

# User Manual

for

## G-864 Cesium Backpack Magnetometer and G-864G Cesium Backpack Gradiometer

P/N 770-00105-01 Rev. B1

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**GEOMETRICS**  
Simplify your search

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# CE

# 03

March 14, 2003

Sunnyvale, California, USA

## EC DECLARATION OF CONFORMITY

We,

Geometrics, Inc.  
Geometrics Europe  
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declare under our sole responsibility that our marine magnetometers, models G-864 and to which this declaration relates are in conformity with the following standards:

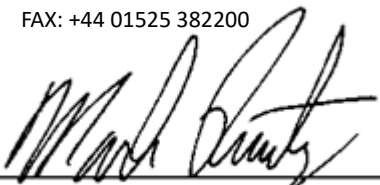
EN 55022: 1995, EN50082-2: 1995, ENV 50140: 1994, ENV 50141: 1994, EN 61000-4-2: 1995, EN 61000-4-4: 1995

per the provisions of the **Electromagnetic Compatibility Directive 89/336/EEC** of May 1989 as Amended by **92131/EEC** of 28 April 1992 and **93/68-EEC, Article 5** of 22 July 1993.

The Technical documentation required by Annex IV(3) of the Low Voltage Directive is maintained by Christopher Leech of Geometrics Europe (address below).

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**Warning**

**This is a Class A product. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.**

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## 1.0 Geometrics' G-864 Cesium Backpack Magnetometer

Geometrics, Inc. is known worldwide for our total field magnetometers and is a leader in magnetometer development. Our magnetic sensors measure the total magnetic field (total field) without directional information. In other words, they take the scalar measurements of the magnetic field, and produce a value that is the magnetic field intensity, regardless of the direction in which the field propagates.

Magnetometers measure the Earth's magnetic field, which occurs naturally and varies with time and in the presence of ferrous materials. Magnetometers are used in a variety of applications and are modified for airborne, marine, and land-based surveys. They can be used to map and locate man-made objects or be used to detect naturally occurring iron or other ferrous minerals associated with economic ore deposits. For example, the mineral magnetite is often associated with kimberlite pipes (diamonds), native gold, copper, and other economic deposits.

Man-made ferrous objects, such as those associated with archaeology, civil engineering, unexploded ordnance, etc., alter the Earth's magnetic field in a way that is detectable with a magnetometer. The strength of the altered field depends on many factors, including the size, iron content, orientation, and depth of the ferrous object. More detailed information on magnetic theory and survey design can be found in the *Applications Manual for Portable Magnetometers*, available on the Resources page of our website, <https://www.geometrics.com/resources/>.

The G-864 Backpack Magnetometer System is based around the highly adaptable G-862 airborne magnetometer sensor. We chose this sensor for its adaptability to different survey types. The G-862 is an optically pumped, cesium, total field magnetometer sensor, which uses the non-radioactive isotope of cesium, in gas form, to make a measurement of the earth's magnetic field. For details on the internal operation of this sensor, please see the research paper on our website Resources page, by keyword searching "Optically-pumped Cesium Magnetometers."

### 1.1 Sensor Performance

The G-862 sensor operates over the earth's magnetic field range of 20,000 to 100,000 nT. Absolute accuracy depends on the sensor orientation, internal light shift, and the accuracy of the external counter's time base. An error due to sensor orientation does not exceed  $\pm 0.25$  nT or 0.5 nT peak-to-peak (p-p) throughout the active zones.

For optimal signal levels while surveying in the far northern and southern latitudes, the sensor will be mounted at  $45^\circ$ ; for mid latitude zones including as far south as Northern S. America, the sensor will be mounted vertically. In a narrow band about the earth's magnetic equator (note not zero latitude necessarily), the sensor will be mounted at  $45^\circ$  or horizontally, with the top of the sensor tilted either North or South as the surveyor walks the survey line. To verify which zone the survey area is in, please see [Appendix I: CSAZ](#) for more detailed information.

Like all magnetometers, performance is primarily dependent upon the counting circuitry employed and the quality of the installation procedures. Compensation and/or noise reduction techniques may be required to minimize magnetic effects caused by navigational and positional errors, radiated electromagnetic noise, and heading error. A complete list of system specifications can be reviewed in [Appendix V: G-864 Backpack Magnetometer Specifications](#).

## 1.2 Environmental Considerations

Optically pumped magnetometers are more sensitive to magnetic field variation than proton and fluxgate types. To realize the full performance of the cesium-vapor technology, special precautions must be taken during planning and execution of the installation.

### 1.2.1 Vibration

Intense vibration of system circuitry can induce micro-phonic noise and shorten the life of system components. The intense vibrations are typically not seen in a walking survey, however if in larger arrays the system is mounted on a cart behind an ATV it may be a concern. Some attachment points may be prone to intense vibration, and we recommend the use of good quality shock mounts that are designed to isolate the sensor components from as much of the intense vibration as possible.

Special care should be taken in securing or routing the cable to reduce the risk of encountering hard or sharp objects that could damage the cable. Those components used to mount the sensor or any or any objects near this sensor should be non-magnetic to minimize the system heading error.

### 1.2.2 Temperature

The G-864 system is designed to operate over an ambient temperature range of -35 to +50°C. In an enclosed region it may be necessary to provide adequate cooling by free-flowing air. If the sensor and electronics are in an unconfined region, convection cooling is generally adequate. The cesium lamp only needs to dissipate 3 to 4 watts of heat and when operating in cold regions providing some insulation or baffling will help reduce the sensor's power consumption.

The sensor requires a minimum warm up period of 10-15 minutes. In cold regions the warmup period will be longer and, to avoid delay, we recommend that the sensor power be left on overnight when ambient temperatures are expected to fall below -10°C.

## 2.0 Unpacking the G-864

The components shipped with the system will vary depending on the configuration ordered. The G-864 is configurable to address the survey needs of both near and deep surface investigations. Deeper geological investigations require a sensor mounted further from the ground surface to remove the sensor from the magnetic effects of surface debris or other near surface artifacts. For near surface investigations, such as archaeology and UXO surveys, having the sensor closer to the ground is important to enhance the size of the target anomaly. Moreover, for near surface surveys, having multiple sensors as a linear array allows the operator to cover more area in a single survey line, as well as calculate the gradient measurement which will provide more information on the targets located in the data.

For deep search, the G-864 is configured with the sensor mounted onto a backpack and extending above the operator's head. The sensor will be connected to the electronics module by a 3ft. (1m) cable, to fit onto the backpack without snagging branches or other obstructions.

For near surface investigations, the G-864 is configured with either one or two sensors (for the gradiometer configuration) and mounted onto an aluminum staff assembly that is positioned out in front of the surveyor. The sensor(s) will be connected to the electronics module by a 9ft. (2.7m) cable, to allow for

mounting on a staff for carrying or on a cart for towing behind a vehicle. The sensor electronics module is well suited to act as a counterweight on the staff to make a balanced unit for easy surveying.

## 2.1 System Inventory

Below is a list of parts and quantities included in the single sensor Magnetometer System with Backpack Mounted or Staff Mounted Sensor, and the dual sensor Gradiometer System with Staff Mounted Sensors.

\*Batteries and Quantities depend on Battery Option chosen at time of order.



P/N	Description	Backpack Mount	Staff Mount	Gradiometer
900-00390-02	G-864 BACKPACK ASSEMBLY	1	1	1
900-00308-01	G-864, TABLET GETAC & CHARGER	1	1	1
860-00162-01	G864 TABLET CHEST HARNESS	1	1	1
860-00128-01	GPS ASSEMBLY-TALLYSMAN	1	1	1
850-00005-01	CARRYING CASE ASSEMBLY	1	1	2
900-00342-33	G-862 CESIUM ELECTRONICS & SENSOR W/3 FOOT CABLE	1	none	none
840-00095-01	G-864, DATA-LOGGER TO MAG 3FT CABLE, SINGLE MAG	1	none	none
820-00630-12	180 DEGREE SENSOR CLAMP ASSY, G-864 (Clamp & 1ft Staff)	1	1	2
820-00595-01	G-86X ELECTRONICS CLAMP ASSY W/LOCKING KNOBS	2	2	4
900-00342-39	G-862 CESIUM ELECTRONICS & SENSOR W/9 FOOT CABLE	none	1	2
840-00095-02	G-864 DATA-LOGGER TO MAG 7.5FT CABLE, SINGLE MAG	none	1	none
840-00207-01	G-864, 2 MAG GRADIOMETER MAG TO DATALOGGER CABLE	none	none	1
820-00123-01	LOCKING SENSOR STAFF B	2	5	5
820-00127-01	LOCKING STAFF JOINING KIT	none	none	1
340-00022-02	GRADIOMETER TEE-LOCKING TYPE	none	none	1
820-00109-01	ASSY, G-86X STRAP HANGER-STAFF END	none	1	1
335-00071-01	STRAP, SUPPORT	none	1	1
820-01048-01	LONG STRAP CLAMP ASSY	none	1	1
445-00313	8 INCH CABLE GRIP STRIP (1 PKG)	0	1	1
170-00044	AC ADAPTER PLUG KIT	1	1	1

P/N	Description	Backpack Mount	Staff Mount	Gradiometer
820-00232-01	BATTERY-LI-PO TYPE 29.2V*	2 if ordered	2 if ordered	2 if ordered
820-00303-01	LITHIUM BATTERY CHARGER ASSEMBLY – POWERSTREAM*	1 if ordered	1 if ordered	1 if ordered
840-00127-01	BATTERY ADAPTER JUMPER ASSEMBLY-POWERSTREAM*	1 if ordered	1 if ordered	1 of ordered
820-00231-01	BATTERY PACK-LEAD ACID*	2 if ordered	2 if ordered	2 if ordered
820-00348-01	ASSY, BATT. SPACE 24VCD 1.5A CHRGR TESTED*	1 if ordered	1 if ordered	1 if ordered
840-00176-01	ADAPTER CBL, CHARGER TO BATTERY PACK*	1 if ordered	1 if ordered	1 if ordered
900-00393-01	G-864, LEAD ACID BATTERY POUCH*	1 if ordered	1 if ordered	1 if ordered

\* Ordered separately.

For the most current part numbers and options please contact a Geometrics salesperson at [sales@geometrics.com](mailto:sales@geometrics.com).

## 2.2 Battery Options

The G-864 offers two battery options, Lead Acid or Lithium Polymer (Li-Po). The batteries shipped with the system will be the batteries requested at the time of order. Lead acid batteries have traditionally been used in our backpack systems. The Li-Po battery was designed to offer a more lightweight, longer lasting battery solution to customers.

Li-Po batteries must be discharged to 30% before they can ship, **so these batteries will need to be charged when received**. The Li-Po battery consists of two packs of cells, each at 88W-hr rating, which, with the correct documentation, is below the current standards for shipping on planes. Check airline and/or courier regulations before shipping these batteries. Geometrics is not responsible for any issues with Li-Po battery transport after it has been shipped from the factory.

The Lead Acid battery packs are fully charged before leaving the factory. However, depending on storage time, they may need to be recharged.

Lead Acid batteries will power the single sensor system for ~5 hours and the gradiometer for ~3 hours. The Li-Po batteries will power the single sensor system for ~7 hours and the gradiometer for ~5 hours. Cold temperatures will increase magnetometer current requirements and decrease battery capacity. Recharge time is approximately 6 to 8 hours per battery.

NOTE: To best maintain battery life, periodically charge the batteries (about every 4 months) when not in use.

