



**CSAZ  
CESIUM MAGNETOMETER  
OPERATING ZONE  
SOFTWARE**

*Operation Manual*

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## I. INTRODUCTION

CSAZ is a stand alone Windows™ program designed to inform Cesium magnetometer users about proper sensor orientation in all parts of the world and in all survey directions. CSAZ also provides information about the Earth's magnetic field parameters including field strength (total field), inclination (angle of the Earth's field relative to the surface of the Earth) and declination (angle between magnetic north and true or geographical north). Using the IGRF (International Geo-Magnetic Reference Field) model, CSAZ presents a quick and easy way to determine these values anywhere in the world.

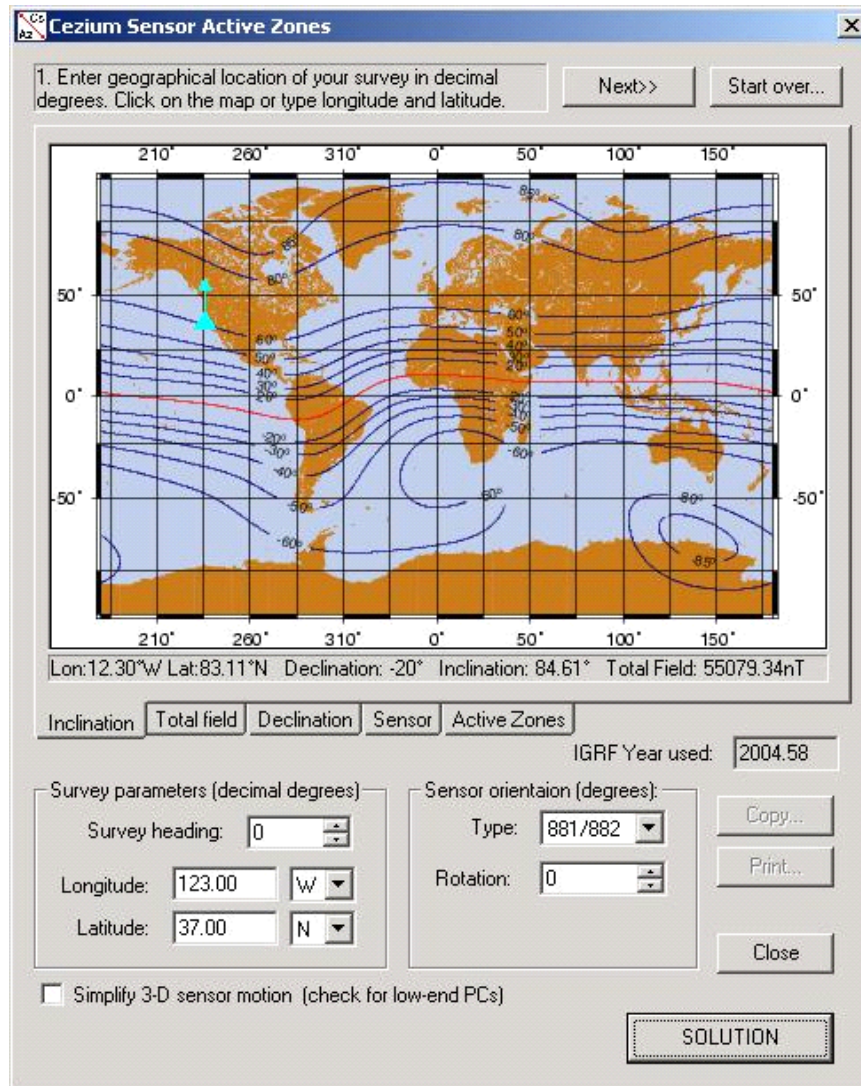
The software operates in two modes, Simple Solution and Advanced Operation. In Simple Solution, after entering latitude and longitude of the survey area (or clicking on the world map) and indicating the survey direction, the program provides an immediate graphical model of the properly oriented cesium sensor. The view can be rotated to provide various viewing angles of the orientation that provides maximum signal and best performance. In Advanced Mode, the user may vary the survey direction or the orientation of the sensor rotation and or tilt to observe sensor signal-noise-ratio as a function of orientation and survey direction.

