User Guide

For

MagEx

Portable Land Magnetometer

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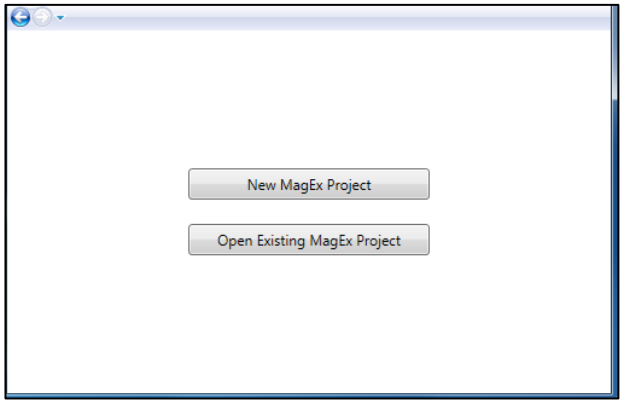
1.0 Create a Project in Survey Manager

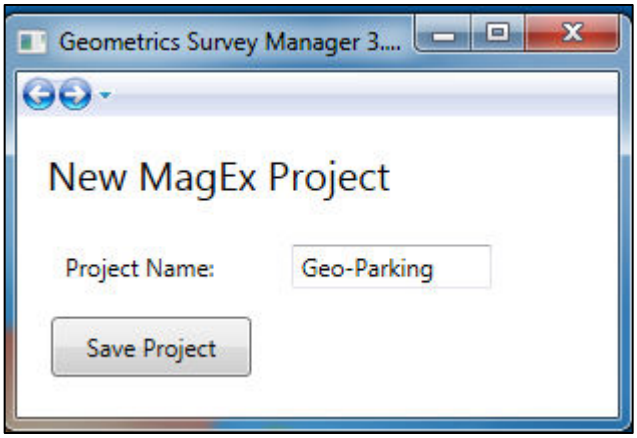
To create a new project, you may use our Survey Manager software on your PC or the MagNav app on the tablet, though most users find it easier to create their project on a PC. After creating the project file, import it into the MagNav app on the tablet. At that point, the tablet acts as the data logger for your MagEx magnetometer.

The first step is to create a New Project in which to save your surveys. To begin, open Survey Manager on your computer and choose **MagEx** from a list of other compatible Geometrics magnetometers.

On the next screen, choose **New MagEx Project**.



Name your project. Press **Save Project** and choose where to save your project (.**dbt)** file.



The next step is to decide how you will navigate your survey, either with GPS or with physical markers.

1.1 Understanding the Three Navigation Modes

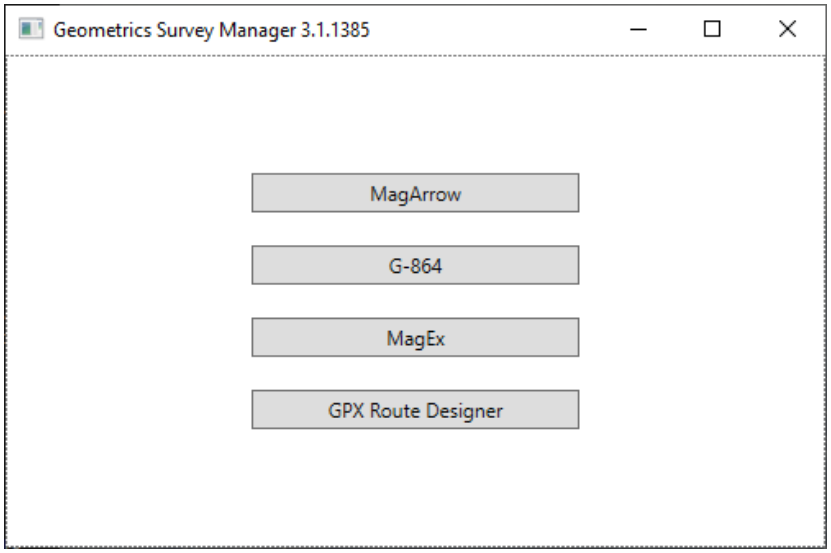
MagEx allows users to record the navigation route in 3 different ways - Free-hand GPS navigation, GPS navigation with a Route file and Marked navigation. If you are performing a survey using either GPS navigation with a Route file or marked navigation, your next step will be to set up your route parameters. If you are using the Free-hand GPS navigation, you can skip forward to **Create Surveys in Project**

1.1.1. Free-hand GPS Navigation

Use this mode if you want the instrument to automatically collect GPS locations. In this mode, the surveyor simply moves the sensor over the ground and the software does the work. You will not use a Route file or need to place physical locations in the field.

1.1.2. GPS Navigation with a Route File

In this mode, you will use both a pre-defined route and the GPS. This mode is used primarily to keep your line spacings equal as you perform the survey. You will still need to import a route file in Latitude/Longitude format, and you will create this just as you would create the route file for a marked navigation. To create a route file go to the home page of the Survey Manager to see the following screen below. Select GPX Route Designer. Complete the fields in the route designer. When a new marked survey is created you can choose the Route File from a list of all the Route Files you have created. The Route File can be based either on XY Coordinates or GPS locations. This is explained in detail in section 1.2 below.



1.1.3. Marked Navigation with Route File

Use this mode if you don't have reliable GPS signal or need sub-meter positioning accuracy. Physical markers such as cones, tapes, flags or other landmarks will be used to define your survey lines. For a marked navigation you will have to create a route file first. This is shown in the next section.

1.2 Setting Route Parameters with Route Designer

Begin by closing and re-opening Survey Manager or use the "←" on top left corner to return to the home page and click the button for **GPX Route Designer**. This opens the Route Designer module and is where you define the navigation parameters for your survey lines. Once you are familiar with the system, you may choose to create your routes first and then create your project. Fill out each field with the information you have about your survey. All distances are in meters. (2 examples are given on the next page.)

1. **Name** your route.

2. For **Route Type**, choose either Latitude/Longitude or Cartesian(X/Y) from the dropdown menu.

3. Choose the location where you will begin the survey in either X, Y or Latitude/Longitude coordinates, depending on your Route Type. Latitude/Longitude are in degrees.

4. Define the **End of first line** by using either the Azimuth and length or the endpoint location. The azimuth angle is 0 degrees in North direction and increases clockwise.

5. **Line offset direction** - define the location of your next line (left or right from first line).

