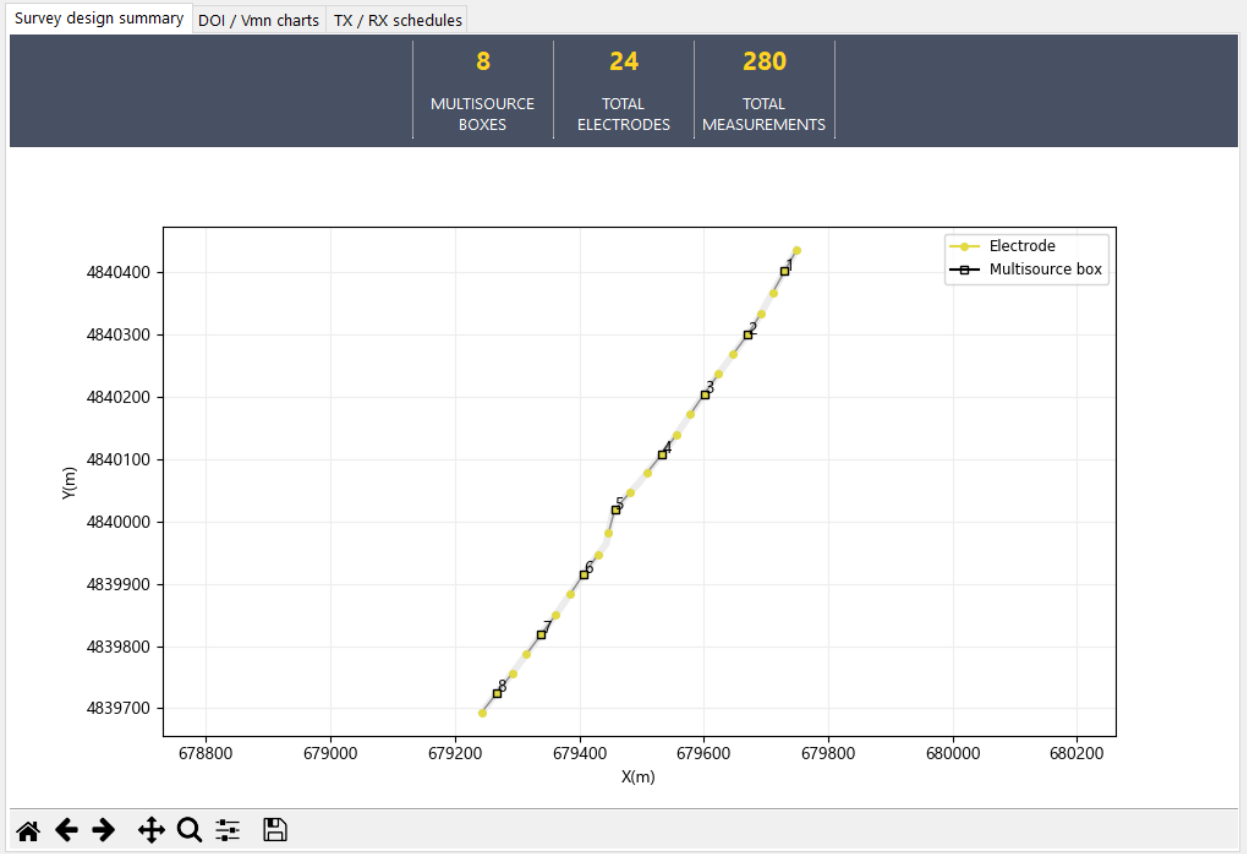


Fig. 11.1: Tab with the sensors summary.

The tab has a horizontal bar at the top with three boxes summarizing the main properties of the project:

- the total number of **Multisource** boxes distributed over the survey area;
- the total number of **electrodes**;
- the total number of **measurements**.

This information is accompanied by a figure containing the map with the plan view of the sensors. The coordinate system (x, y) used for the representation is UTM; conversion of geographic coordinates (Latitude/Longitude) is based on the ellipsoid defined in the *Georeferencing* section of the *Preferences* panel (default is WGS84).

CHAPTER 12

“DOI/Vmn charts” tab

The**DOI/Vmn charts** tab allows to explore the values for **maximum sensitivity and depth of investigation** for the different combinations of receiving dipoles/transmitting n-poles and to check how the Vmn signal changes when the background resistivity or the input current is modified.