## II. SIMPLE CSAZ OPERATION

For users not familiar with magnetometer orientation principles CSAZ provides a quick “best fit” graphical solution. The program employs a Mini-Wizard located at the top of the dialog window to instruct the user in the proper sequence of data entry and solution generation. Simply follow these steps (press “Start over” to repeat the procedure):

- 1) *Enter geographical location of your survey in decimal degrees. Click on the map or type longitude and latitude.* This first step defines the survey location. Your position can be entered manually (north or south latitude, east or west longitude) or entered automatically by clicking your position on any of the maps (See Figure 1 below.). When the survey position is entered manually, the survey location (arrow) will be updated on the map. Press “Next”. (Note: you can select on of the other map views – total field, inclination, or declination – and this will not affect the orientation solution.)
- 2) *Enter true geographical heading of your survey.* Type (or use the spin box – up and down arrows to the right of the data entry box) to enter your survey heading. In general, surveys are run in a bi-directional mode and because the cesium sensor has automatic hemisphere switching, the solution for one direction is applicable in the opposite direction as well. Note that this entry is true heading, NOT magnetic heading. Therefore you must not use a magnetic compass to obtain this information. However, in many cases magnetic heading is very close to the true geographical heading. The declination value in the window below the maps indicates variance between true north and magnetic north. Press “Next” when you have completed this step.

- 3) *Select your magnetometer model: Generic (two degrees of freedom) or 881/882 (one degree).* If you have G-881/882 magnetometer, select “881/882”. Otherwise, select “Generic” which is appropriate for the G-858, G-822/823 and G-880. Because of the fixed sensor head employed in the G-881/882 the program allows rotation of the sensor in single plane only (rotating the entire magnetometer fish tube). The other models allow rotation AND tilt (forward and backward motion of the sensor on its mount) and thus provide two degrees of freedom. Do not enter any orientation angles at this time. Press “Next” when complete.



**Figure 1 CSAZ-II Main Window**

- 4) *Now press the “Next” or “Solution” button to see the suggested sensor orientation.* This step causes the program to calculate the proper sensor orientation and displays a solution window that provides an image of the 3-dimensional (rotatable) sensor model. (See Figure 2 below) The model is labeled

forward (direction of travel), down (earth surface direction) and right (right hand side of the sensor platform). A brief description of how the sensor is to be oriented is displayed in the Mini-Wizard window box. Moving the mouse cursor over the model while holding down the left mouse button will rotate the model. Pressing the keyboard Ctrl button and left mouse button will allow in and out zooming of the 3-D picture. The graphical model shows the proper sensor orientation relative to the magnetometer frame and direction of travel. You may then select the “Active zones” tab to see the theoretical Larmor signal amplitude with the selected orientation and direction of your survey (your survey direction will be shown by the red arrow). You may copy this picture to the clipboard by pressing the Copy button or print it for future reference by clicking the Print button.

- 5) To repeat the procedure press the “Start over” button.

The recommended solution also can be obtained by pressing the “SOLUTION” button at any time during data entry or revision without using the mini-wizard. When the “SOLUTION” is pressed, the program uses the currently entered survey parameters and selected magnetometer type to calculate the optimal orientation solution.

**NOTE: The simple solution is generated using specific rules that encompass field inclination angle, sensor angle and active zones as defined by the survey location and IGRF field information. There are some survey parameters that are not considered, for instance whether the survey will be bi-directional only or whether tie lines will be used in an orthogonal survey line method (cross hatch).**

**Since simple solution cannot anticipate all of these variants, we strongly recommend that after receiving a simple solution, users make trial adjustments to the sensor rotation and tilt while watching the Active Zone signal-to-noise ratio display to see if improvements or more generic solutions can be found that better serve the survey design. This is the subject of Section IV.**