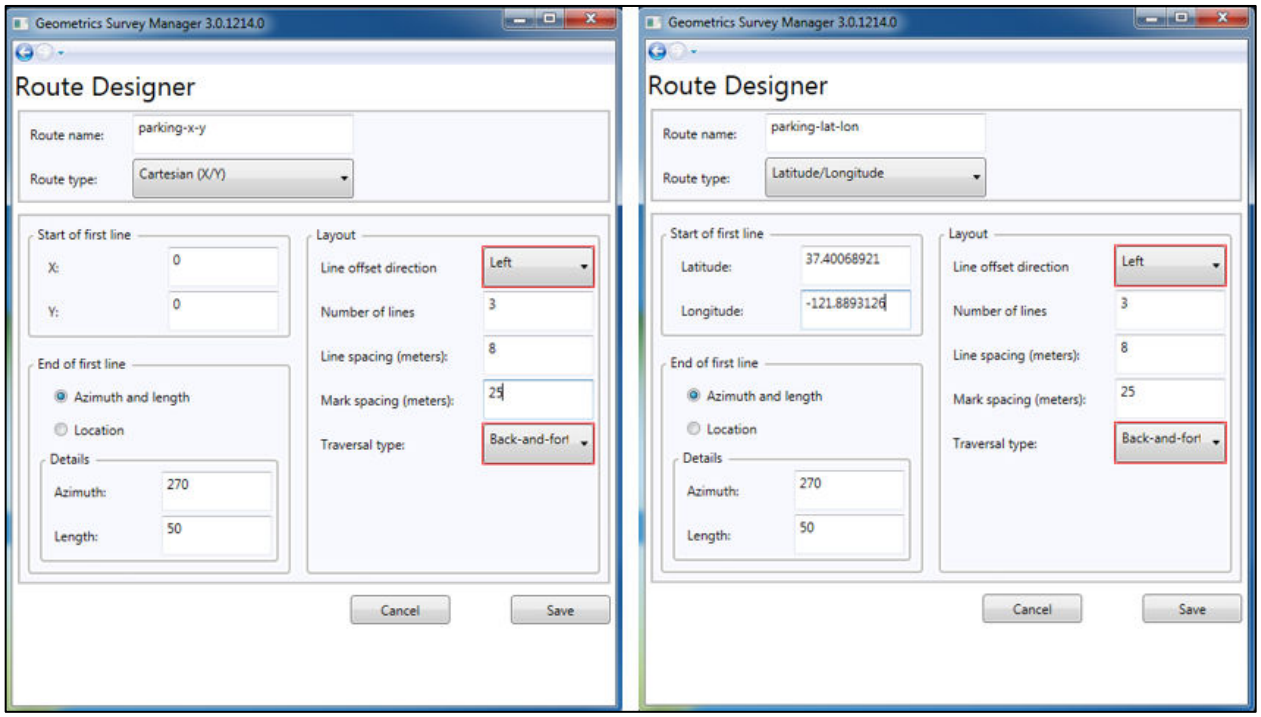
6. Input the **Number of lines** and the **Spacing** between them.

7. **Mark spacing** describes the distance between 2 adjacent marker points. Make sure that the length of the survey lines can be divided by the mark spacing.

8. Choose your **Traversal type** as either a back-and-forth (most common) survey or a survey where each traverse starts from the same side and goes in the same direction.

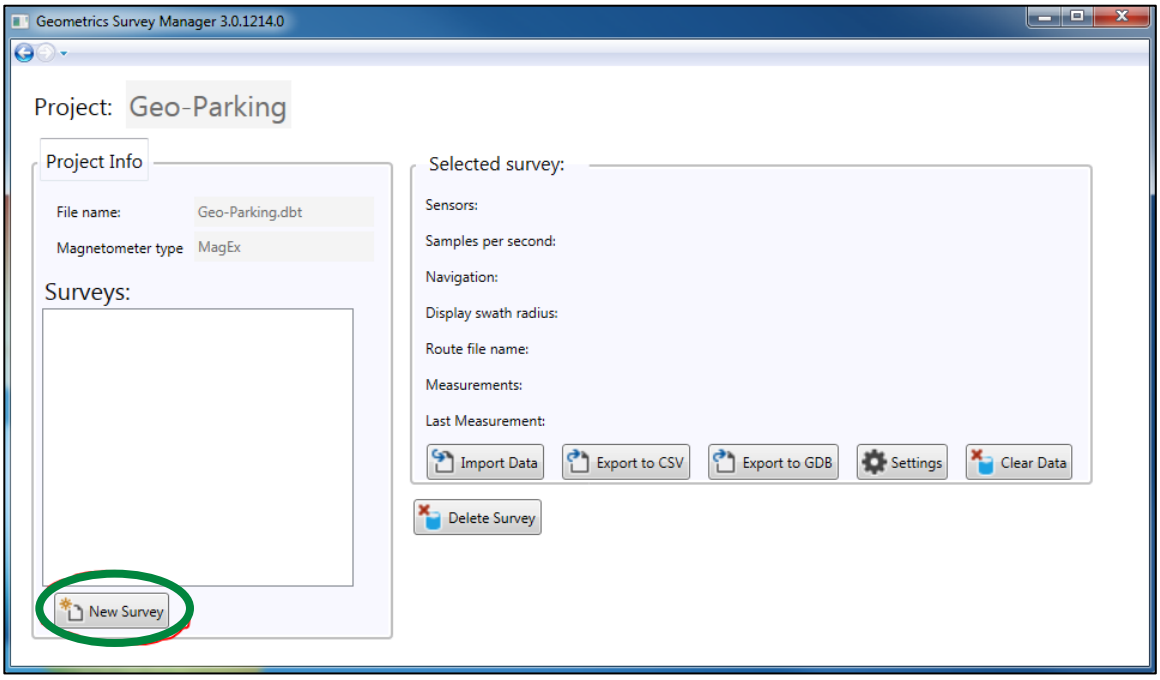
9. When you finish, make sure to press **Save** to save your Route file.