The tab consists of a horizontal bar at the top, where the commands for analysis are hosted, and two graphs, one for maximum sensitivity/depth of investigation (left in Fig. 12.1) and one for potential Vmn (right).

12.1 Select transmitters

This section allows to select the transmitting n-pole used to perform the analysis. The tool calculates maximum sensitivity, depth of investigation and potential Vmn related to **all receiving dipoles in combination with that specific TX n-pole**.

12.2 Set field parameters

The parameters here are related to the fieldwork scenario:

- **Background Rho**: this is the value (in Ohm m) of the site background resistivity.
- **Injected current**: this is the value (in mA) the user supposes will be able to inject into the ground at the transmitting dipoles.

To make the changes effective, click on the arrow button **Apply**. The defaults (100 Ohms m and 1000 mA) can be changed in the *Field parameters* section of the *Preferences* panel.

12.3 Sensitivity/depth of investigation chart

This plot represents the values of **maximum sensitivity** (orange *marker*) and of **maximum depth of investigation** (red *marker*) for each combination of TX/RX. Positioning the mouse pointer inside the graph allows to view (horizontal

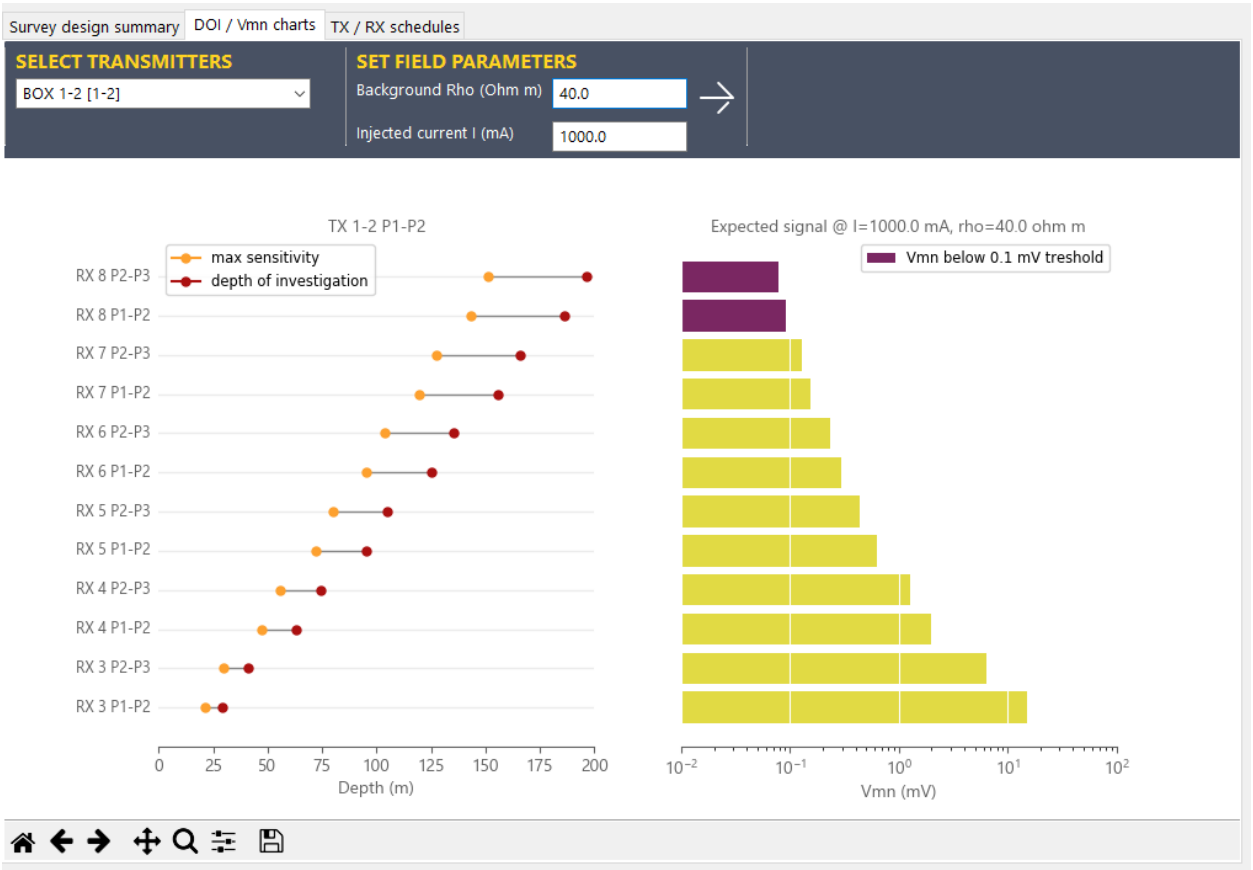


Fig. 12.1: Charts with maximum sensitivity, depth of investigation and expected Vmn signal.

bar at the top-right) the value of the z depth in meters at the selected point.

The **depth of investigation estimate** is performed, first, integrating the analytic sensitivity function – for the given n-pole – and then by calculating the *median z depth*, so that the area under the sensitivity curve is equal to the 50% of the total area (Edwards, 1977[1] ; Baker, 1991[2]).