## 2.3 Getac Tablet

The G-864 uses a Getac ZX70 Android tablet as the main data logging, and user interface device. This model is a ruggedized tablet that has been modified to reduce the magnetic characteristics of the tablet for a clean survey. One of the main modifications is the removal of the speaker components, which are very magnetic.

**Getac offers a warranty on their products. Register the tablet to take full advantage of the warranty, and make warranty claims on the Getac website:**

<https://support.getac.com/>.

Geometrics cannot support issues that arise from utilizing tablets that are not shipped with the system from the factory. The data logging software was tested with the latest version of Android at the time of shipping and will be maintained to the latest standard at each subsequent release.

## 2.4 Data Logger Box Components

The G-864 data logger box is attached to the aluminum frame of the Mystery Ranch Backpack. The pack frame commercial hardware has been replaced with brass and aluminum parts, removing all ferromagnetic components to keep the system magnetic self-signature to a minimum, thus reducing heading error and other platform noise. Never replace hardware with untested bolts, nuts, or rings. Always test the hardware first by turning on the magnetometer and moving the hardware near the sensor. System components should have less than 0.5nT effect at 2ft (0.6m) from the sensor.

### 2.4.1 Recessed Power Button

The power button is located on the bottom, left side of the data logger box. Turn the system on only after all cables are connected. The button should turn green to show that power is applied. The button will recess into the box when pressed.

### 2.4.2 Reset Button

The reset button is located at the top of the box and used if the G-864 processor is not responding. A reset will not fully turn off the magnetometer, so the sensors do not need to be warmed up again.

### 2.4.3 USB Port and Cover

The data logger box includes a USB port on the top of the box for data storage and firmware updates. If for any reason the data connection is lost, or the data is corrupted or accidentally erased on the tablet, the USB stick will have a backup record for data processing. The USB provided is 32GB, which can store up to 2 years of continuous data before needing to be replaced.

### 2.4.4 LED Status Lights

The backpack electronics box has five LEDs that are labeled to indicate their meaning. These LEDs help to ensure the system is working properly and to help when troubleshooting.

Blue POWER LED - signifies that the battery is connected and has sufficient voltage to power the system.

White PPS LED - signifies the system is receiving and is locked to PPS signal. This LED will be off if no PPS is detected. The PPS message is essential for surveying accurately for timing purposes and a survey should not begin without first having the white PPS LED active.

Orange GPS LED - signifies that the logger box is receiving GPS messages. The system requires both the GPGGA and GPRMC messages. The GPGGA is used for counting the number of satellites and time information. The RMC message is used for the date to be included in the final exported data. The orange LED will blink at the rate of the GPS message (1Hz).

Green MAG LED - signifies that magnetometer data is being received. The green LED will blink at the rate of the magnetometer sample rate.

Red USB LED - a slow flash signifies that data is being written to the storage unit.

#### 2.4.5 Heat Sink

There is a heat sink on the backpack to allow heat generated from the internal electronics to dissipate and avoid overheating inside the box. It is important to keep this heat sink clean and intact. If wear and tear is observed on the heat sink, please contact Geometrics to evaluate if it needs to be replaced.

#### 2.4.6 Connectors

Located underneath the data logger box are connectors marked to represent the appropriate device to be connected. Each connector has a different number of pins. Note that the matching cable connectors are keyed and contain an outer ring. **With the cable connector and data logger box connector touching, rotate the cable connector until the keys align, then tighten the outer ring to secure the connection.** Forcing the connectors together could potentially damage the pins, requiring the unit to be returned for repair.

### 2.5 Backpack Adjustments and Assembly

The backpack provides an ergonomic, and relatively lightweight solution for carrying the magnetometer in a secure manner over harsh terrain. The backpack consists of a military-grade, fabric Mystery Ranch pack, an aluminum frame, data logger box, and one aluminum staff pole with bolt lock screws. The sensor and sensor electronics, GPS receiver, battery, staff assembly, and cables will need to be connected and assembled.

#### 2.5.1 Adjusting the Backpack to the Individual User

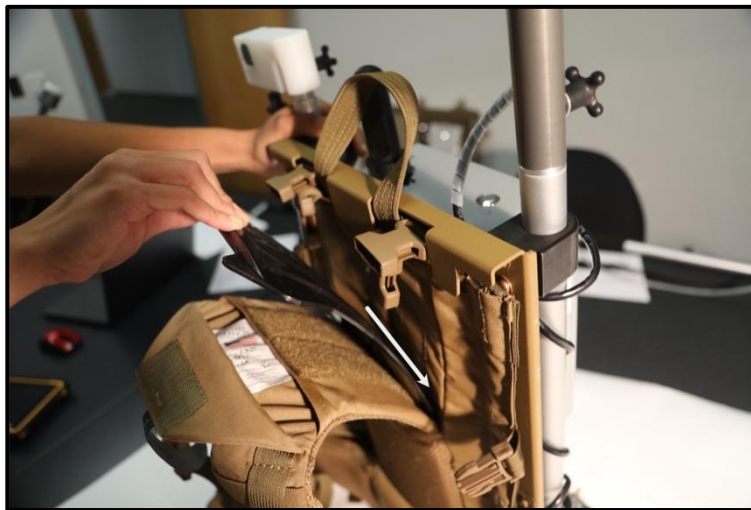
The Mystery Ranch Pack Frame is professional grade with a sliding Velcro secured adjustment system. The first time the pack frame is worn, it may be necessary to adjust the fit for the individual user.

1. Put the pack on, connect the waistband buckle and connect the smaller buckle supporting the shoulder straps. Adjust both to fit comfortably. Note where the shoulder harness pads come to rest on the shoulders. The wearer may find the straps are too high or too low. Adjust the straps until you achieve the correct fit, which is where most weight is resting on the hips and only about 20% is on the shoulders.

2. To extend or compress the shoulder harness, disconnect the buckles above the shoulder harness, peel back the flap, and locate the black plastic Velcro Release Tool as shown by the white arrow in the figure below.



3. Remove the Velcro Release Tool and insert it between the shoulder harness and the pack frame, breaking loose the Velcro.



4. Move the shoulder harness section up and down to correctly position the height of the shoulder pads.



5. When the correct height of the shoulder harness is achieved, remove the Velcro Release Tool, and then replace the tool in its original pocket. Reconnect the buckles and put the pack on one last time to verify the fit.

## 2.6 Mounting and Connecting the Battery

Depending on the batteries ordered, the backpack frame components will be slightly different.

1. Mounting
  - a. To mount the lithium polymer battery, place it in the frame backpack support with the Caution Sticker facing up.
  - b. To mount the lead acid battery, place it in the bag.
2. Locate the battery cable and the connector on the battery. With the two connectors touching, rotate the cable connector until the keys line up and then tighten the outer ring to secure the connection.
3. Locate the connector on the data logger box labeled BATTERY. Feed the battery cable through the opening behind the battery and make the connection. For image of proper connection, please see the image in the below section.

## 2.7 Mounting and Connecting the GPS

The G-864 comes with a non-magnetic Tallysman GPS. This specific antenna was chosen for its non-magnetic properties which allows the GPS to be mounted within 1ft. of the sensor and not interfere with the magnetic measurements. The GPS can be mounted on either side of the backpack frame.

1. To mount the GPS, line up the open slit on the GPS antenna with the black knob on the aluminum staff on the backpack and tighten the knob.

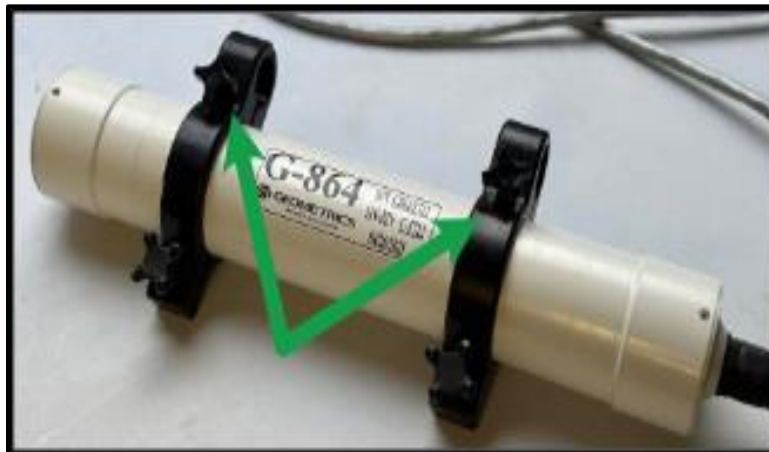
2. Wrap excess cable around the aluminum staff or bunch at the bottom of the backpack to protect the cable from getting snagged during a survey. Secure with cable tie wraps.
3. Feed the GPS cable through the opening behind the battery to the connector labeled GPS on the data logger box. With the two connectors touching, rotate the cable connector until the we keys line up and then tighten the outer ring to secure the connection.



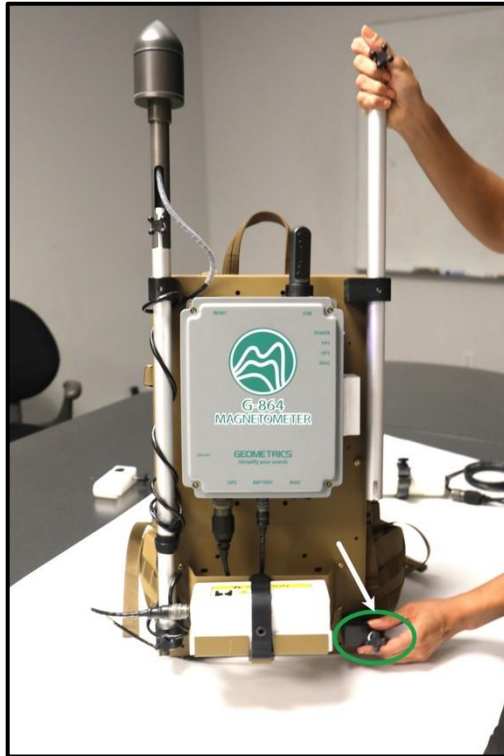
## 2.8 Backpack Mounted Sensor Configuration

Magnetometers with 3ft sensor-to-electronics cables are suitable for the backpack mounted configuration.

1. To assemble the sensor onto the backpack, first place two electronics clamps around the electronics bottle, keeping the clamps loosely fitted.







2. On the backpack, loosen the lower knob securing the aluminum staff section and lift it from the bottom support.





3. Line up the open holes on the electronics clamps with the aluminum staff while re-inserting the section into the bottom support on the pack frame. Tighten the black knob securing the aluminum staff into the bottom support.
4. Secure the electronics clamps to hold the electronics bottle in place by first tightening the bolt lock closest to the aluminum staff section, and then tightening the other bolt lock to secure the sensor in place.
5. At the top of the same aluminum staff section, mount the sensor clamp, securing it to the staff with the bolt lock.
6. Place the sensor in the sensor clamp and tighten the bolt lock closest to the sensor to hold the sensor in place. Avoid overtightening as the sensor clamp can crack if too much pressure is applied.



Magnetometers with 9ft sensor-to-electronics cables are required for the staff mounted sensor configuration. In this configuration, the electronics bottle will be the counterweight to the sensor on the staff assembly.

1. To mount the sensor and electronics onto the staff assembly, first place two electronics clamps onto the electronics bottle, keeping the clamps loosely fitted (like Step 1 above).
2. Attach the sensor electronics bottle to a bare aluminum staff section, by loosening the bolt locks on the electronics clamps enough to fit the staff section through.