10. Use "←" to navigate back to the home page.

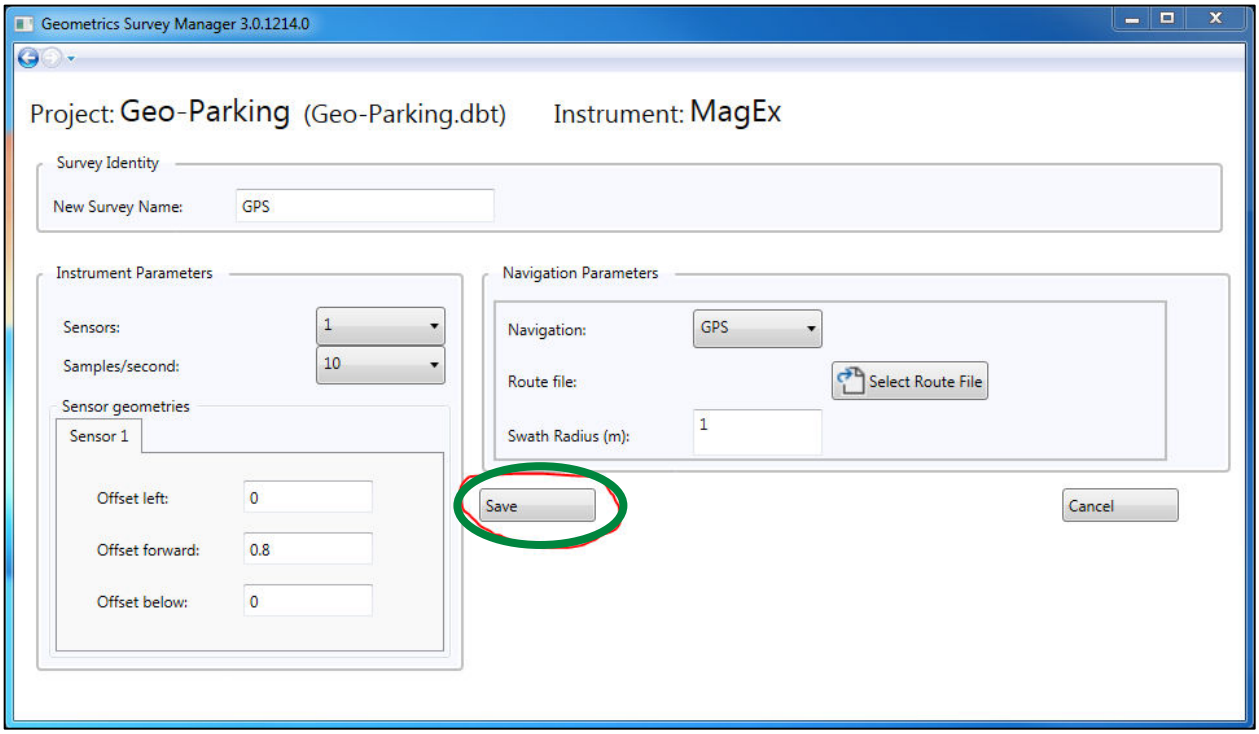


1.3 Create Surveys in Project

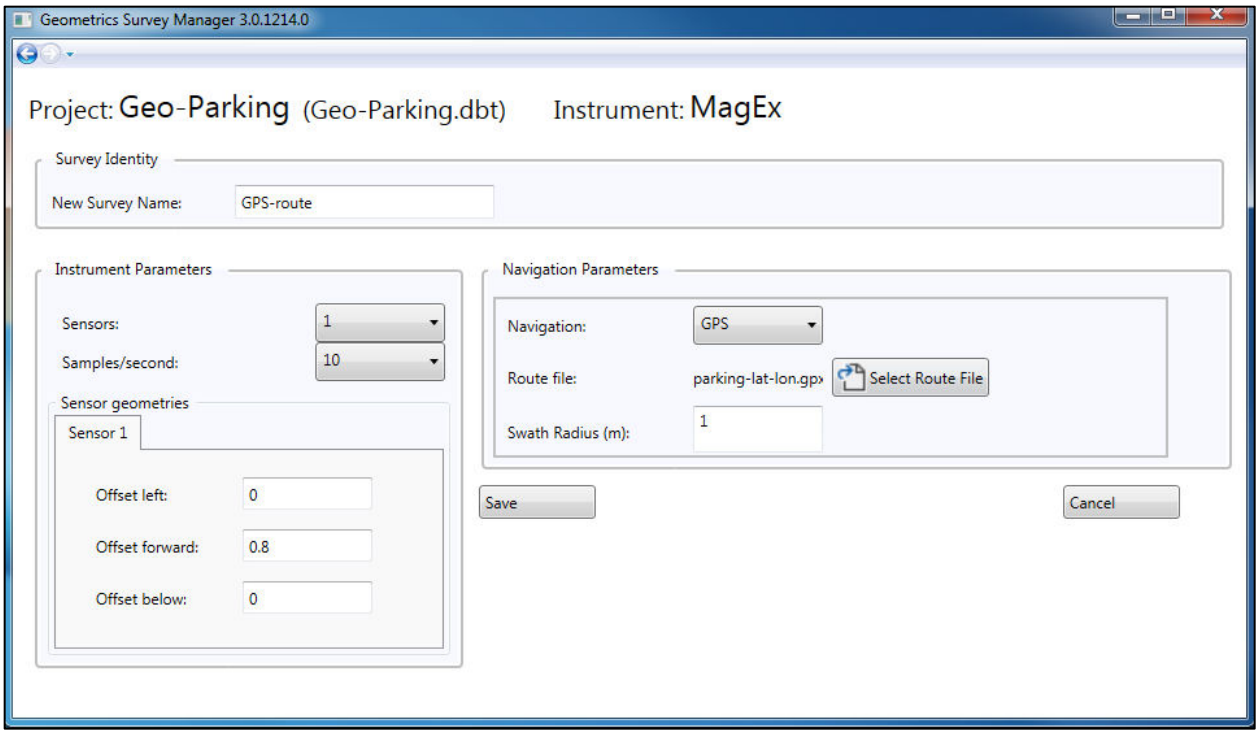
On Survey Manager home page, select **MagEx** and choose **Open Existing MagEx Project**. Find the project you created and open it. Once your project is open, click **New Survey**. You will set up your survey on the next page.