Note: For peculiar arrangements of the transmitting and receiving electrodes, in particular when dipoles are strongly orthogonal, the sensitivity curve with depth can change of sign and show multiple local extremes, which can make sometimes not very reliable the estimate of the depth of investigation. For these particular measurements, or for models that take into account complex scenarios of 3D distribution of resistivity, or, again, in case of marked topographic variations, it may be useful to save the project to DATA file through the command *Save project* of the *Open and save project* panel and perform a specific modeling with advanced tools, such as the ERTLab64 ™ software.

12.4 Vmn signal graph

This plot represents the expected Vmn potential (in milliVolt) for each combination of the TX/RX. The scale of representation of potentials is logarithmic. The bars are green if the (absolute) value of Vmn is between the minimum and maximum thresholds specified in the *Field parameters* section of the *Preferences* panel. For signals **below the minimum threshold** the bar turns purple, as displayed in Fig. 12.1 : in the example this happens for the P1-P2 and P2-P3 dipoles of RX8 box for the Box1-Box2 transmission n-pole, electrodes P1-P2. Similarly, for signals **above the maximum threshold** (overload risk at the receiver) the bar turns to red. Positioning the mouse pointer inside the graph allows to view (horizontal bar at top-right) the value of the potential Vmn in milliVolt at the selected point.

[1] L.S. Edwards, 1977. A modified pseudosection for resistivity and induced-polarization. Geophysics, 42, 1020-1036.
[2] Barker, R.D., 1991. Depth of investigation of collinear symmetrical four-electrode arrays. Geophysics, 54, 1031-1037.

CHAPTER 13

“TX/RX schedules” tab

The **TX/RX schedules** tab contains the sheets with the coordinates of the generated electrodes, with details on n-poles and measurements pseudo-plots.