3. Next, attach the staff section with the foam grip and tighten the bolt lock.



4. Then attach another a bare aluminum staff section and tighten the bolt lock.



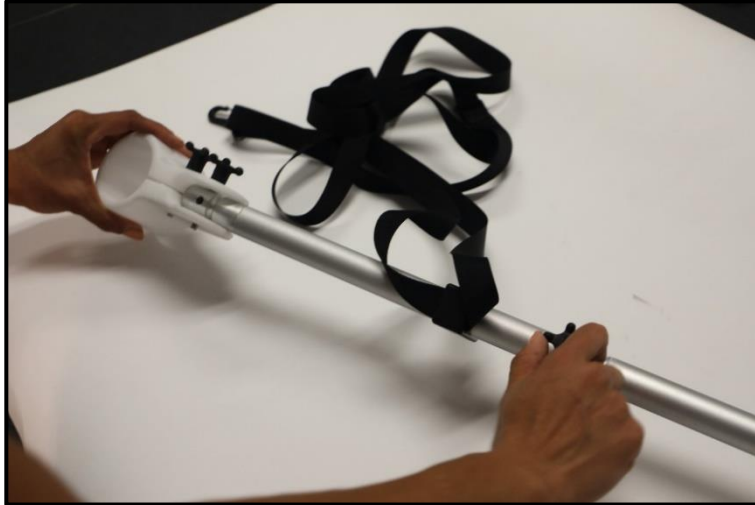
5. Connect the sensor clamp to the aluminum staff section containing the black strap. Start by removing the bolt lock from the sensor clamp as shown below.



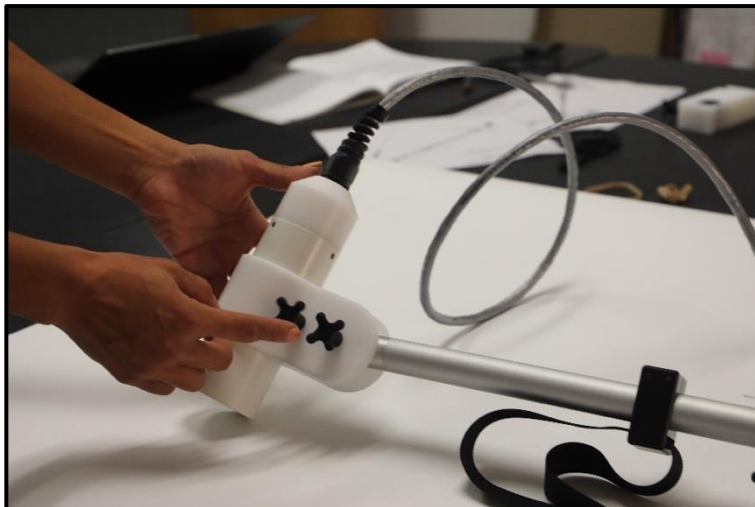
6. Line up the holes on the sensor clamp and aluminum staff section. Replace the bolt lock.



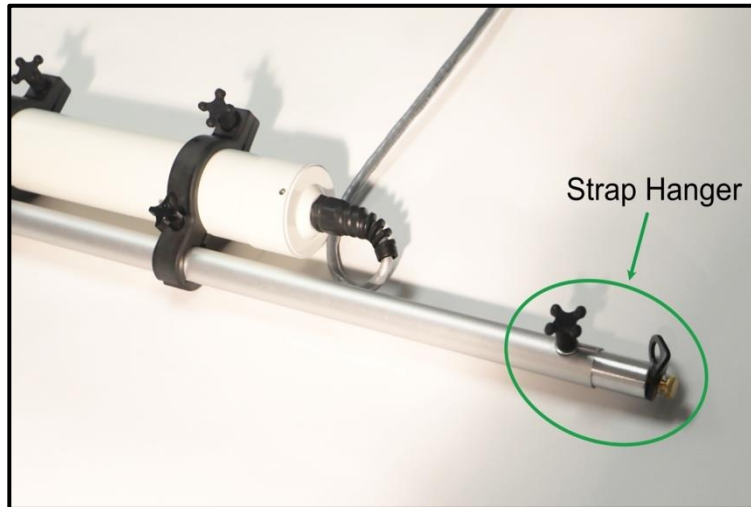
7. Connect this section to the staff assembly and secure with the bolt lock.



8. Place the sensor in the sensor clamp. Tighten the bolt lock closest to the sensor to hold the sensor in place. Avoid overtightening as the sensor clamp can crack if too much pressure is applied.



9. To the backmost staff section holding the electronics, connect the strap hanger - a small aluminum staff piece with a loop. Tighten the bolt lock.

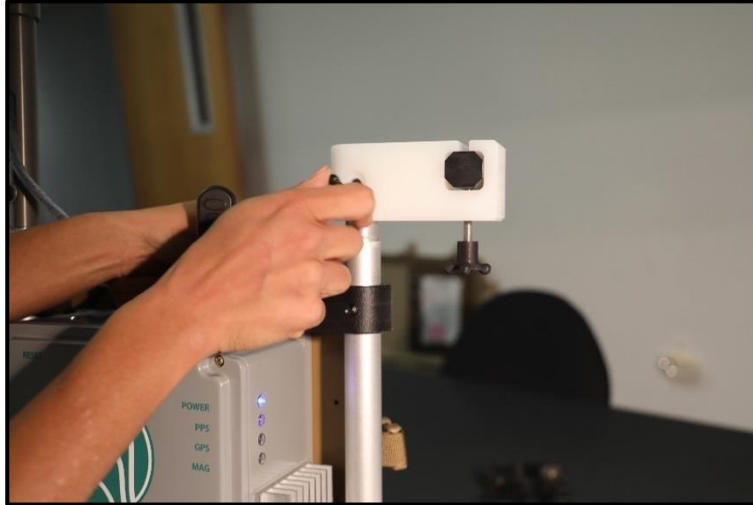


10. Clip the end of the long black strap to the strap hanger.



11. Place the white strap clamp onto the aluminum staff section on the backpack and tighten the bolt lock to secure in place.





12. Connect the sensor data cable to the sensor electronics bottle and to the connector on the data logger box labeled MAG. Rotate the cable connector until the keys align and use the outer ring to secure the connection. Extra cable can be tied to the staff assembly using cable tie-wraps.
13. Put on the backpack. With the help of another person, lift the completed staff assembly with the black strap and slide the strap into the strap clamp on the backpack, trying best to center it and keep the staff assembly horizontal.



14. Adjust the positioning of the strap in the clamp until the weight is properly balanced and the staff assembly can be comfortably held using one hand. When balance has been achieved, secure the black strap in place using the bolt lock.
15. Further adjust the height of the staff assembly using the sliding clamp on the black strap.





16. It may be necessary to adjust the orientation of the sensor to the requirements of the survey location. Please see the section below: Sensor Orientation and Adjustments.



## 2.10 Staff Mounted Sensor Configuration: Gradiometer

Only systems with two magnetometers and the 9ft sensor-to-electronics cables are suitable for the gradiometer staff mounted sensor configuration. In this configuration, the two sensor electronics bottles will act as counterweights to the sensors.

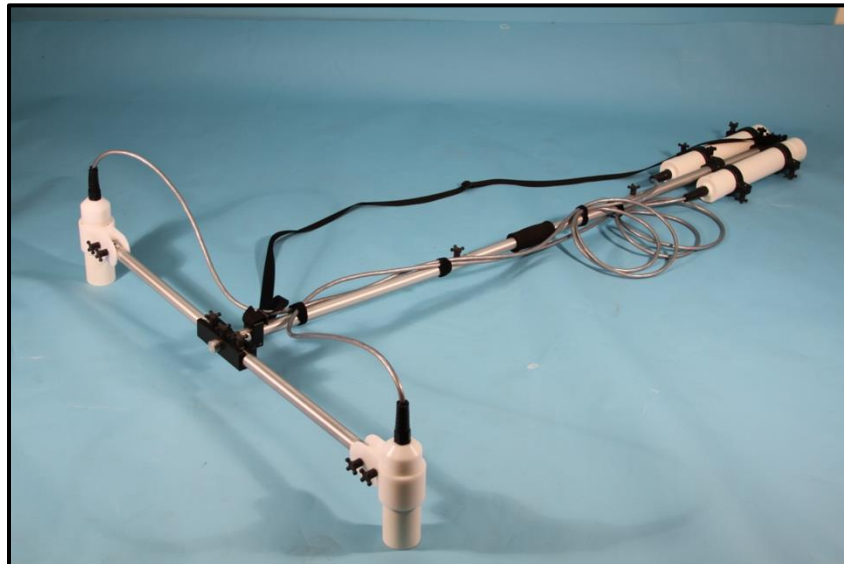
1. To assemble the gradiometer staff assembly, place two electronics clamps around both sensor electronics (as in Step 1 above).
2. Attach all 4 electronics clamps to a bare aluminum staff section by loosening the bolt lock on the electronics clamps enough to fit the staff sections through (like Step 2 above).
3. Next, attach the aluminum staff section with the foam grip, and tighten the bolt lock (like Step 3 above).

4. Attach a bare aluminum staff section to the section with the foam grip (as in Step 4 above). Tighten the bolt lock.
5. The next section contains the long black strap. Attach the gradiometer "T" section to the section with the long black strap.



T-Section and Long Black Strap Section

6. Attach the two sensor clamps to the two openings on the T-Section.
7. Place the sensors inside the sensor clamps. Tighten the bolt lock closest to the sensor to hold the sensor in place. **Avoid overtightening as the sensor clamp can crack if too much pressure is applied.**
8. Connect the strap hanger, a small aluminum staff piece with a loop (like Step 9 above) to the backmost staff holding the electronics.
9. Clip the end of the long strap to the strap hanger (like Step 10 above).



10. Place the white strap clamp onto the aluminum staff section on the backpack and tighten the bolt lock (like Step 11 above).

11. Connect the gradiometer data WYE cable to both electronics bottles and to the connector on the data logger box labeled MAG. Rotate the cable to align the keys and use the outer ring to secure the connection. Extra cable can be tied down to the staff assembly using cable tie-wraps.
12. Put the backpack on by lifting by the strap at the top of the frame. With the help of another person, lift the completed gradiometer staff assembly by the black strap and slide the strap through the strap clamp on the backpack, trying best to center it (like Step 13 above).
13. Adjust the positioning of the strap in the clamp until the weight is properly balanced and the staff assembly can be comfortably held using one hand. When balance has been achieved, secure the strap in place using the bolt lock (like Step 14 above).
14. Further adjust the height of the staff assembly using the sliding clamp on the black strap (like Step 15 above).
15. It may be necessary to adjust the orientation of the sensors to the requirements of the survey location. Please see section below: Sensor Orientation and Adjustments.

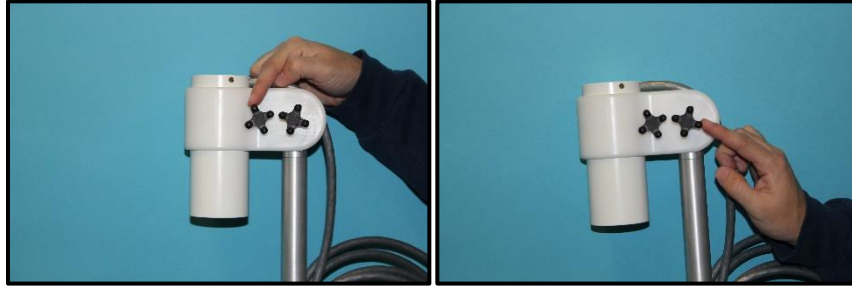


### Sensor Orientation and Adjustments

The sensor may be mounted vertically, at 45° to the vertical, or horizontally. Once the proper orientation is selected for a specific area, it will always mount in that same manner when surveying in the same area.