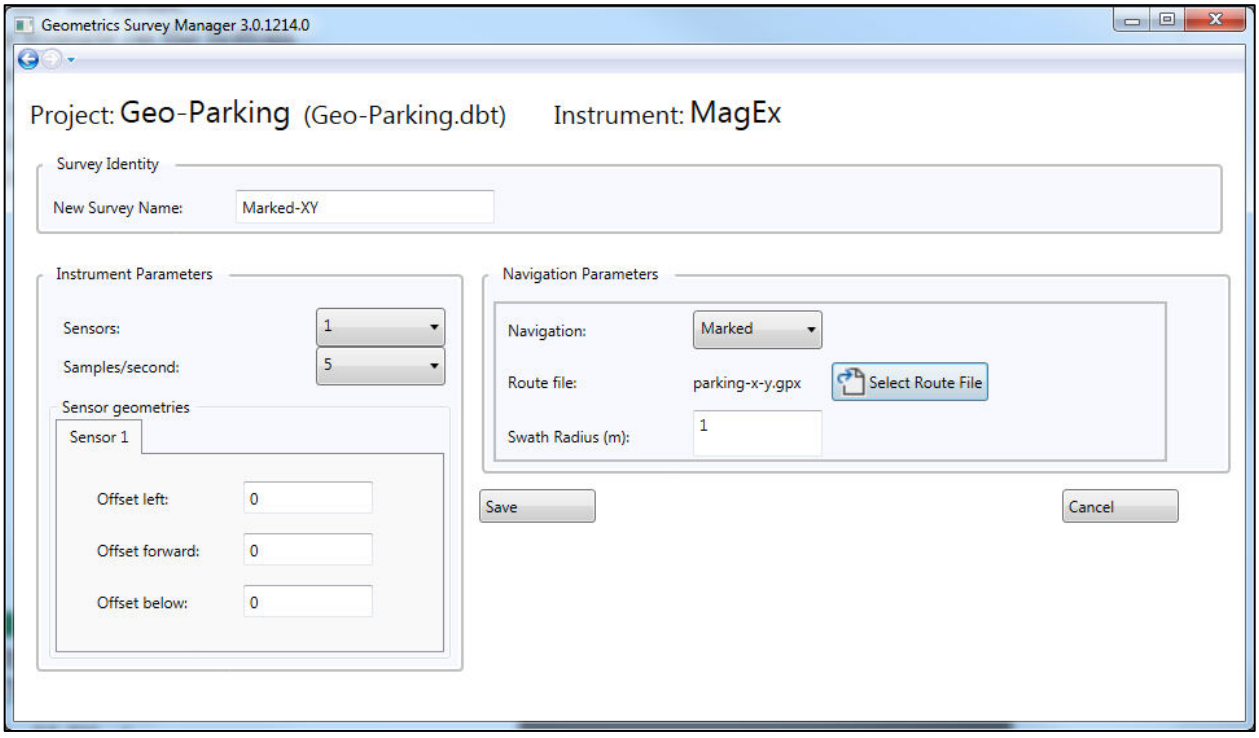
Name the survey and fill in the survey parameters as shown below. If you are using the **Free-hand GPS Navigation**, choose **GPS** in the **Navigation** dropdown menu and no Route File needs to be selected. Click **Save** to save your survey parameters.



If you are using the **GPS Navigation with a Route file**, set up other parameters similarly as the **Free-hand GPS Navigation**. Then click **Select Route File** and choose a Latitude/Longitude type route file. Make sure to click **Save** to save your survey to the project.

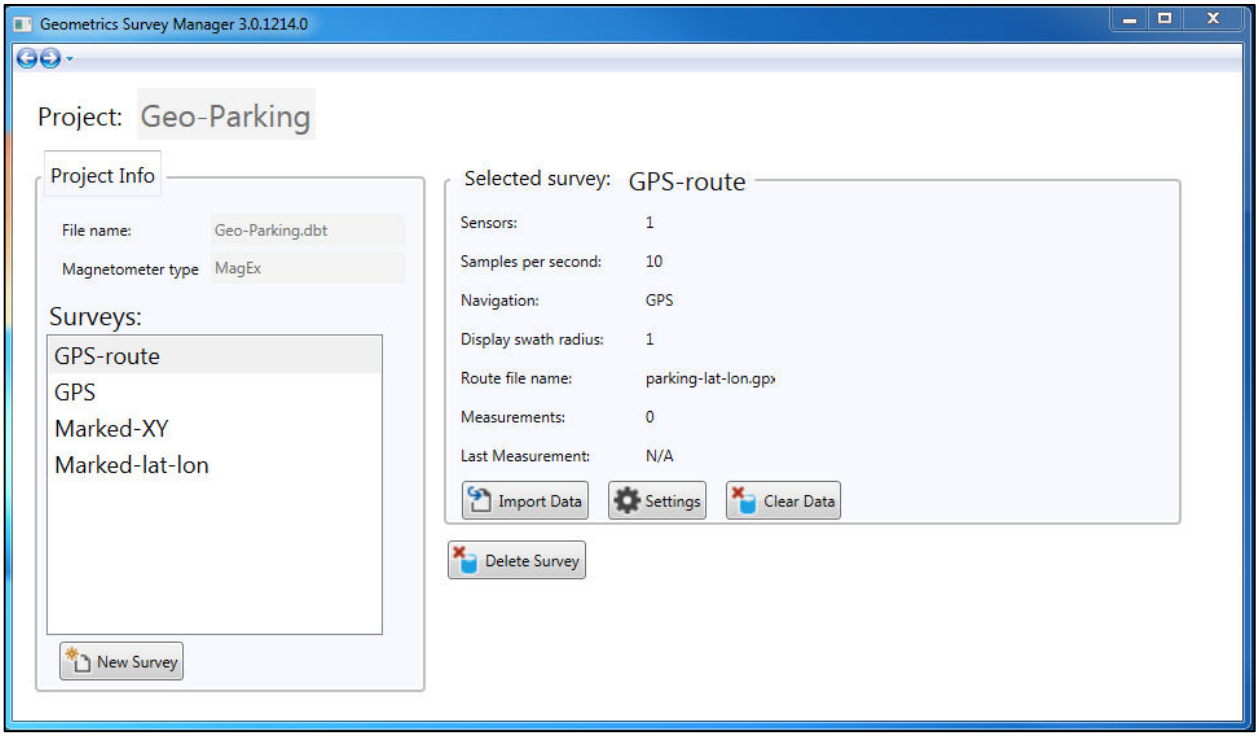


If you are using the **Marked Navigation**, set the **Offset forward** to 0 and select **Marked** in the **Navigation** dropdown menu. Either a **Cartesian (X/Y)** or a **Latitude/Longitude** Route file can be used. *Make sure to save your survey!*