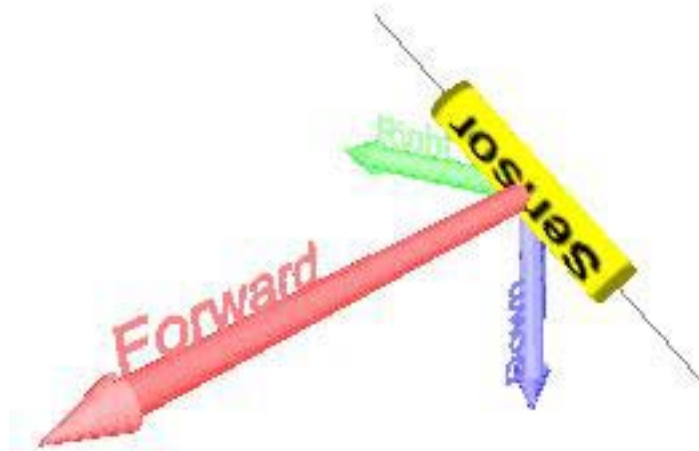
### **III. CSAZ ADVANCED MODE AND DETAILED DESCRIPTION**

The following section describes the main CSAZ window in detail:

- 1) **Mini-Wizard Window** – At the top of the program box provides step-by-step operation instructions. Simply follow these directions to generate a recommended solution for your magnetometer type, survey area and direction. See section I.
- 2) **Tabbed Window Control** – This area is available in the middle of the CSAZ dialog box with the following features:
  - a) **Inclination** - This tab shows a world map of the inclination of Earth’s magnetic field. When the mouse is moved over the map, its geographical position in

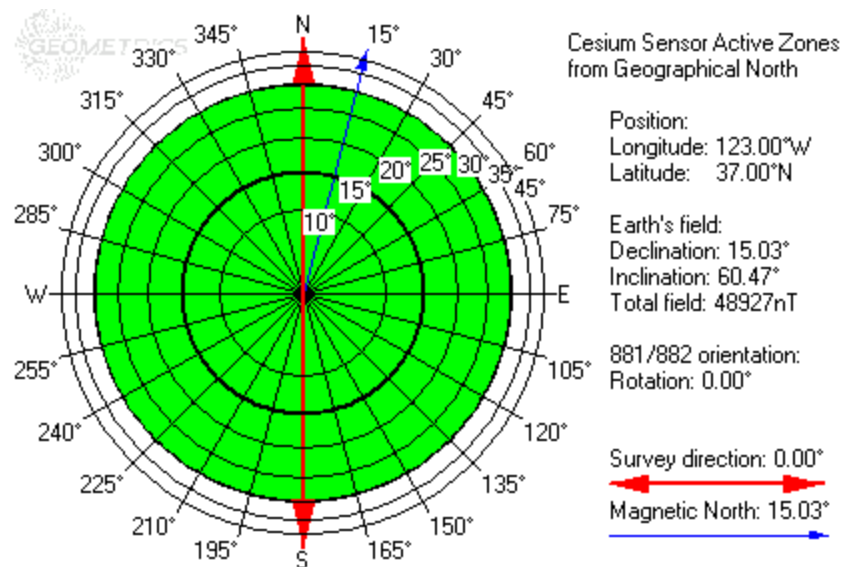
Latitude and Longitude is shown on the status line at the bottom of the screen along with the magnetic field parameters (declination, inclination and total field) computed using the IGRF model. Clicking on the map sets the survey location, marked as a triangle and an arrow. The middle of the triangle is the actual survey position.

- b) **Declination and Total field** - These tabs are identical to the first tab except they display world declination and total field maps. They are for information purposes only and have exactly same functionality as the first tab.
- c) **Sensor** - This tab shows a 3-D picture of the sensor along with the magnetometer body axis. (See Figure 2 below) Dragging the mouse cursor with the left mouse button depressed rotates the picture. Dragging with both the left mouse button and Ctrl key depressed will zoom the picture in and out. This graphic model is provided to help the user understand how the cesium magnetometer sensor should be oriented relative to the magnetometer body. There is no relationship between the picture orientation and the heading of the survey.