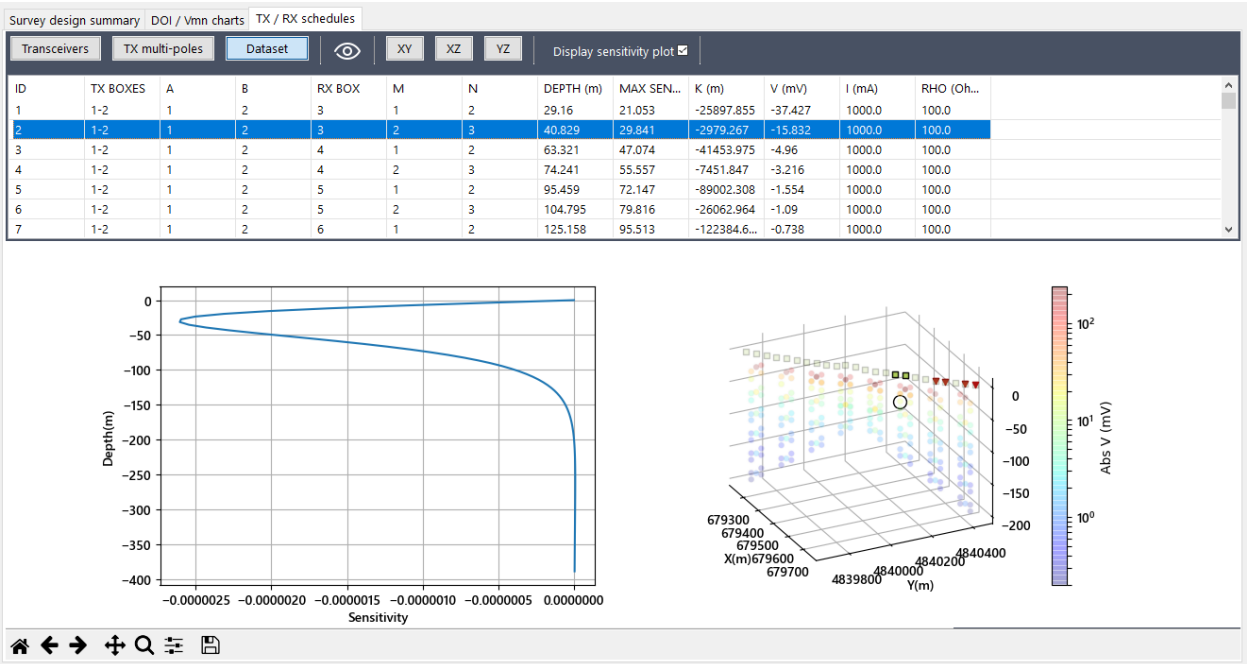
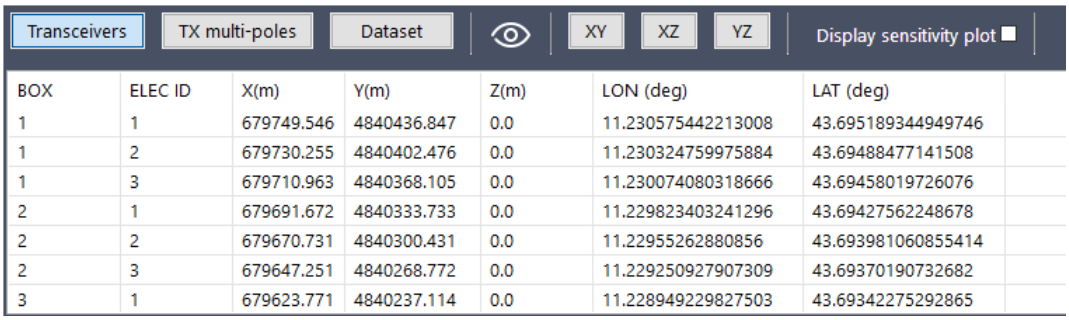


Fig. 13.1: Tab with sensor properties and pseudo-plots.

The tab consists of a topmost section with the toggle commands for selecting schedules to be displayed and a lower portion hosting the graphs.

13.1 Transceivers schedule



BOX	ELEC ID	X(m)	Y(m)	Z(m)	LON (deg)	LAT (deg)
1	1	679749.546	4840436.847	0.0	11.230575442213008	43.695189344949746
1	2	679730.255	4840402.476	0.0	11.230324759975884	43.69488477141508
1	3	679710.963	4840368.105	0.0	11.230074080318666	43.69458019726076
2	1	679691.672	4840333.733	0.0	11.229823403241296	43.69427562248678
2	2	679670.731	4840300.431	0.0	11.22955262880856	43.693981060855414
2	3	679647.251	4840268.772	0.0	11.229250927907309	43.69370190732682
3	1	679623.771	4840237.114	0.0	11.228949229827503	43.69342275292865

Fig. 13.2: List with the properties of the transceivers.

The list of the transceivers contains information on the box electrodes:

- Multisource box identifier.
- Electrode number (1, 2 or 3).
- X, Y and Z UTM coordinates in meters.
- Geographic coordinates: longitude and latitude in degrees and decimals of degree.

13.2 TX multi-poles schedule

TX BOXES	A	B
1-2	1	2
1-2	2	3
1-2	1	3
2-3	1	2
2-3	2	3
2-3	1	3
3-4	1	2

Fig. 13.3: List with the properties of the TX multi-poles.

The list of TX multi-poles contains information on the TX combinations:

- Identifiers of the group of TX boxes.
- TX+ (A) box electrode.
- TX- (B) box electrode.