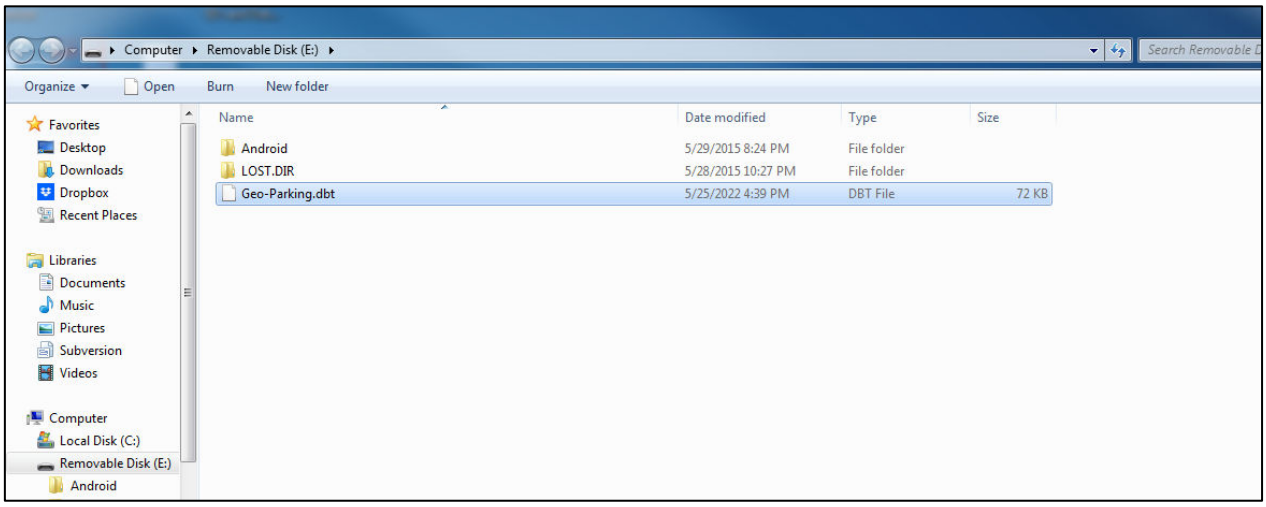
A Route Map is required for a Marked Navigation. Creation of the Route Map is explained in

After creating your survey, it will be visible on the project page. All your surveys will be visible here. Select one of your surveys to check the settings or delete.

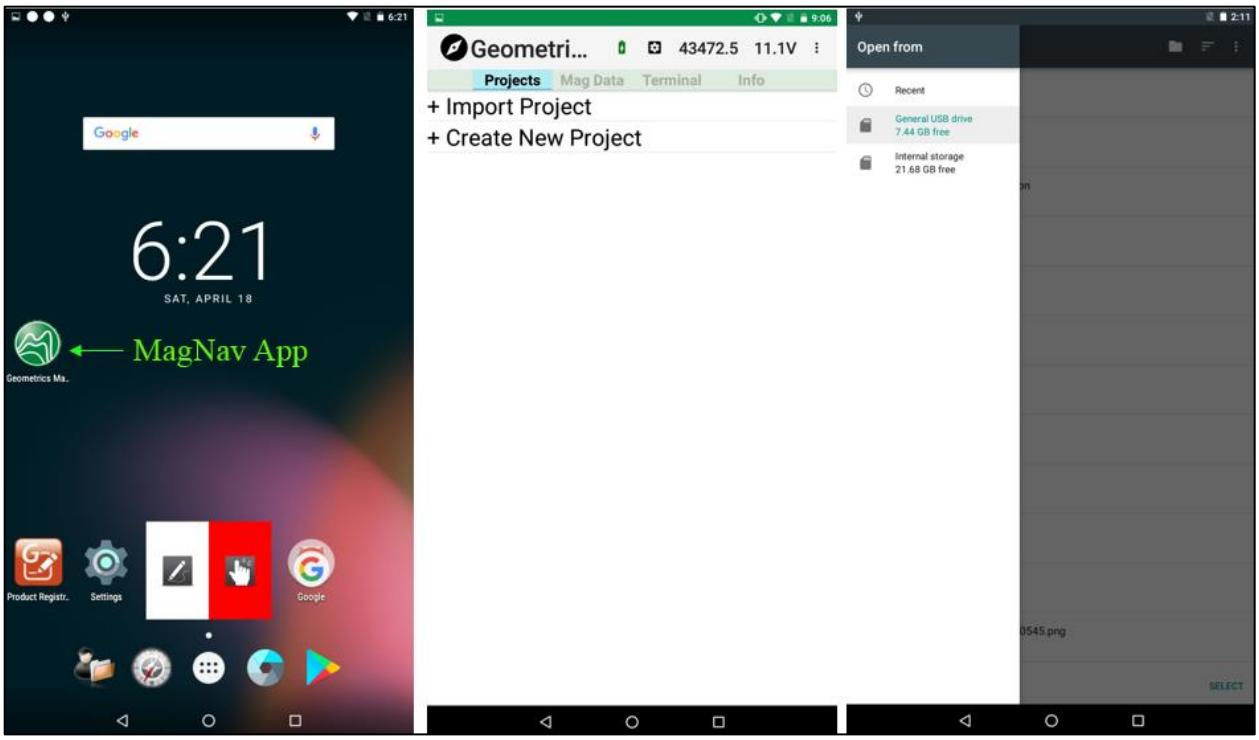


2.0 Import the Project into the Tablet

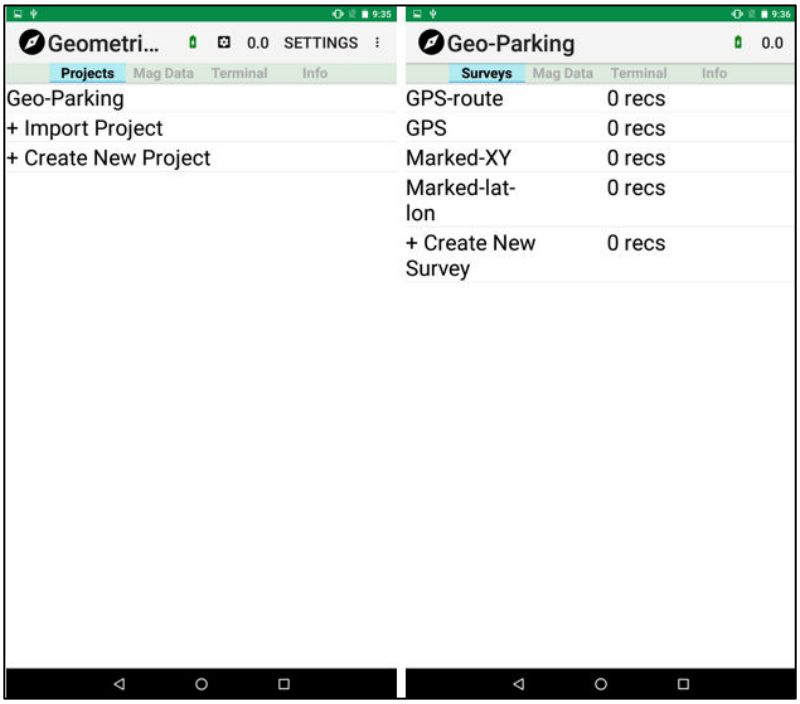
Insert a flash drive into the computer and copy the project file (.dbt) to the flash drive. Safely eject the flash drive and insert it into the tablet.