In the far northern and southern latitudes, the sensor will be mounted at 45°; for the mid latitude zones including as far south as Northern S. America, the sensor will be mounted vertically. In a narrow band about the earth's magnetic equator (not zero latitude necessarily), the sensor will be mounted at 45° or horizontally, with the top of the sensor tilted either North or South as the survey line is walked. To verify the survey area zone, please see [Appendix I: CSAZ](#) for more detailed information.

There are two bolt lock knobs on the sensor clamp. The knob closest to the sensor tightens the sensor in the clamp. The knob furthest from the sensor is for rotating the sensor clamp and reorienting the sensor.



Loosen the knob furthest from the sensor to allow the sensor clamp to rotate up to 45 degrees or horizontally as needed. If the sensor needs to be tilted at an angle to the survey direction, fully remove the knob furthest from the sensor and rotate the sensor clamp 90 degrees until the holes line up and, then reinsert the knob and tighten.

### 3.0 Survey Manager

Survey Manager is a simple program for managing G-864 Projects, creating Surveys with set parameters, creating Route Files, and converting data files. Survey Manager will routinely be updated. If issues arise, please check for the latest version at [www.geometrics.com/software](http://www.geometrics.com/software), or contact [sales@geometrics.com](mailto:sales@geometrics.com).

NOTE: In previous versions of Survey Manager, the terms "Project" and "Survey" were used differently than the latest versions described in this manual. Previous manuals used the term "Survey" to mean "Project" and the term "Acquisition" to mean "Survey".

Install the Survey Manager executable file from the Geometrics USB drive that shipped with the system. Once installed, the "Geometrics Survey Manager" program shortcut icon will appear on the desktop. Double-clicking the icon to open the software. The Home Screen is shown below.

### 3.1 Managing Projects in Survey Manager

The main function of Survey Manager is maintaining Projects, creating Surveys with specific parameters, and converting data files for third party data processing. and magnetic measurements.

On the Survey Manager main page, select **G-864**, and there will be two options - New G-864 Project and Open Existing G-864 Project. Please review the descriptions of each item in Survey Manager below.

**New G-864 Project:** Create a new Project, create Surveys, and load Route Files.

**Open Existing G-864 Project:** Open an existing Project file from the PC library; edit, delete, and create New Surveys within the Project.

**Project:** A group of Surveys. Project files are \*.DBT files and can also contain Route Files for Marked Surveys. The Project name should correspond to the site location, target of interest, or overall goal of the project.

**Surveys:** Data files within a Project. Contains magnetic data and Survey Parameters for that Survey. When a Survey is selected, the Parameters are shown to the right.

**New Survey:** Create a New Survey and set up the Survey parameters.

**Import Data:** Import data from the PC into the selected Survey. The data file will need to be transferred from the tablet to the PC first.

**Settings:** Review or change the settings of the selected Survey.

**Clear Data:** Delete all data in the selected Survey file.

**Delete Survey:** Delete Survey and all data in the file.

### 3.2 Creating a New Survey in Survey Manager

**New Survey Name:** Survey names should be specific to the survey area and perhaps contain information about the parameters set for that Survey.

**Sensors:** The number of sensors being used.

**Samples/second:** Measurement sampling rate. The G-864 has the capability of operating at different sample rates. It is important to keep in mind the local mains frequency when selecting the sample rate. Sample rates at integer factors of the mains frequency will alias the noise from the electrical grid to zero. For frequencies of 60Hz, select 1, 2, 5, 10, 20Hz, whereas for 50 Hz select from 1, 2, 5, 10, 25Hz.

**Sensor geometries:** Measurements of the sensor's location relative to the GPS. These offsets will be used to calculate the actual sensor location during data exports and analysis. For Offset Left, positive is to the left of the GPS, right is negative. For Offset Forward, if the sensor is in front of the GPS, then it is a positive number, if it is behind the GPS, it is negative. For offset below, it is the vertical difference between the sensor and GPS.

**Navigation:** Method used to assign locations to measurements in this survey.



**GPS:** Use GPS to navigate. A location for each magnetometer reading will be interpolated from GPS data. This setting will allow for free-hand GPS Acquisition. Use this setting when there is no exact plan for surveying a site.

**Marked:** When using cones, tapes, or other physical landmarks for defining the survey. When 'Marked' is selected, a Route file must be loaded into Survey Manager. A location for each magnetometer reading is interpolated from waypoint locations in the Survey's Route file, evenly distributing data points between marks.

**GPS/No PPS:** Use GPS to navigate. A location for each magnetometer reading will be interpolated from GPS data. However, GPS will not be synched to 1PPS signal.

**Base Station:** This field is used when the magnetometer being used is a stationary base station magnetometer, such as Geometrics model G-862RBS Base Station. For the use of the G-864, this can be ignored.

**Route File:** Files used for navigation. Import previously created Route files here. The route files must be in GPX format. There are many GPX creating websites and programs which will work, or use the function found in Survey Manager, described below.

**Swath Radius:** The radius of the track that appears in the navigation UI. This is mainly a QC function for the operator to determine the area that has been covered. Green dots with the defined swath radius appear at each GPS location to show where the surveyor has walked. For the best data density, the Swath Radius should be at minimum half of the chosen line spacing.

**Save:** Save the newly created Survey.

**Cancel:** Cancel creation of the Survey.

### 3.3 Converting Survey Data Files in Survey Manager

After the survey is complete, the data files will need to be loaded into Survey Manager for conversion into a usable format. Survey Manager has a quick way to convert G-864 Survey files into GDB, Geosoft Database file, or a standard .CSV files, which are acceptable by most magnetic data post processing programs.

1. Move Project files from the tablet to the PC library using a USB or data transfer cable.
2. Open Survey Manager, select G-864, select Open Existing G-864 Project.
3. Select the G-864 Project file to convert from the PC library. A list of Surveys will appear in Survey Manager.
4. Select a Survey and choose to export to CSV or GDB.
5. Select Export Options to include or exclude records without GPS location information.
6. Select Options for Date and Time.
7. Select Export, choose a location on the PC to save the file, and give the file a name.
8. A popup should appear saying "Export complete."

### 3.4 Creating GPX Route Files in Survey Manager

This function is a quick way to create GPX files for Marked Survey Navigation. On the Survey Manager main page, select **GPX Route Designer**.

**Route name:** The Route name should contain information about the survey site layout.

**Route type:** Select **Latitude/Longitude** if working in GPS coordinates; this is used for GPS surveys. Select **Cartesian (X/Y)** if working in Cartesian coordinates; this is used for Marked Surveys.

**Start of first line:** Provides the origin of the survey line. If working in Lat/Long, use decimal degrees. If working in Cartesian coordinates, the unit of measurement is in meters. Starting with origin at (0,0) is acceptable.

**End of first line:** Select **Azimuth and length** to enter the compass direction of the first survey line in degrees and the length of the line in meters. (0 degrees will correspond to a North survey, 90 degrees is East, 180 degrees is South, and 270 degrees is West). Select **Location** to enter a Lat/Long position in decimal degrees.

**Line offset direction:** This determines if the subsequent survey lines are positioned to the left or to the right of the first survey line.

**Number of lines:** Creates the number of lines to the left/right of the initial survey line. This number does not include the initial line. For a total of 10 lines, enter 9 as the number of lines.

**Line spacing (meters):** Distance in meters between adjacent lines.

**Mark spacing (meters):** Distance between marks along a survey line. If using a GPS survey this is irrelevant as the GPS will automatically mark every second.

**Traversal type:** Choose between bidirectional (in a back-and-forth, lawnmower type pattern) or omnidirectional, where surveyor returns to the baseline and surveys in one direction.

**Cancel:** Cancel creation of the Route file.

**Save:** Save the Route File

### 3.5 MagNav User Interface Software

MagNav software was designed to meet the basic needs of the operator for collecting magnetic data quickly and efficiently. The software contains modern features to simplify magnetic surveying. The magnetic data from the sensor(s) and GPS data stream can be seen in real time; the navigation window displays swath width and coverage; a color contour magnetic field map can be created on the tablet while in the field.

MagNav will be preloaded onto the Getac tablet shipped with the system. If for any reason the software gets uninstalled, the latest version can be downloaded from Geometrics website here, <https://www.geometrics.com/product/g-864-magnetometer/>, under Downloads. If any assistance is needed, please contact [support@geometrics.com](mailto:support@geometrics.com).

### 3.6 Moving Projects from Survey Manager to MagNav

After creating a Project in Survey Manager, it can be loaded into the MagNav software on the tablet using a USB drive. The backpack does not need to be nearby or turned on to do this. When setting up the system for the first time, it is recommended that you use a new, empty USB drive because it may be necessary to format – thus permanently erase any existing data – the USB drive.

Turn on the tablet and insert the USB drive. Swipe down on the screen to open the menu and see that the USB drive is being read. If the settings show that the USB drive “Device is Unsupported,” then you must format the USB drive. Follow the formatting steps described on the tablet. This will erase all data on the USB.

1. Eject the USB from the tablet and insert it into the PC.
2. Move the saved Project files (.DBT files) to the USB drive from the PC’s library.
3. Properly Eject the USB from the PC.
4. Insert the USB into the tablet.
5. Open MagNav.
6. On the Projects page, select Import Project.
7. Navigate to the USB storage device and select the Project .DBT file.
8. When successfully imported, the Project will be listed in the MagNav Projects tab.
9. Properly Eject the USB drive from the tablet (swipe down upper menu and Eject).

### 3.7 Creating New Projects in MagNav



*To Create a New Project in MagNav, the backpack does not need to be nearby, or Wi-Fi turned on. However, Projects can be created with the backpack system running.*

1. Turn on the tablet and open MagNav.
2. On the Projects page, select Create New Project.
3. Select G-864, enter a Project Name, and click OK.
4. On the Projects Page, select the newly created Project.
5. Select Create New Survey.
6. Enter a Survey Name and Parameters, click OK.
7. The Survey will be listed on the Surveys page.

### 3.8 Starting a Survey in MagNav

\*If MagNav is currently running on the tablet, completely close the MagNav software program before turning on and connecting to the backpack system Wi-Fi. Do this by pressing the bottom right square and swiping the program away to kill the program.

1. Make sure the sensor(s), GPS, and battery are properly connected to the backpack electronics box. Make sure the surveyor is not wearing anything magnetic.
2. Push the Power Button on the backpack to turn it on. The LEDs will perform a series of flashes indicating the system is warming up.
  - a. Blue POWER LED should remain solid; White PPS LED should flash once per second, Orange GPS LED should flash once per second, Green MAG LED should flash 10 times per second, Red USB LED will flash momentarily and then will remain off. If they don't behave this way, let the system warm up for a few seconds, then press the Reset button.
3. On the tablet, connect to the backpack system Wi-Fi. The backpack Wi-Fi access point is given a unique name, such as "G864-21090003." The tablet may connect automatically.
4. Start MagNav
  - a. The **Projects** tab is the first screen that will appear.
  - b. Click the **Mag Data** tab, or swipe to the left, and an active magnetometer data trace will appear. Double tap the screen to center the magnetometer data race at a proper scale.
  - c. Click the **Terminal** tab, and the real-time numeric magnetometer intensity values and GPS data string will be visible.
  - d. Click the **Info** tab, and general information about the instrument will be displayed, including the software version, battery voltage remaining on the backpack, number of GPS satellites and if GPS is coming in.
5. Return to the **Projects** tab and select a Project to start.