13.3 Dataset schedule

The list of measurements contains information on the total set of TX/RX combinations. Each row displays:

- The TX boxes combinations.

- The electrodes of each box working as TX+ (A) and TX- (B).
- The RX box.
- The electrodes of the RX box working as M and N.
- The **maximum depth of investigation** of the n-pole (in meters).
- The depth at which the **maximum sensitivity** of the n-pole is recorded (in meters).
- The **K geometric factor** of the n-pole.
- The expected **Vmn signal** (mV).
- The value of the **injected current** at TX (mA) that produces the potential Vmn at the receiving dipole.
- The **apparent resistivity** (Ohm m) for the measurement.

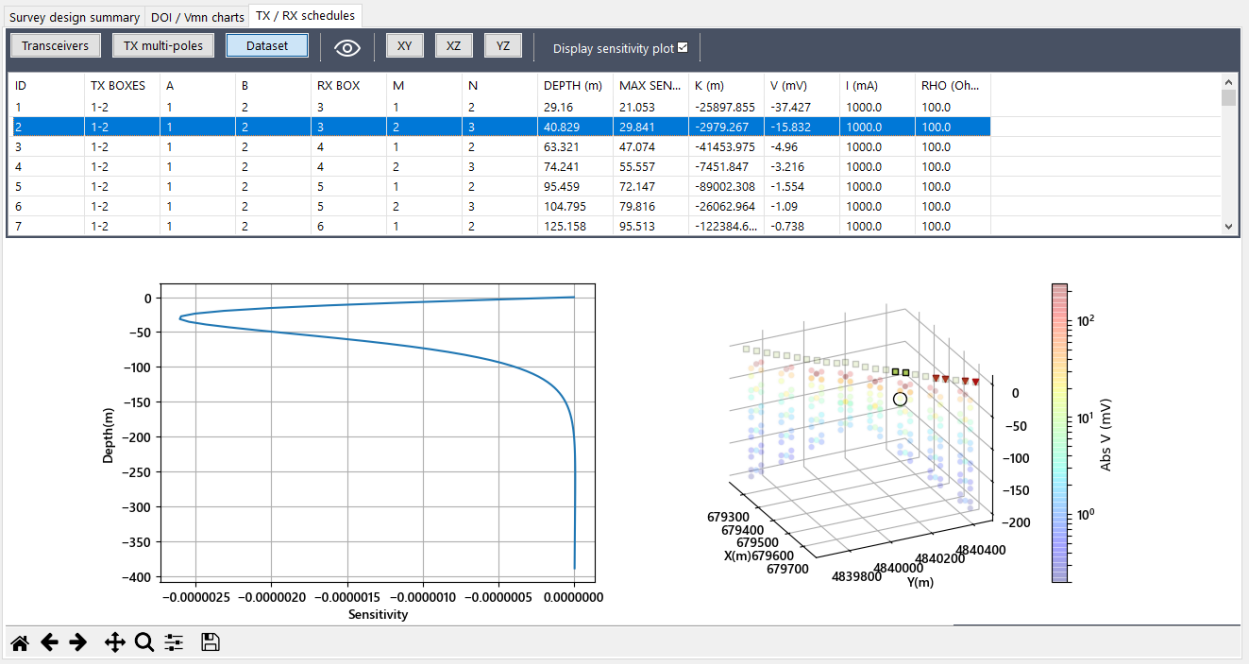


Fig. 13.4: List with the properties of n-poles.

The list of n-poles is the only one that has interactive features: selecting one table row allows **to highlight the measurement** in the pseudo-plot view: only the electrodes of the n-pole are colored (red for TX, green for RX) and the measurement is emphasized by a highlighter circle. Remaining electrodes and measurements are represented in transparency. In addition, if the **Display sensitivity plot** checkbox is checked, the sensitivity plot for that n-pole is shown. To remove the transparency of the quadrupoles from the graphs click on the command **Refresh view** of Fig. 13.5.

Fig. 13.5: Refresh view command.

The XY, YZ, XZ buttons allow to define the views on each of the three planes of the space.