Turn on the tablet and open the Geometrics MagNav app. On the MagNav home page, click **Import Project**. Navigate to the external USB drive and select the project file (.dbt).



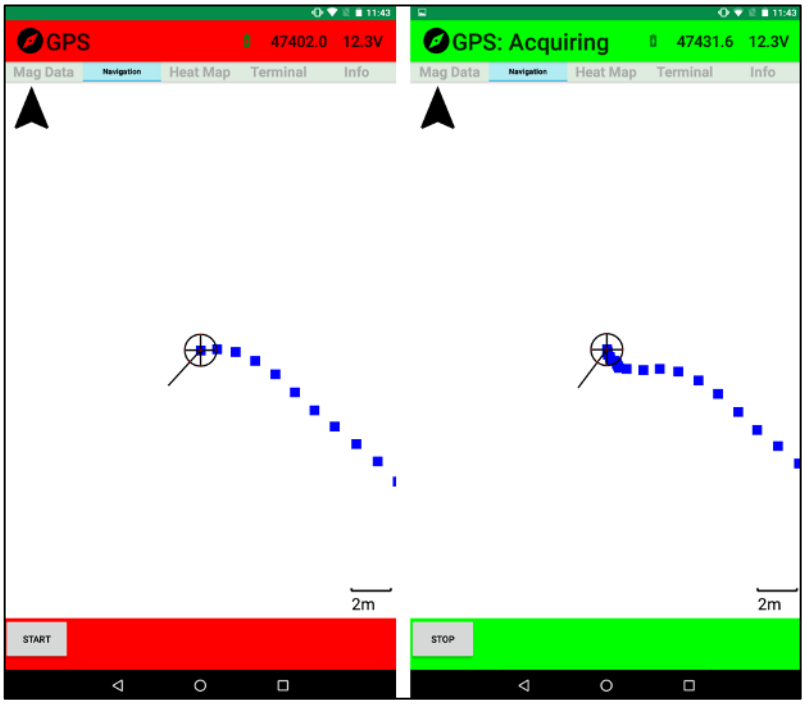
After the project is imported, the project name should appear on the MagNav home page. Click the project name to enter the project home page, where individual surveys should appear.



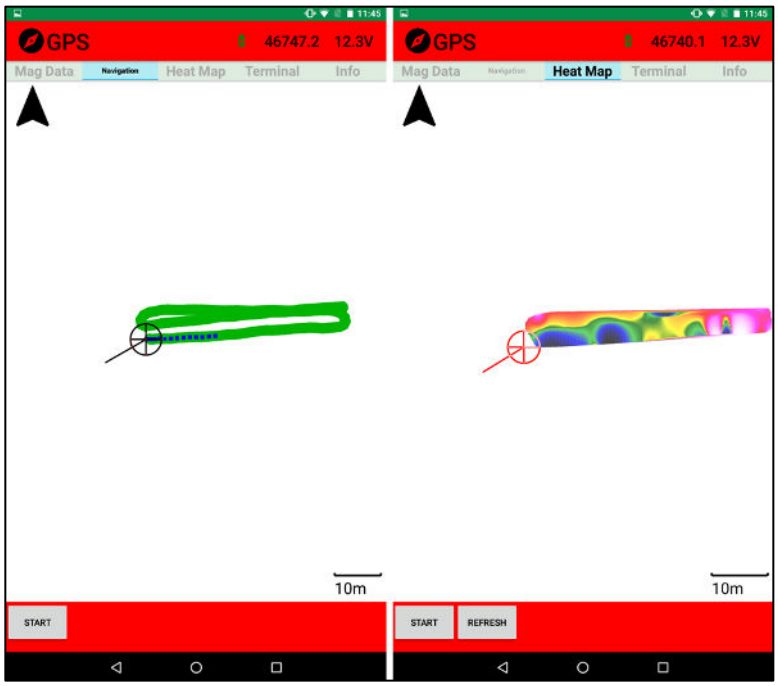
3.0 Collect the Survey Data

3.1 Free-hand GPS Navigation

Enter the **GPS** survey and click the **Navigation** tab to display the GPS location. The background color is red before the survey starts (below Left). Once you are physically located at the starting point, click **START** to collect data. The background color turns green during the data acquisition (below, right).

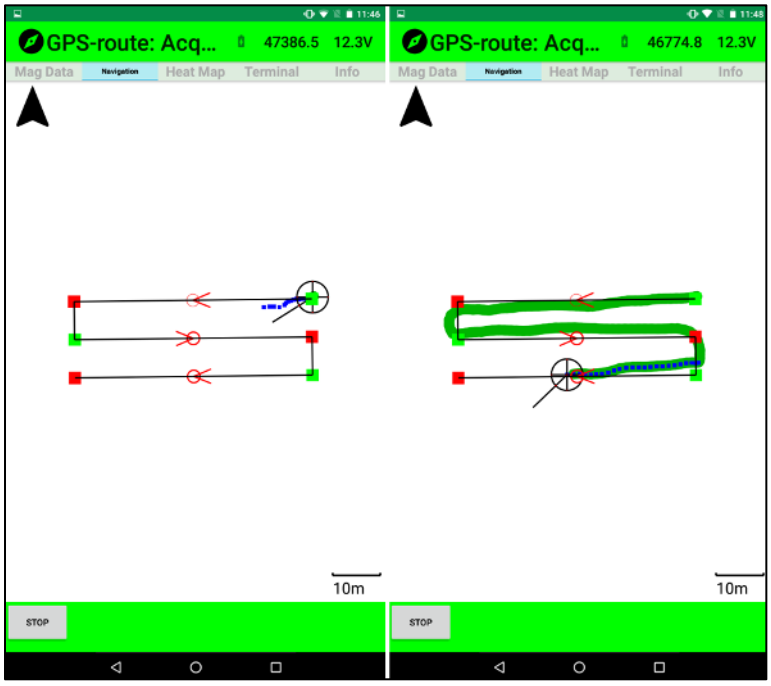


After finishing the data acquisition, click **STOP**. The route where the data is collected will be displayed (below left). Click the **Heat Map** tab **and** press **REFRESH**. A heat map of the collected data will be plotted (below right).