**Figure 2 Graphical Sensor Model**

- d) **Active zones** - This picture displays theoretical normalized Larmor signal strength as a function of Geographical (true) survey heading (see Figure 3 below). Signal strength is plotted as a polar diagram with the circle grid values marked in degrees (white boxes with degrees below). These values represent the angle between the sensor axis and the Earth's magnetic field vector. For instance the 45° circle corresponds to maximum signal strength. Maximum signal is always achieved when the angle between sensor's long axis and Earth's magnetic field is 45°. It is recommended that for best performance the theoretical signal exceed the 15° degree circle (bold circle) in the survey direction (see below for more discussion).



**Figure 3 Active Zone Larmor Signal Plot**

The outer ring of the polar plot represents all possible survey directions relative to true North. The red arrow on the polar plot shows the actual survey direction and blue arrow shows the direction of magnetic North. Note that the survey direction arrow is bidirectional, meaning that the survey is usually performed in alternating lines at 180° with respect to one another.

- 3) **IGRF Year** - To compute the Earth's magnetic field parameters, the program uses the IGRF (International Geomagnetic Reference Field) model and current PC time. The time is displayed in typical IGRF notation (i.e., decimal year.)
- 4) **Survey Parameters** - These include approximate survey location (in decimal degrees) and survey heading (decimal degrees from geographical or true North). The location can be set by clicking on one of the maps or typed in the data box. Heading must be entered by hand (or use the spin box up/down arrows to set it using the mouse). There is no need to set very precise locations or headings. An accuracy of +/- 0.5 degree is generally sufficient for good results.
- 5) **Sensor Orientation** - Depending on the type of magnetometer employed, there will be one or two degrees of freedom in sensor orientation. With the sensor rigidly fixed to the main sensor tube, the G-881/882 system has one plane of rotation (spinning the main tube body). Other cesium sensors (G-858, G-822/823 and G-880) can both rotate and tilt relative to the sensor platform. Therefore the two choices for magnetometer type are "Generic" and "881/882", generic referring to the other systems listed above. To better understand how the angles affect sensor orientation, use the "Sensor" tab to show the magnetometer platform frame axes and how the sensor should be oriented relative to these axes.
- 6) **Solution** - This button is provided obtain one of the predefined orientation solutions based on survey area location, survey proposed heading and magnetometer model. When this button is pressed the program sets the sensor orientation angle to the most optimal value and activates the "Sensor" tab to show a three-dimensional picture of the sensor. An explanation of the orientation is displayed at the top of the window in the Mini-Wizard area. If there is no solution is available, a warning dialog is posted. To inspect the active zones for a proposed solution, press the "Active zones" button.



- 7) **Copy/Print** - These buttons copy the currently activated window onto the Windows™ Clipboard (as a bitmap) for use with other applications or prints them to an installed printer. Both the “Active zones” window content and the 3-D sensor orientation pictures can be printed or copied.
- 8) **Simplify 3-D Sensor Motion** - This button should be checked if a low end PC without a 3-D graphics card is used to run CSAZ. Typical output will be jerky if there is insufficient video processing power. When this option is selected, the program shows only the outline of the sensor model while being rotated.
- 9) **Close** - This button closes the program.

## IV. EXAMPLES MAKING SENSOR ADJUSTMENTS FOR OPTIMUM SIGNAL

This section describes the process of making experimental adjustments to the rotation and tilt of the sensor for optimizing these parameters for given headings and survey locations. We will consider two examples, one in the northern mid-latitudes and one on the magnetic equator. We suggest that you open CSAZ to follow along with the process.

### 1) Example 1

Consider the following scenario:

A survey is conducted in the North Sea at Longitude 2° E, Latitude 57° N. Survey direction is 90° or true East (& West). We will use this in Generic Survey mode (two degrees of freedom).

**Cesium Sensor Active Zones**

1. Enter geographical location of your survey in decimal degrees. Click on the map or type longitude and latitude. Next>> Start over...