6. The **Surveys** tab is the first to appear.
7. Select a Survey to start from the **Surveys** tab.
  - a. The **Mag Data** tab is first to appear. Double tap the screen to center the magnetometer data race at a proper scale.
  - b. The **Navigation** tab shows current position, a north arrow, and a scale. As the surveyor moves, a green dot and blue “Surveyor Icon” with a pointer will move. The green dot will be a size corresponding to the swath radius for the selected Survey. The trail of blue breadcrumbs represents current position, and the pointer indicates direction of travel. *If the Swath Radius was chosen carefully, good coverage of an area can be attained by painting the area solid green.*
  - c. The **Heat Map** tab is where color contour magnetic field maps will be created after some data has been collected. Click **REFRESH** to grid the data.
  - d. The **Terminal** tab shows real-time numeric magnetic field and GPS string values.
  - e. The **Info** tab has information about the Survey including the Project name, Survey name, Swath radius, battery voltage, GPS satellites used, etc.
8. Select the **Navigation** tab, and click Start, and data will begin being acquired and saved.

### 3.9 Surveying with Marked Navigation in MagNav

1. From the Projects tab, select a Survey that uses Marked Navigation with a Route File.
2. The **Mag Data** tab is first to appear. If the live mag data does not appear, return to the list of Surveys, and re-select the Survey. Note that the title of the page is colored red, indicating that data is not being acquired or saved.
3. Select the **Navigation** tab. The Navigation view will appear with a plan view of the survey area route with lines, marks, and arrows. It also includes other important elements:
  - a. Title bar and tool bar, both colored red, indicating that data acquisition has not started.
  - b. A blue circle (called the “Surveyor Icon”) with a single line protruding out from the circle (Pointer). The Surveyor Icon shows the GPS location of the surveyor, and the Pointer shows the forward direction surveyor using the compass in the Android tablet. [Search online for “android compass calibration” for instructions on calibrating the internal compass in the tablet].
  - c. A distance legend and north arrow, indicating true north.
4. When the surveyor reaches the start of the line and is ready to begin, tap the “START LINE” button. A circle will surround the next mark in the line. Immediately start walking to the cone or flag in the field that is represented by the destination circle.

5. When you reach that cone or flag, tap the “MARK” button, and keep walking along the line, pressing “MARK” as the sensor passes each cone or flag. Each time you pass a mark, the segment that you just completed will be re-drawn with a bolder brush.
  - a. When a mark is selected, the text in the lower right corner will show the course over ground according to the GPS, the bearing (or direction to the mark), and the distance to the next mark.
6. When you approach the last mark in the line, the “MARK” button will change to “END LINE.
7. When you reach the final mark and press “END LINE”, data acquisition will stop.
8. Collect the remaining lines following the same steps as for the first line, until the entire route is completed.

### 3.10 Data Transfer from Tablet to PC

When the survey is completed, copy the Project .DBT file that is saved in the tablet memory and transfer it to the USB drive.

1. Navigate to the MagNav Project page.
2. Hold on to the project you want to export until the options appear.
3. Click EXPORT PROJECT and then select the external USB drive.
4. Click SELECT on the bottom right to copy the data (.DBT file) to the USB drive.

Note that the MagNav app will NOT over-write an existing .DBT file. You will need to delete the existing .DBT file on the USB drive before exporting.

Eject the USB from the tablet and plug it into the PC with Survey Manager.

Open the .DBT file in Survey Manager (see section *Converting Survey Data Files in Survey Manager*) and export the file as a CSV or GDB file to be opened in any third-party software package.

### 3.11 Correcting Mistakes

There are two primary methods to deal with errors or interruptions while in the field, Interrupt Data Collection and Delete Data.

1. **Interrupt Data Collection.** Let’s say that you successfully collected data on the first segment of a line. You have started traversing the second segment, and MagNav is waiting for you to press “Mark,” after which the next mark will be circled, indicating that you are ready to walk the next segment. But something interrupts you, and you won’t be able to finish this segment correctly. In this case,
  - a. Press the “STOP” button. Data recording will stop, and any data that was collected after finishing the prior segment will be ignored.
  - b. After dealing with the interruption, start the survey line where you left off, or if the interruption was a physical barrier or impediment such as a wall or creek, start the survey line at the next mark.

2. **Delete Data.** Perhaps you realize that the data you have collected on some segments is invalid. In this case,
  - a. Press and hold the mark at which you want to start deleting data. Select “Delete data.” The point will be circled to indicate the starting point of deletion. Note that you can cancel deletion by pressing the cancel button.
  - b. Next, press and hold the mark at which you want to end deletion. Press “Delete data.” The display will show that a section of data has been deleted.
  - c. Go back to the last valid mark and continue the survey.

### 3.12 Deleting a Project in MagNav

1. From the Projects tab, hold down the name of the Project.
2. A popup will appear in the top right. Select Delete Project.
3. Press OK when asked to confirm.

## 4.0 MagMap & MagPick

Geometrics offers free software for processing magnetic data, MagMap and MagPick. These can be downloaded from the Geometrics website, <https://www.geometrics.com/software/>.

### Import Collected Data to MagMap

After finishing the survey and the data has been moved to the computer with Survey Manager and MagMap installed it is time to load the data into MagMap for data processing. First, the data stored in the tablet is as a .DBT file which is not initially read into MagMap.

1. Open Survey Manager and select G-864/Open Existing G-864 Project.
2. Select/Open the file to be read in from your PC Library.
3. When the Project file is read in, the settings for the file are updated. Select the Survey to export and then choose to export as CSV.
4. Open MagMap, click Open and choose the correct file extension in the bottom right drop down (SURFER \*.dat, Interpolator \*.INT, \*.txt, Comma-separated \*.csv, IAGA 2002).
5. Choose the file, and the following “Data file definition” screen will appear:

**Data file definition**

Data file name: D:\Savoy Data - 864\3. CSV Files From Survey Manager\savoy-E-coarse.csv

**Position information**

X: 5: LongitudeSensor1 Y: 4: LatitudeSensor1

☒ Check here if X and Y represent longitude and latitude

**Time information**

Time: 3: Time Date: 2: Date

☐ No time stamps, assign by default Format: yyyy-mm-dd (INTERMAGNE)

**Line information**

☒ Don't use lines (all data in one line) Line:

☐ Split data file into lines by distance Split distance: 10000

**Data channels**

6: MagSensor1

Add data channel...  
Remove data channel...  
Remove all channels

How to load: Positions & Data ☐ Use advanced settings Advanced...

OK Cancel

6. Manually change the fields to make sure that they are correct. If using multiple sensors, make sure to add each data channel. Click OK to begin viewing and processing the data.

If using a base station, remember to have the base station file open when ready to export the data from MagMap to ensure that the data is diurnally corrected.

For more information about data processing in MagMap or MagPick, please consult the manuals for those programs on our website at [www.geometrics.com/software](http://www.geometrics.com/software), or contact [MagSales@geometrics.com](mailto:MagSales@geometrics.com).

## Appendix I. CSAZ

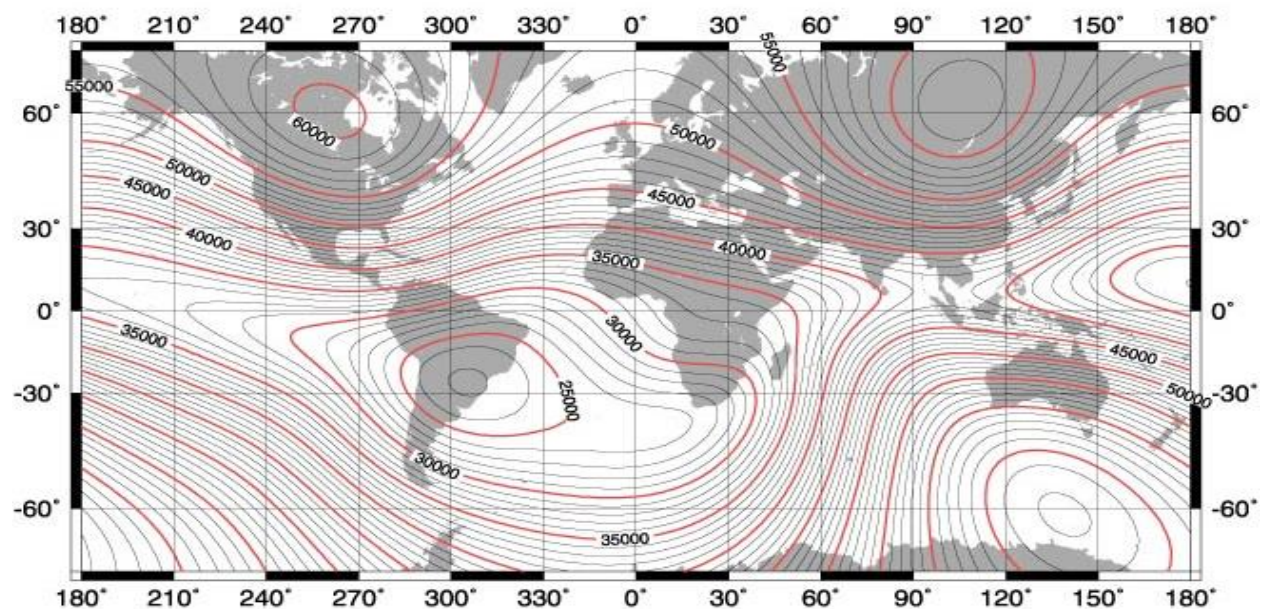
### Cesium Sensor Active Zones

Geometrics wrote the program CSAZ for users of Cesium magnetometers and is used to determine the proper orientation of Cesium sensors at various Earth field dip angles (field inclination). “AZ” stands for azimuth or inclination. The program is located on the Geometrics USB drive included with the G-864. Please read the manual that is imbedded within the program for complete instructions on how to use the program for sensor orientation solutions at various locations on the globe. **NOTE:** Select “Generic” from the Sensor Type drop down for G-864 solutions.

### Cesium Sensor Orientation for Worldwide Operation

Magnetic fields are vector fields. At any point, they are defined by their magnitude and direction. For the G-862 sensor to accurately measure the local magnetic field magnitude, it must be properly oriented relative to the local magnetic field direction.

The sensor head must be oriented so that the local field impinges at an angle of from  $30^\circ$  to  $60^\circ$  to the cylindrical axis of the sensor, for all platform attitudes. Alignments that produce a field/axis angle less than  $15^\circ$  place the magnetic field within the sensor’s “polar dead zone”. Similarly, alignments that produce a field/axis angle greater than  $75^\circ$  place the magnetic field within the sensor’s “equatorial dead zone”. The sensor will not produce usable data when the angle between the earth’s field and the cylindrical axis falls within one of these two zones.