3.2 GPS Navigation with a Route File

You may find that it is hard to keep equal line spacing in the free-hand GPS mode. A route file can help you overcome this issue. Press the triangle button on the bottom of the screen to navigate back to the project home page. Enter the **GPS-route** survey and click the **Navigation** tab. If the latitude and longitude is set up correctly in your route file, you should see the pre-determined survey lines. At the starting point, click START to collect data. During the survey, you can rely on the survey lines to guide your navigation. Stop the survey and plot the data similarly as in the previous section.



3.3 Marked Navigation

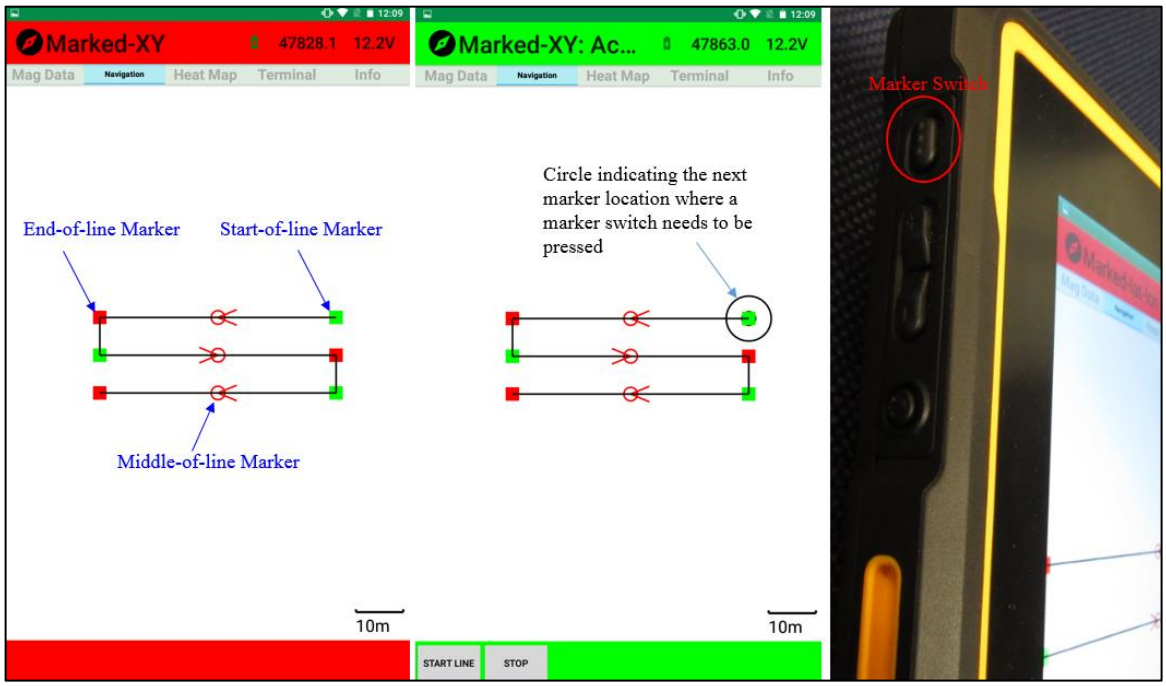
GPS navigations are the most convenient data acquisition modes. However, you may not have reliable GPS signals at some survey sites, or the required positioning accuracy is beyond what is achievable using the GPS. Marked navigation provides a solution in such cases.

On the project home page, enter the **Marked-XY** survey and click the **Navigation** tab. On the survey site, lay out physical markers such as traffic cones, according to the route parameters set up in the route designer.

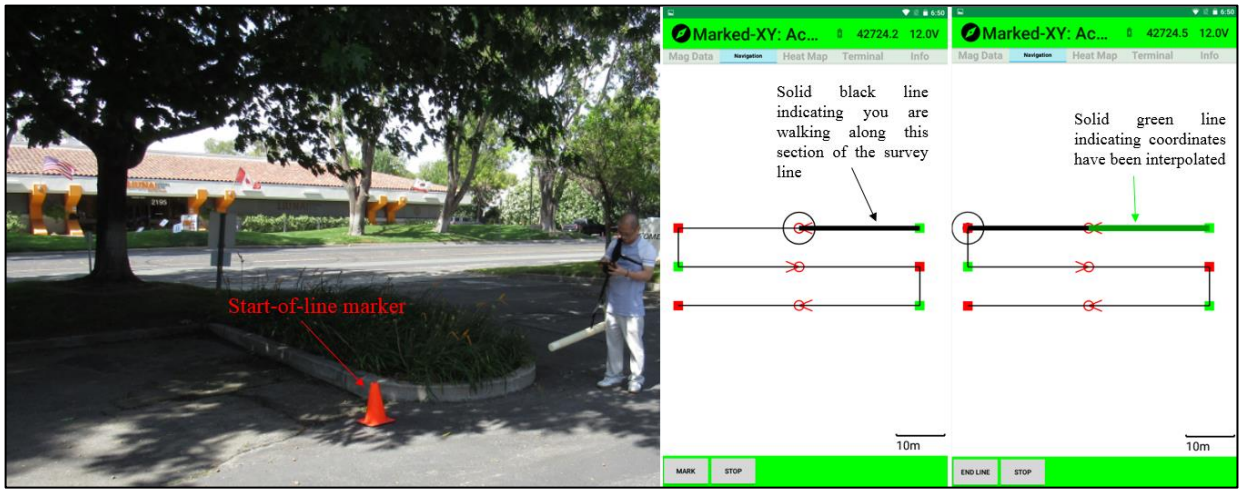
3.3.1 Marker Types

Green Square	■	**Starting point of the survey line**
Red Square	■	**Ending point of the survey line**
Red Circle	●	**Markers within each survey line**
Arrows	→	**Direction of travel**
Green Circle	●	**Location to start next line (press marker switch)**

Press the start-of-line marker to enable the data acquisition. The screen background turns green, indicating that data acquisition starts. *This does not include the positioning information.* At the same time, a circle also appears on the marker where you should mark the location next. Marking the location can be done by pressing the button on the screen or the physical marker switch on the tablet or the physical button on the handle of the device.