Lon: 159.94°W Lat: 34.75°S Declination: 19° Inclination: -55.94° Total Field: 47284.20nT

**Survey parameters (decimal degrees)**

Survey heading: 90

Longitude: 2.00 E

Latitude: 57.00 N

**Sensor orientation (degrees):**

Type: Generic

Rotation: 45

Tilt angle: 0

☐ Simplify 3-D sensor motion (check for low-end PCs)

IGRF Year used: 2004.67

Copy... Print... Manual... Close

**SOLUTION**



Clicking on the “Solution” button generates the following solution as seen in Figure 5:

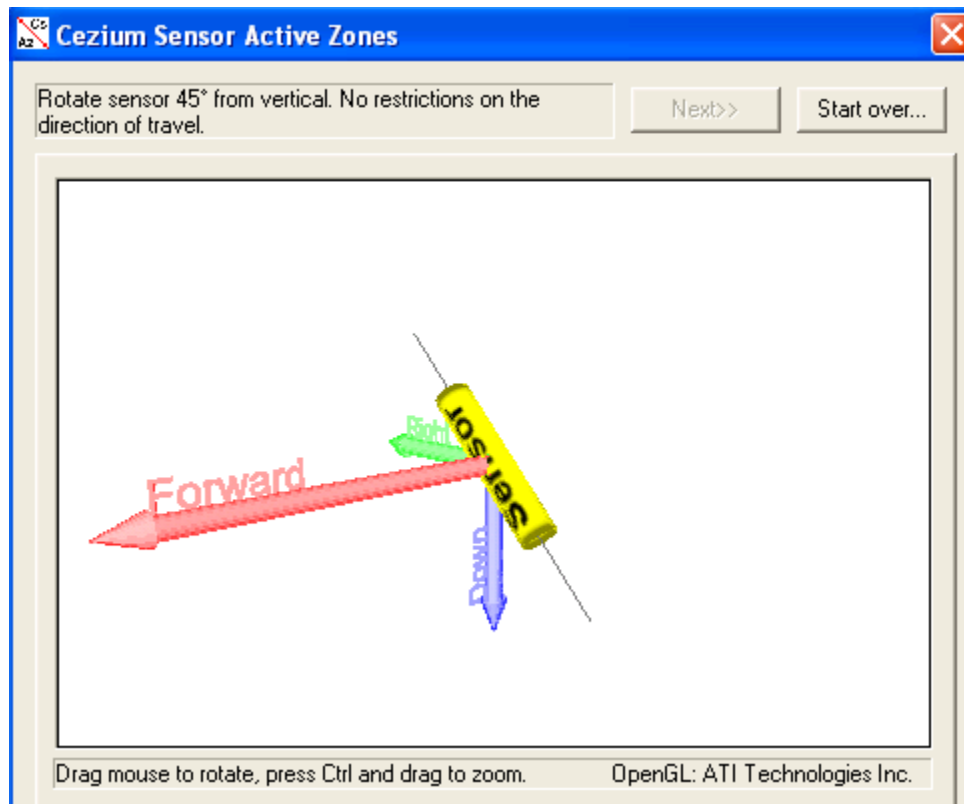
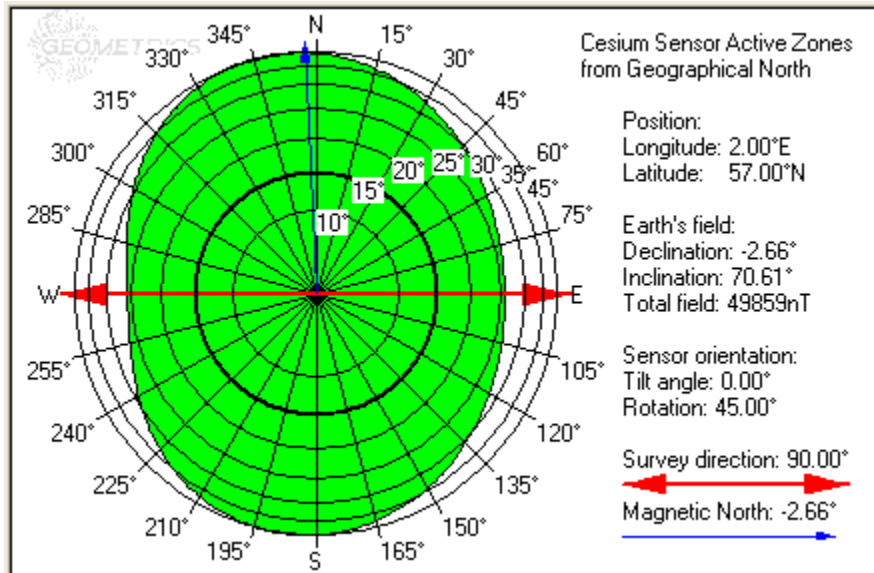