13.4 Pseudo-plot

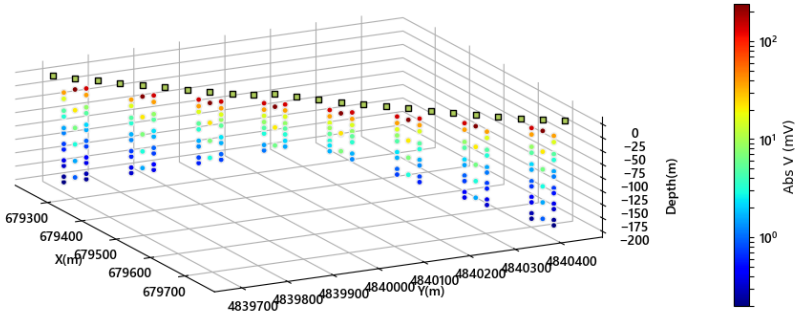


Fig. 13.6: Example of pseudo-plot.

The pseudo-plot sumarizes the salient features of n-poles in terms of coverage, depth of investigation and signal strength. The plot displays the position of the sensors. The n-poles (colored points) are defined on the basis of the graphic properties described below.

- On the xy plane, then-pole is conventionally placed at the **center of the RX dipole**.
- The n-pole is placed at the z depth corresponding to the **maximum depth of investigation**.
- The color scale assigned to the measurements is the one defined by the range of **absolute values of the Vmn** signal.

13.5 Sensitivity plot for the quadrupole

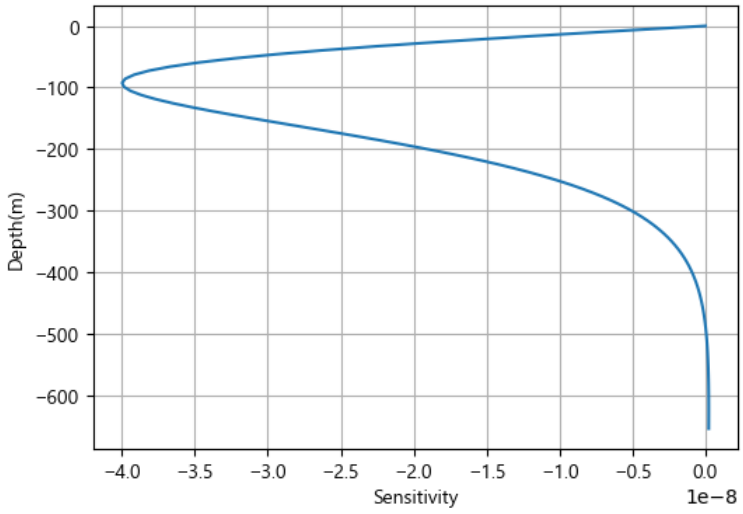


Fig. 13.7: Example of sensitivity plot.

This plot shows the behavior of the **sensitivity of n-pole with depth**. This is the function that is integrated for the calculation of the maximum depth of investigation.

CHAPTER 14

Credits

ERTdesign would not exist without the fundamental contribution of the resources listed below. The author is deeply grateful to developers and *community* who have contributed to implement, maintain and document these tools.

14.1 Software and libraries

Python 3.6.5 and Python Standard Library

License: https://docs.python.org/3/license.html
Learn more: https://www.python.org/

wxPython 4.0.1

License: https://wxpython.org/pages/license/
Learn more: https://wxpython.org/

matplotlib 2.2.2

License: https://matplotlib.org/users/license.html
Learn more: https://matplotlib.org/

numpy 1.14.3

License: http://www.numpy.org/license.html
Learn more: http://www.numpy.org/

scipy 1.1.0

License: https://www.scipy.org/scipylib/license.html
Learn more: https://www.scipy.org/

pyinstaller 3.3.1

License: http://www.pyinstaller.org/license.html
Learn more: http://www.pyinstaller.org/

14.2 Document generator

The application documentation was generated using the tools:

sphinx 1.7.4

License: https://github.com/sphinx-doc/sphinx/blob/master/LICENSE
Learn more: http://www.sphinx-doc.org/en/master/

sphinx Read the Docs theme

License: https://github.com/rtfd/sphinx_rtd_theme/blob/master/LICENSE
Learn more: https://readthedocs.org/

14.3 Icons

The application icons are designed by Enes Dal.

License: https://creativecommons.org/licenses/by/3.0/
Learn more: https://www.iconfinder.com/iconsets/freeline