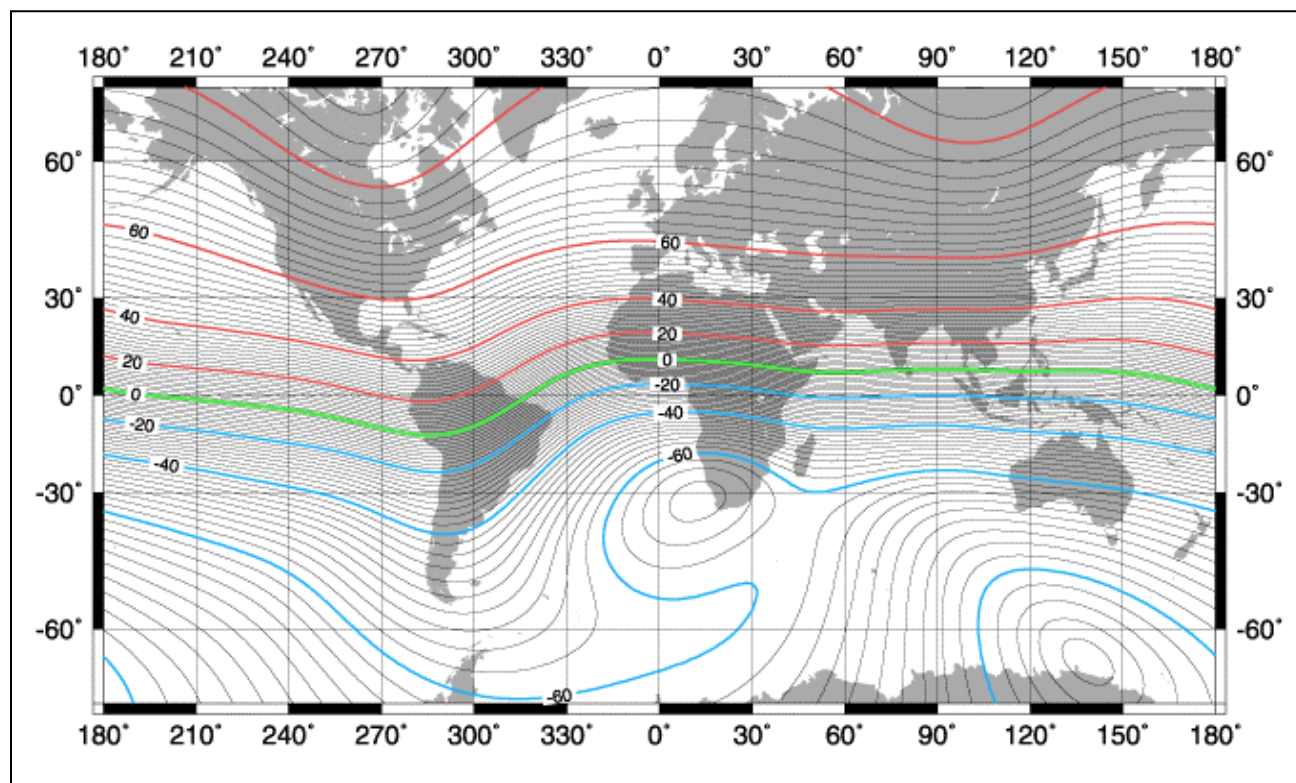


Map of the Earth's Magnetic Field Intensity

Unless the sensor is quite near very magnetic objects, the local magnetic field will be almost entirely due to the earth's magnetic field. Therefore, in latitudes where the inclination of the earth's field vector is  $45^\circ$ , vertical orientation of the sensor's axis will allow operation in all practical survey orientations. In Equatorial



regions, it may be necessary to orient the sensor horizontally and at an angle to the survey direction. In Polar Regions, the sensor may be mounted with its major axis tilted east or west to obtain the desired angle.



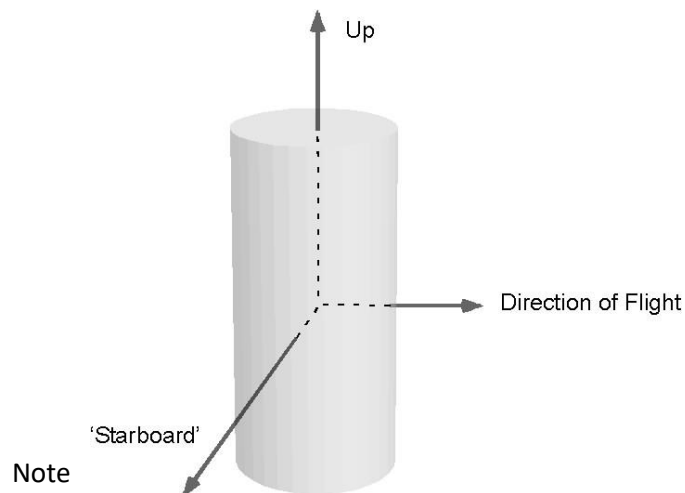
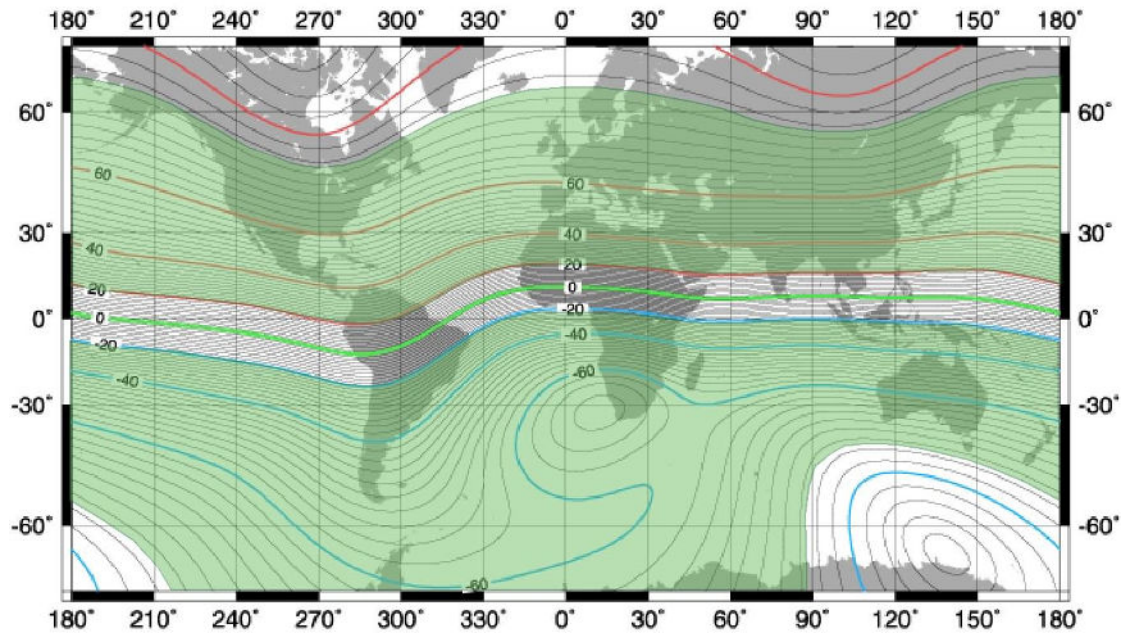
Map of the Earth's Magnetic Field

The maps in the two figures above may be used to determine the inclination and total intensity of the Earth's magnetic field in the intended area of survey. This inclination information should be used to adjust the sensor orientation for the best performance in the survey area. The intensity information may be used as a check of the system operation.

Regarding sensor orientation, the Earth's surface can be divided into three zones based upon magnetic field inclination: mid-latitude, equatorial, and polar. Within each of these zones, a particular sensor orientation will yield adequate signal strength over the entire zone. These regions and the corresponding sensor orientations recommended for each region are shown in the following figures.

In addition to the diagrams provided here, the program CsAz may be used to calculate the sensor's output for a particular orientation for the magnetic field attitude in the survey area. This is a DOS program and is provided on the Magnetometer Support USB supplied with the magnetometer.

## Mid-latitude Zone

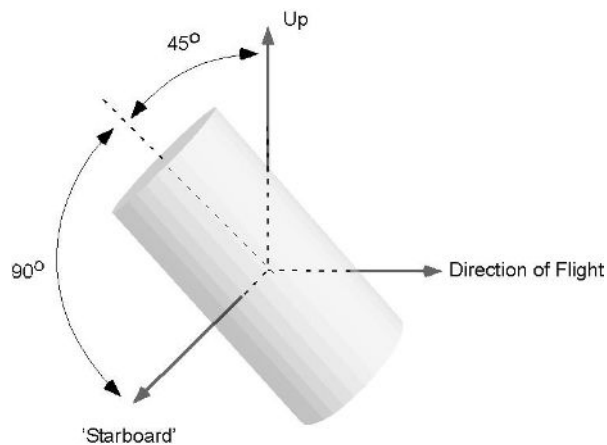
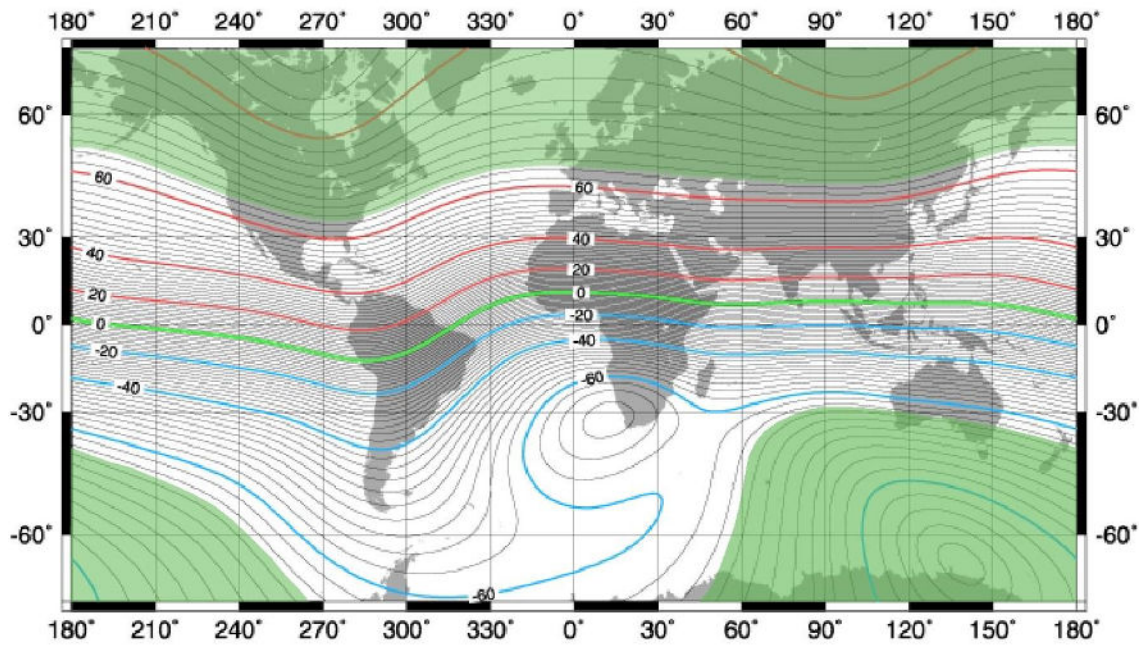


*The diagram to the left shows the recommended sensor orientation for operation in mid latitudes. This zone is shown as the shaded regions above and includes those areas where the absolute inclination of the Earth's magnetic field is greater or equal to 20° and less than or equal to 75°. There are no restrictions on the direction of travel when using this sensor orientation*

that the orientation zones overlap with one another by 10° of magnetic inclination. In these regions of overlap, there are two different recommended sensor orientations. In this region, the magnetic field is nearly horizontal and there will be some restrictions on the direction of survey. Choosing one of the two recommended orientations will provide survey directions most suitable for the survey area.