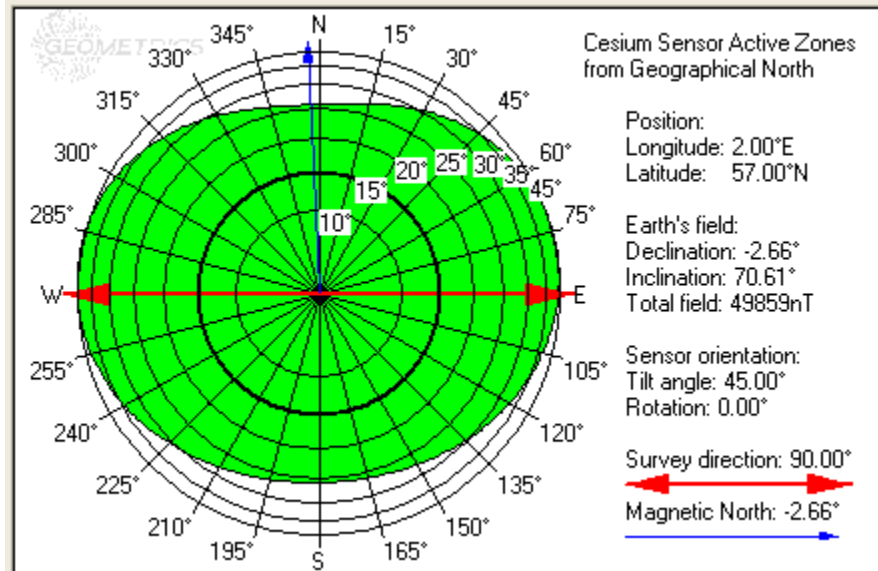
Figure 5

With following Active Zone plot:



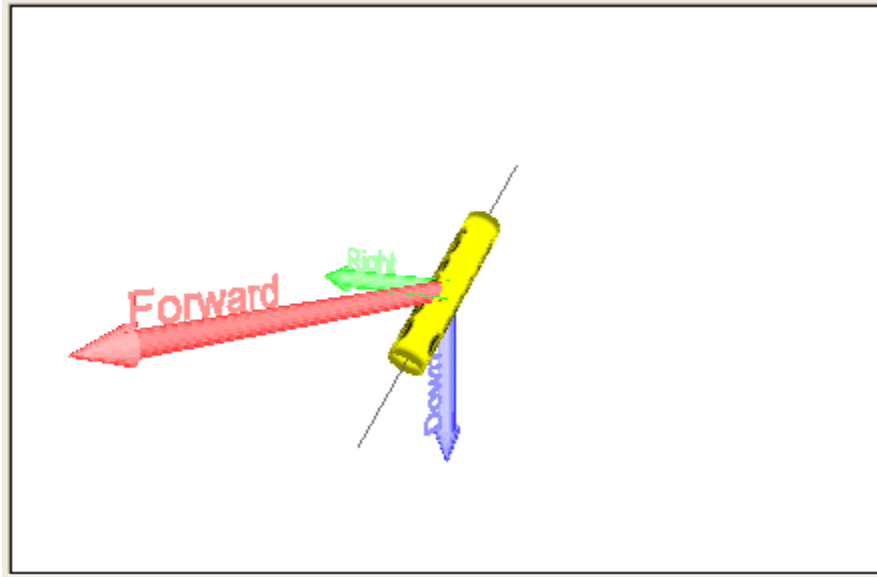
**Figure 6**

Note that the “kidney bean” long axis in Figure 6 is in the North-South direction. We would have higher signal if the pattern were rotated 90°. Now with the Active Zone plot displayed, change the rotation to 0° and the tilt to 45°. Figure 7 shows the new active zone plot.



**Figure 7**

Clicking on the sensor tab gives us this orientation for optimum signal:



**Figure 8**

The rotated orientation in Figure 8 will give us maximum signal in the East-West survey direction.