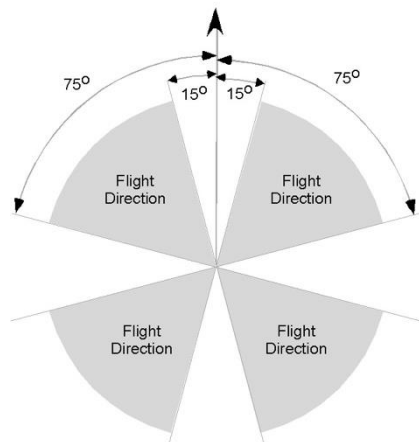
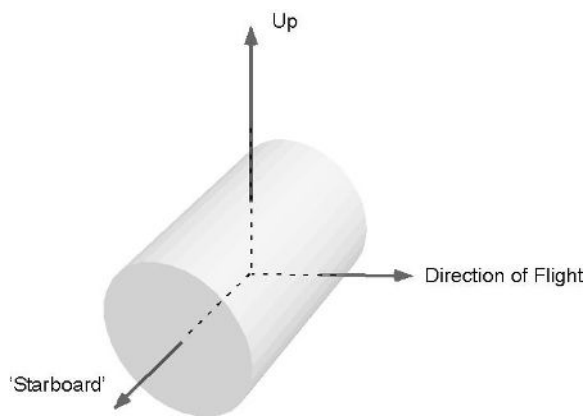
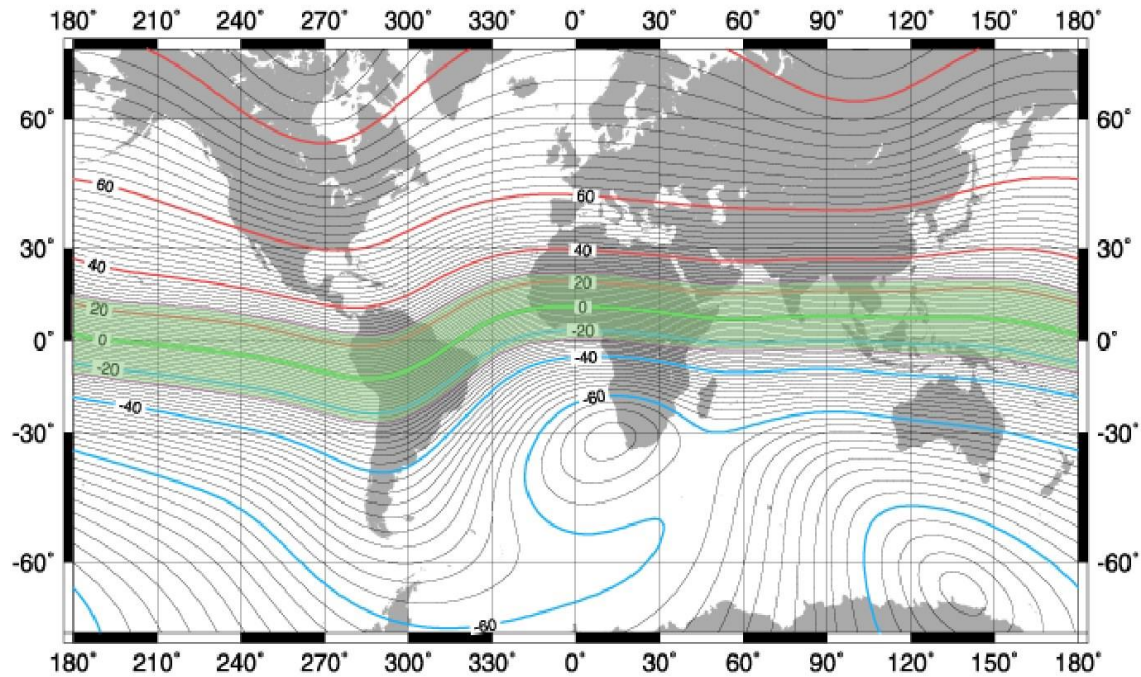


## Polar Zones



*The diagram to the left shows the recommended sensor orientation for operation in polar latitudes. This zone is shown as the shaded regions above and includes those areas where the absolute inclination of the Earth's magnetic field is greater or equal to  $65^\circ$ . There are no restrictions on the direction of travel when using this sensor orientation.*

## Equatorial Zone



The diagram to the left shows the recommended sensor orientation for operation in equatorial latitudes. This zone is shown as the shaded region above and includes those areas where the absolute inclination of the Earth's magnetic field is less than or equal to 25°.

*There are restrictions on the direction of travel when using this sensor orientation in this region. The bottom diagram to the left shows the directions where the sensor will produce good signal strength. These directions are 60° wide and are centered on 45°, 135°, 225°, and 315°.*

## Appendix II. Troubleshooting Table

The table below is a troubleshooting guide to help quickly locate the probable cause of the most common system problems.

Symptom	Probable Causes	Corrective Actions
Long warm-up time.	Low voltage.	Increase voltage (minimum 24 VDC at the electronics) or repair the Coax cable.
	Low ambient temperature.	Insulate sensor housing.
	Low heater setting.	Adjust heater to 34.5 K-ohms: contact factory for details.
	Defective internal sensor or electronic components.	Return sensor and electronics to Geometrics for repair.
Noisy magnetic field readings.	Local field is noisy.	Locate and eliminate sources of noise or relocate sensor.
	Sensor not oriented correctly.	Refer to the Sensor Orientation section of this manual or use MagPick IGRF and CsAz software to model magnetic field and sensor behavior, and correct orientation if necessary.
	Heater setting incorrect.	Adjust heater to 34.5 K-ohms: contact factory for details.
	Signal amplitude too low with correct orientation.	Adjust signal amplitude or return sensor and electronics to Geometrics for repair.
	Sensor cable or connector worn or damaged.	Replace sensor cable and connector assembly.
Sensor cable kinked or cut.	Handling or mechanical problem.	Change handling or mechanical mount. Then replace sensor cable and connector.
Excessive current consumption.	Damaged multi conductor cable.	Replace multiconductor cable.
	Defective sensor or electronics.	Return sensor and electronics to Geometrics for repair.

Preventing a problem is almost always less costly than correcting the problem. We recommend checking the following items as part of any new installation or whenever an existing installation is altered. It is also recommended that these items are checked periodically as part of a scheduled platform or system safety check.

### 1. Power check

- a. Minimum 24 Volts DC at electronics bottle. 28VDC recommended

- b. Maximum 35 Volts DC at electronics bottle
  - c. Starting current 1 Ampere at 28 Volts
  - d. Running current 0.3 to 0.6 Ampere at 28 Volts depending upon ambient temperature
- 2. Connector checks
  - a. Dirt or corrosion
  - b. Bent pins
  - c. Back-shell tight
- 3. Cable jacket check
  - a. Kinks
  - b. Abrasions
  - c. Cuts
- 4. Sensor orientation
  - a. Use CsAz to model sensor behavior
  - b. Adjust sensor orientation and observe dead zones
  - c. Return sensor to correct orientation for the survey area
- 5. Field readings
  - a. Reasonably close to CsAz model estimate
  - b. Sample to sample noise less than 0.1 nT @ 10 Hz when not moving
- 6. Larmor amplitude check and adjustment (Authorized Repair Facility only)
  - a. Potentiometer on sensor-driver board adjusted for 2.0 Volts Peak to Peak at 50,000 nT after 20 minute warm up
- 7. Heater check and adjustment (Authorized Repair Facility only)

## Appendix III. Firmware and Software Updates

Geometrics' G-864 Cesium Backpack Magnetometer uses three separate software packages:

1. **Geometrics Survey Manager** - Windows software for managing G-864 Projects
2. **Geometrics G-864 Embedded** - Software running in G-864 backpack, and

### **Geometrics MagNav - Android app running on Getac tablet**

#### **Geometrics Survey Manager**

1. The installation program – SurveyManagerInstaller-xx.exe – installs Survey Manager on Windows laptops or desktops. It works like any other Windows installer: simply accept the default values, and it will be installed.
2. When the program is running, the version number appears at the top of the application window. Verify that the correct version has been installed.

#### **Geometrics G-864 Embedded**

1. Take the USB drive from the top of the G-864 backpack (from under the black environmental cover) and insert it into the PC.
2. Run the installer – Setup-G864-Embedded-xx.exe
  - a. Insert the G-864's USB drive in the laptop . When running the installer, the new software is being loaded onto the USB drive. When the installer asks for an install directory, choose the USB drive.
  - b. Select a password. It must be exactly 8 characters and numbers: "password" is a good choice or choose some other simple key such as "pass0001". This password is not really for security purposes, but to prevent accidental logins or interference from other Wi-Fi devices such as drone controllers, phones, or other systems, which will sometimes log into open or non-password-protected Wi-Fi access points. From the point of view of the Getac tablet's Wi-Fi system, the G-864 is a normal Wi-Fi access point., so when connecting MagNav to the backpack, it may be required to enter the new password. If the password is changed (by running the install again) it may be required to ask the Wi-Fi settings on the Getac to forget the old password before connecting with the new one.
  - c. Select a Wi-Fi channel. 4 is a good default value.
  - d. After the installation is done, and before removing the USB from the laptop, check for the .CFG file and a file named "btb.bin" on the USB. These files contain the information for the new software.
  - e. Before removing the USB drive, use the "eject" choice in the Windows file explorer to make sure that the installation data is securely written to the USB drive. If the USB is removed without using "eject", the program update on the USB drive may be corrupted.
  - f. Insert the USB drive into the socket in the top of the G-864 backpack and turn on the power. During this process the new software will be installed into the backpack, and the

database in the USB drive will be initialized. The installation takes about 30 seconds. Once the lights on the side of the backpack start their normal pulsing and flashing, the installation is complete.

- g. Leave the USB drive in the G-864, and screw on the black environmental cover.

### **Geometrics MagNav**

The application install file – \*.apk – installs the app on the Getac tablet:

1. Copy the .APK file to a USB storage device.
2. Use the file explorer application on the Getac to find the .apk file on the USB drive. Find “External Storages”, and then the USB drive. It may be an oddly numbered folder.
3. [When the .APK file is found, select it. Android will ask to confirm installation.](#)
4. After confirming, Android will take a few seconds to install.
  - a. If install succeeds, the app is ready to run.
  - b. If the installation doesn’t succeed, there may be an earlier, incompatible version of the app on the tablet.
    - i. Use Android preferences/Apps to find Geometrics MagNav.
    - ii. Tap on the app and choose “Uninstall”. Uninstalling this earlier version will not harm any previously collected data.
    - iii. Install the app again from the APK. This time it will work.
5. Move MagNav to the Android desktop (if it’s not already there) as follows:
  - a. Find the app in one of the desktop app folders.
  - b. Press and hold the app icon, and then drag the icon a little while still pressing.
  - c. The folder will disappear, and Android will allow dragging of the app to a place on the desktop.
6. Start the app. Go to the Status page and verify that the version is correct.

## **Appendix IV. Surveying Principles**

This section outlines the principles of performing a magnetic survey for anomaly location. It covers setting up, performing the survey and location of items of interest within anomalous zones. Regional or geologic surveys for mineral exploration require a different set of procedures and are not covered in this overview. However, many of the guiding principles are identical and review of this section will be helpful.

### **Guidelines for Small Ground Magnetometer Surveys**

The general comments below cover only the site layout and preparations for a survey. The survey objectives, determination of parameters for the instrument data collection and the actual data processing and map preparation are covered elsewhere.



To accomplish a successful ground survey magnetometer data acquisition, survey path over the ground and processing of the data into map form must be handled in a precise and accurate manner. Each element is completely interdependent upon the others and if one is compromised in quality or accuracy then all are compromised. During a survey, possibilities for error are numerous and great care and concentration are required to avoid mistakes, some of which may be so serious as to require starting the survey over. The focus should be on completing the survey completely error-free.

Typically, the most difficult surveys are those involving detection of small magnetic targets and the presentation of an accurate 1 or 2 nT contour map. In these cases, the survey must include: a close line spacing (1-2 m) with precise tracking in both the X and Y directions; diurnal correction (0.5 nT or better); correction of heading errors from instrument and/or operator; maintaining the sensor a constant distance above the ground; and absolutely no mistakes in procedure and data processing.

### **Number of People**

Under certain conditions, the survey can be laid out and run by one individual; but this is rare and risky. It is far better to have a minimum of two people closely involved and ideally, three or even four people. Not only must the layout and marking of the survey lines be considered but also an individual must be designated to maintain a separate survey log, set up the base station, and operate the portable magnetometer. Note also that the operator doing the walking may require relief, for oftentimes the terrain and distance conspire to make his job very grueling.

### **Survey Efficiency**

Speed and cost-efficiency in completing the survey is of course the ideal objective. This does not, however, require the use of innovative short cuts, new gadgetry, or excessive manpower, but rather the avoidance of mistakes and errors. Efficiency will only be achieved by avoiding confusion, the immediate correction of errors, and using fail-safe procedures. All the methods suggested below are simple, low tech, and relatively slow, but proven effective. They can easily be improved but at the risk of greater time, poorer survey quality or greater cost. So, in the beginning, keep it as simple as possible.

### **Layout of the Survey Track**

Having determined the optimum line spacing, layout the survey area in a square or rectangular format with the lines running N to S if possible. Use a Theodolite if available (a theodolite is a precision optical instrument for measuring angles between designated visible points in the horizontal and vertical planes); otherwise use a measurement tape (non-stretch) of the required length. Designate one side of the area to be the "baseline" and layout and mark on this line each survey profile. Note that any stakes driven into the ground must be non-magnetic. (Wooden stakes driven into the ground will work well but may not be visible at distance.) If the site is reoccupied in the future, it may be desirable to drive a one-meter iron rod (re-bar) into the ground at each corner of the survey area as a permanent marker.

Since the profile line markers may not be visible at a distance, a method must be found that will allow the Magnetometer operator to locate and follow the line: a light cord or rope stretched on the ground between the beginning and end of each line; a long PVC pipe or other colored marker to be held at the end of each line and then sequentially moved; use of spray paint to mark a series of dashes along the path of each line, etc.

If the terrain is rough or bushy, ground markers along each line will be essential. Otherwise, if the terrain is flat and each end of the line is readily visible, a marker at each end and in the center may suffice. (The operator should have at least two markers to line up on when starting a line.) Whatever method is chosen, it must be completely non-magnetic, positive, easily moved in a coordinated way, and must give the operator a precise direction.

Note that coordination between the people moving the markers is sometimes difficult and frequently a source of error. In addition, if the survey lines are closely spaced, e.g., one- or two-meter separation, the operator may have trouble distinguishing between which marker to head for. The most certain and positive method in all cases is to mark the path by stretching a light string or rope the entire length of the pathway or, to paint or otherwise mark the ground at short intervals.

If the area to be surveyed is larger than say 100 x 100 meters or difficult to walk through, then the area should be broken up into convenient sub-sections which overlap by at least one profile line. If some sections of line are not passable, then provisions should be made for the operator to detour around them but only after establishing a procedure to stop/start (pause) and annotate the data. (This must be simple and fully coordinated with the data processing.) At all times, Magnetometer operator must be always aware of the current line, and the line number must agree with the line number recorded in the data. This is once again a frequent source of error and should be double-checked by another person.

In no case should a survey be started until all lines have been laid out and marked, and all aspects of the survey carefully re-checked. A few hours more or less at this stage means very little. What is crucial is to prevent major errors (or even minor ones) that may cost extra days of **time and effort**.

### **Diurnal Correction**

There are many types of surveys that do not require correction for time varying field errors (diurnal). Generally, they involve large magnetic targets such as pipelines and tanks, or coarse line spacing, or where the survey may be accomplished in a very short period of time. In these cases, once it is determined that a severe magnetic storm is not in progress, the survey can proceed without the normal base station correction and with good reliable results. Note that the high measurement rate of the G-864 allows a rapid walking speed along the profile line. Thus, even large target anomalies are covered within tens of seconds, reducing the potential Diurnal effects.



Surveys that involve very close line spacing, small or subtle targets, or where the maximum accuracy is desired, require diurnal correction from a base station installed close to the survey area. Ideally, equal sensitivity and measurement rates to the field instrument should be employed in the base station. In general practice, whatever instrument is available is used. In most cases this works well even during periods of relative high field activity.

It should be remembered that "diurnal error" will have the same effects in the mapping process as "location error", and that without correction, low amplitude/high frequency anomalies could appear in the measured data that would seem to be targets, but in fact would not be real. In addition, if the survey has been broken up into blocks that are acquired on different days, the blocks will not fit smoothly together unless a diurnal correction is made, and their DC level shifted.

There are also other types of local magnetic field disturbances that can seriously affect map accuracy and quality. These include ground currents and other local AC or DC fields from power lines or urban electric trains or trolleys. Of these, electric trains or trolleys are the more serious as their effects may be large in amplitude and extend for many miles. Usually, it is more effective to complete the survey at night when these noise fields are greatly diminished.

### **Survey Accuracy**

Commercial survey specifications may allow an "off line" error of up to  $\pm 20\%$  (or more) of the line separation. For a magnetic object having an anomaly extending over several lines, this amount of location error does not prevent the object's detection, but does distort the anomaly's shape, its peak-to-peak amplitude, and its true location. Large changes in speed along the profile line will have a similar effect but can be prevented using intermediate waypoints. (The worst-case condition would be "off line" by  $+20\%$  in one direction and "off line" by  $-20\%$  in the opposite direction with each line having a  $10\%$  change in speed.) Location errors of this magnitude will not seriously change the overall correctness of the final map, considering that this type of survey is primarily for detection/location. This is not the case, however, if the location errors substantially exceed  $\pm 20\%$ , e.g., off by one or more-line separations. This amount of error may cause targets of interest to go undetected, or target anomalies to be shifted in location, resulting in, at worst, an erroneous map or at best an untrustworthy one. Careful layout and accurate tracking along the line will avoid these problems.

### **Survey Credibility**

How does a client or survey manager know that a survey has been conducted properly and that the results are correct and believable? He examines the finished contour map for gross errors in data fit, location of target signatures, and overall map quality.

- 1) Selected anomalies that have been detected are re-acquired to see if they are in the proper location.
- 2) The raw data are examined to ensure that line numbers are correct, data corrections have been properly executed, etc.
- 3) Selected tests are made on the finished data, e.g., a plot of "stacked profiles" to determine that start/stop points are correct, speed changes are not excessive, there are no data gaps, etc.

### **Location of Small Objects within Associated Anomalies**

When data has been acquired over an area and processed into map form, it is often necessary to reacquire the location of each anomaly and dig to expose the ferrous object. The relocation of the anomaly is relatively simple since the coordinates can be taken directly from the map produced. However, the exact location of the object within the anomaly is often times difficult to identify and the convoluted magnetic field can be very confusing.

The anomaly may be sharp and steep (high frequency) indicating a small object close to the surface. It may be just one peak, or it may be multiple peaks depending upon the object's shape, its orientation within the earth's field, and whether the anomaly is largely due to permanent or induced effect. It may appear as a dipole or monopole, and its shape on the map may be further distorted by the distance between profiles, especially if this is large with respect to the object size. Each of these factors will also affect the anomaly signature when the object is much larger in ferrous mass and/or is buried much deeper with the resultant areal coverage of the anomaly much larger (low frequency).

As one sweeps the G-864 sensor over these peaks, it is difficult to conceptually grasp their significance, especially when using the audio output as a reference. To reduce confusion and to provide the basis for a systematic approach, it is very helpful to produce a 3-D map showing each of the peaks and valleys with the perspective of depth. Generally, a high and low pair (monopole) will stand out from the rest of the peaks and if these peaks are relocated using the G-864, the object will be midway between them.

When undertaking this exercise in the field, the audio tone should be turned down or even disregarded with the visual display of the earth's field on the front panel becoming the primary focus. By slowly moving the sensor over the anomalous area, the exact high and low peak can be located and a spot on the ground marked for each. A dipole, in the earth's field inclinations of greater than 60° will have its low North of the high peak, and in horizontal fields (inclination of 0°), the low will be in the center with a high at the North and the South ends. The point midway between high and low will contain the highest gradient and will be directly over the object or very close to it. In those cases where there is only one strong peak, the object will be directly beneath the peak.

For very large anomalies, the distance between high and low peaks may be two to ten meters or even greater. To reduce the amount of digging, it is suggested that a short profile be run completely over the anomaly, passing directly over each peak previously located and marked on the ground. Viewing this profile on the G-864 display will allow the estimation of the point of inflection of the curve between the peaks indicating the point of maximum Gradient (which should be directly over the object), and the depth of burial by means of the half width rule. (Refer to Chapter V of the *Applications Manual for Portable Magnetometers* available at [www.geometrics.com](http://www.geometrics.com))

## Appendix V. G-864 Backpack Magnetometer Specifications

### MAGNETOMETER

**Operating Principle:** Self-oscillating split-beam Cesium Vapor (non-radioactive).

**Operating Range:** 20,000 to 100,000 nT.

**Operating Zones:** The earth's field vector should be at an angle greater than 10° from the sensor's equator and greater than 10° from the sensor's long axis.

Automatic hemisphere switching.

**Noise/Sensitivity:** < 0.004nT/Hzrms. (SX (export) version: 0.02nT/ Hzrms).

**Max Sample Rate:** 25 Hz (Changeable)

**Heading Error:** +/- 0.75 nT over entire 360° equatorial and polar spins.

**Gradient Tolerance:** 20,000 nT/m.

**Temperature Drift:** 0.05nT/°C.

**Data Logger:** Getac ZX70 Android tablet.

**Data Storage:** 1 GB USB drive, 16GB on tablet.

**Data Format:** ASCII

### MECHANICAL/ENVIRONMENTAL

**Backpack:** 4.3 kg (9.5 lb).

**Storage Temperature:** -45° C to +70° C (-48° F to +158° F).

**Operating Temperature:** -35° C to +50° C (-30° F to +122° F).

**Sensor-to-Electronics Cable Length:** 3 ft or 9 ft. (0.9 or 2.7 m); User selectable.

**Electronics Module Dimensions:** DIA: 7 cm; L: 38.7 cm; Weight: .91 kg (15.25 x 2.75 in; 2 lb).

**Sensor Dimensions:** DIA: 7 cm; L: 17.2 cm; Weight: .82 kg with cable. (6.75 in x 2.75; 1.8 lb).

**Weatherproof:** O-Ring sealed for operation in rain and/or 100% humidity; Tablet: IP67 rated.

**Shock:** Survives a 3 ft drop onto a hard surface.

**Power:** 24 to 35 VDC, 15 - 30 W to start and 20 to 35 VDC, 15 W to run.

**Battery:** Lead Acid 4.5 kg (10 pounds); or Li-Po 1 kg (2.2 pounds) options available

Lead Acid: 5 Hours - Single Sensor; 3 Hours - Gradiometer

Li-Po: 7 hours - Single Sensor; 5 hours - Gradiometer

**Warranty:** 2 Years on magnetometer, 3 Years on Getac ZX70 tablet (register with Getac).

**Standard Accessories:** Backpack, staff assembly, sensor and electronics clamps, GPS receiver, 2 batteries and charger, Getac tablet and charger, tablet chest harness, power/data cable, USB Drive for backpack system updates, Geometrics USB drive with software and manuals, shipping/storage case(s).