## **2) Example 2**

Consider the following scenario: The survey is conducted at Longitude  $45^{\circ}$  W and  $2^{\circ}$  N off the coast of Brazil. The survey direction is  $40^{\circ}$  from true north and we are using a G-882 magnetometer with one degree of freedom.

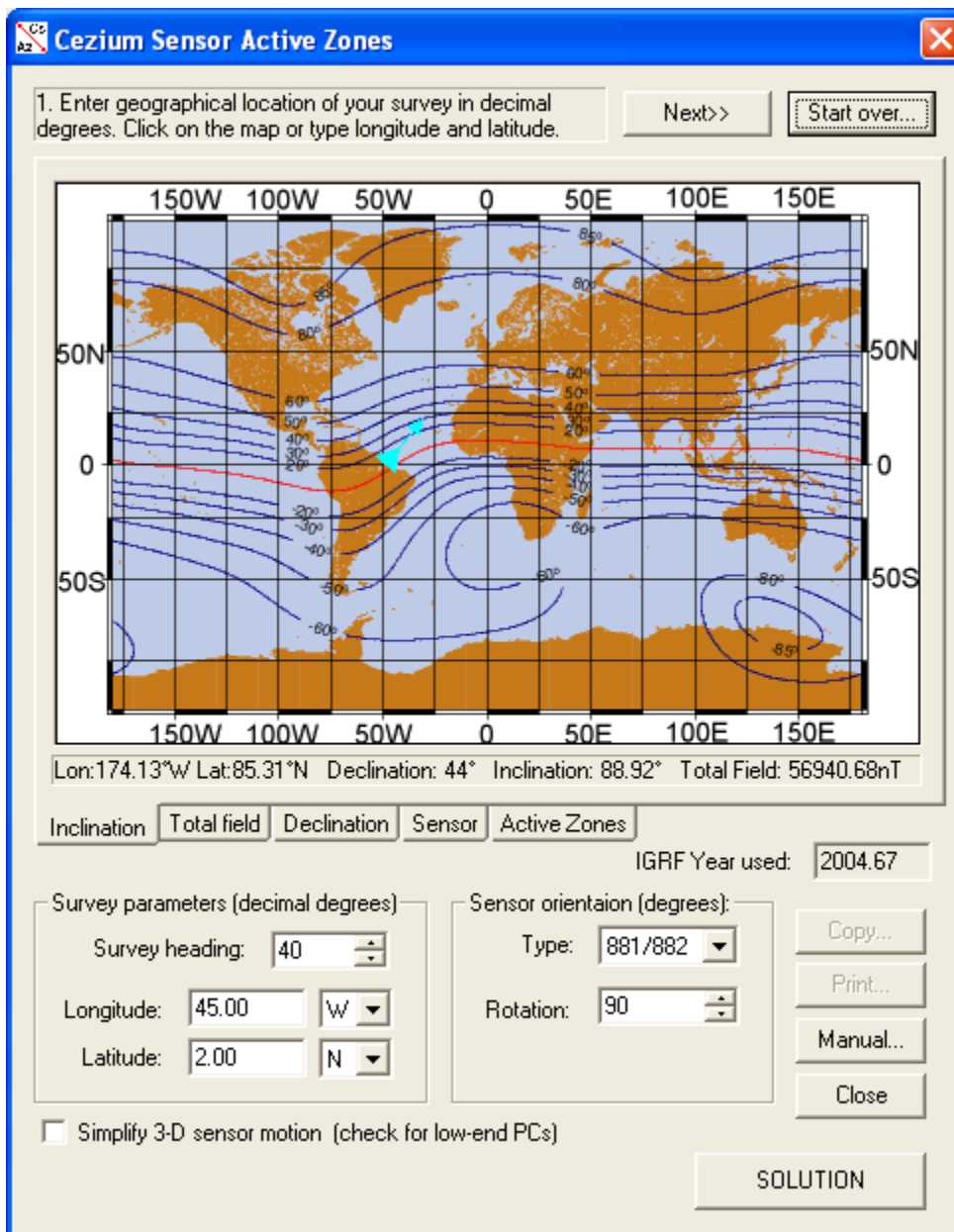


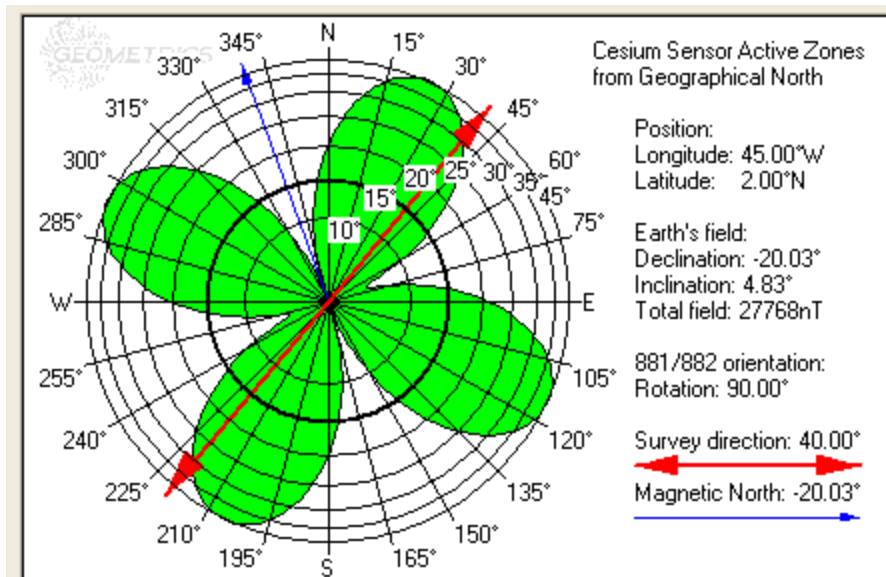
Figure 9

Clicking on the solution provides this result which recommends rotating the sensor 90 degrees as shown on Figure 10 below:



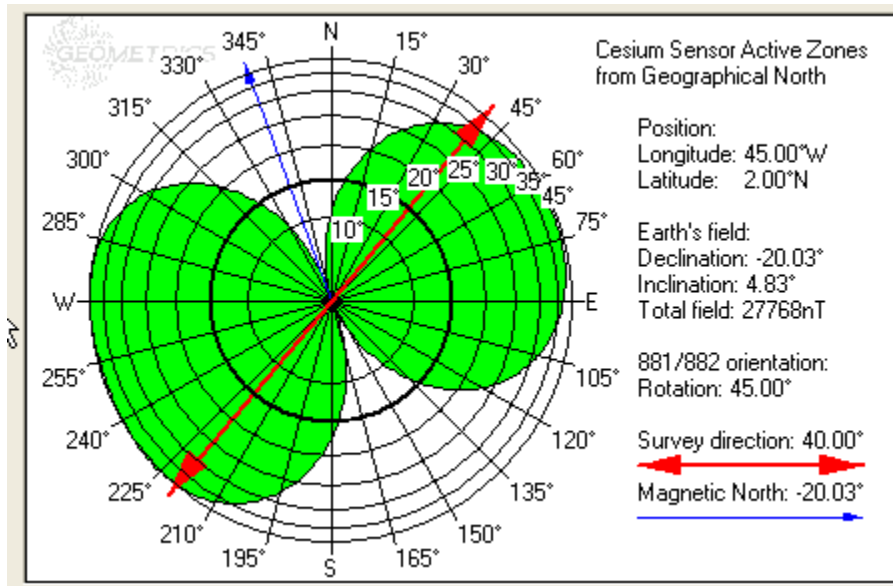
**Figure 10**

Now click on the Active Zone tab and see this signal-to-noise pattern:



**Figure 11**

While this solution shown in Figure 11 provides an optimal solution for bi-directional surveys and orthogonal surveys, we may determine that we will only be using a bi-directional survey path. In this case we can adjust the rotation to give wider “latitude” in ship’s heading to improve overall performance. Set the rotation to 45° and observe the pattern shown in Figure 12 below.



**Figure 12**

## **CONTACT:**

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