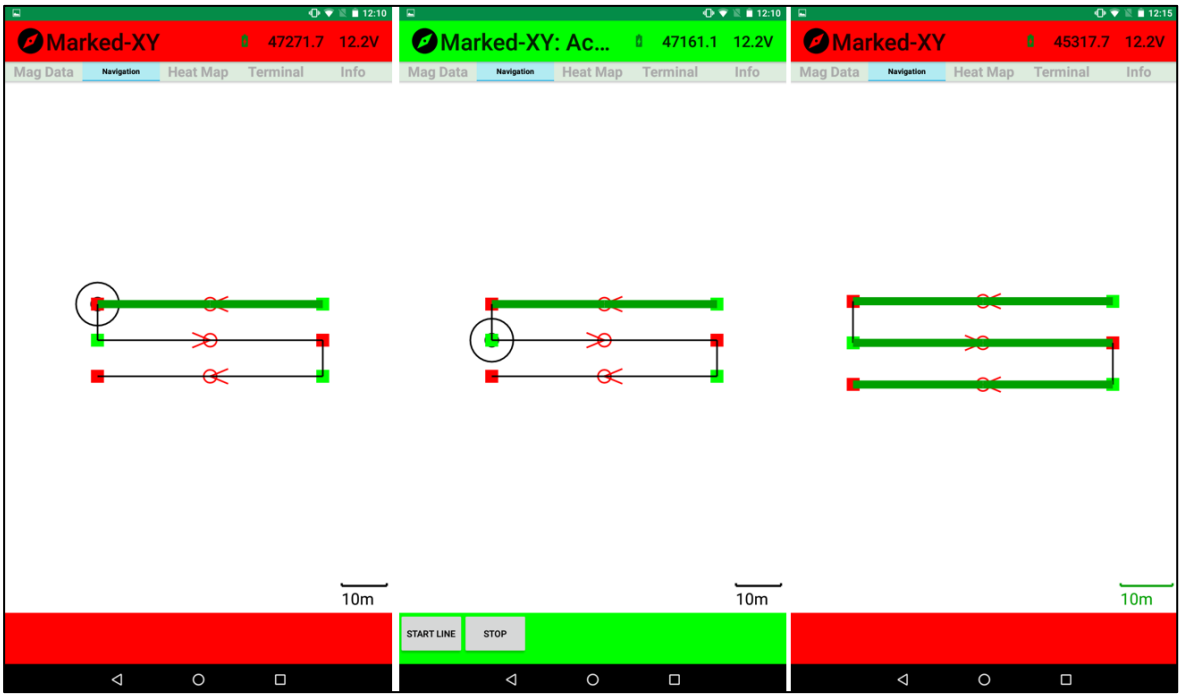


The device assigns the pre-determined marker coordinates (from the route file) to the data point once the marking signal is received. The coordinates between 2 markers are interpolated assuming a constant speed in a straight line. It is a good practice to NOT start a survey line exactly at the start-of-line markers. Instead, backing off from a starting marker by a couple of meters and walking towards the marker. When the sensor (tip of the device) is above the marker, using one of three methods to mark the location. Once the starting location is marked, the circle moves to the next marker location and a solid black line appears. The solid line indicates that you are walking along this section of the survey line. When two or more locations are marked, sections with interpolated coordinates are highlighted by solid green lines.



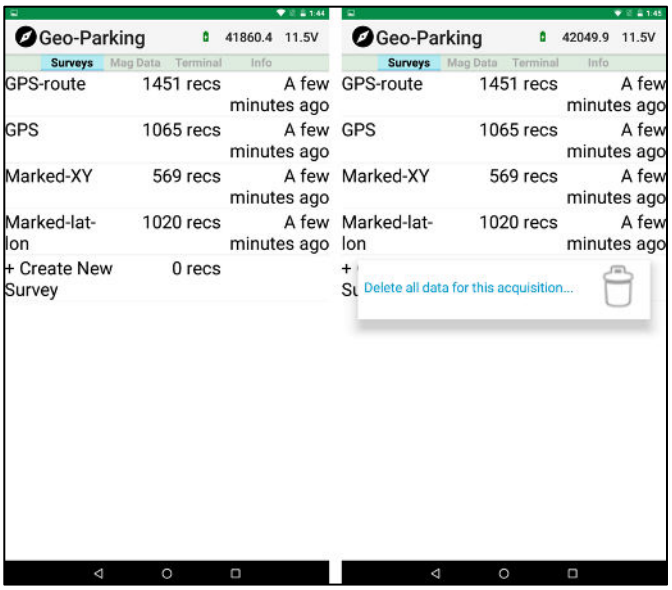
Keep walking along the line at a constant speed and press the mark switch whenever the sensor is above marker locations until the end-of-line marker location is marked. At this point, data acquisition stops and the screen background turns red. To enable data acquisition of next survey line, press the

next start-of-line marker and repeat the previous steps. When the survey is complete, all lines should be covered by solid green lines. Go to the **Heat Map** page to plot the data. If for some reasons users need to delete one or more data segments, please refer to the Appendix section. Note that the minimum time interval between two marking signals is 3 seconds. Otherwise, the second marking signal will be ignored!



4.0 Delete the Survey Data

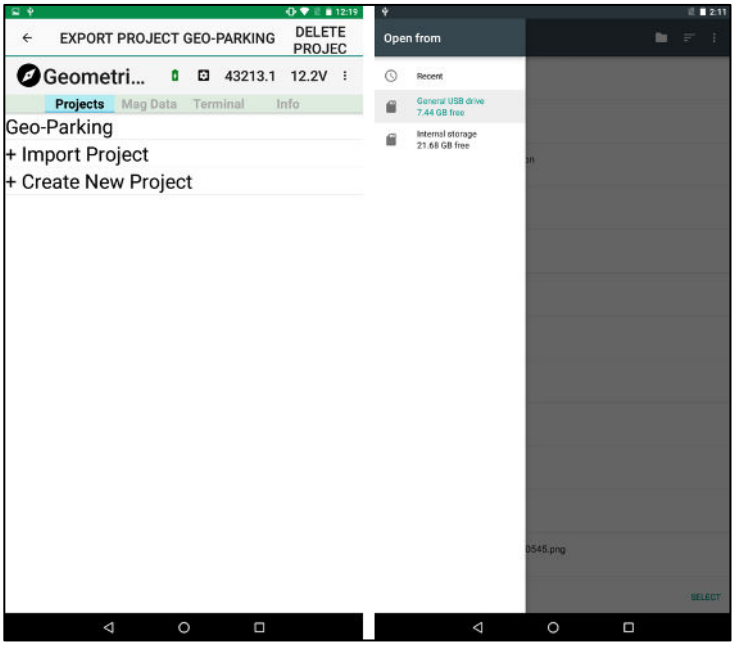
Click the triangle button on the bottom of the screen to exit to the project home page. Hold on to the individual survey name until the delete window appears. Click the delete icon (garbage can) to delete the survey data. After deletion, there should be 0 records under the survey name.



5.0 Export the Survey Data

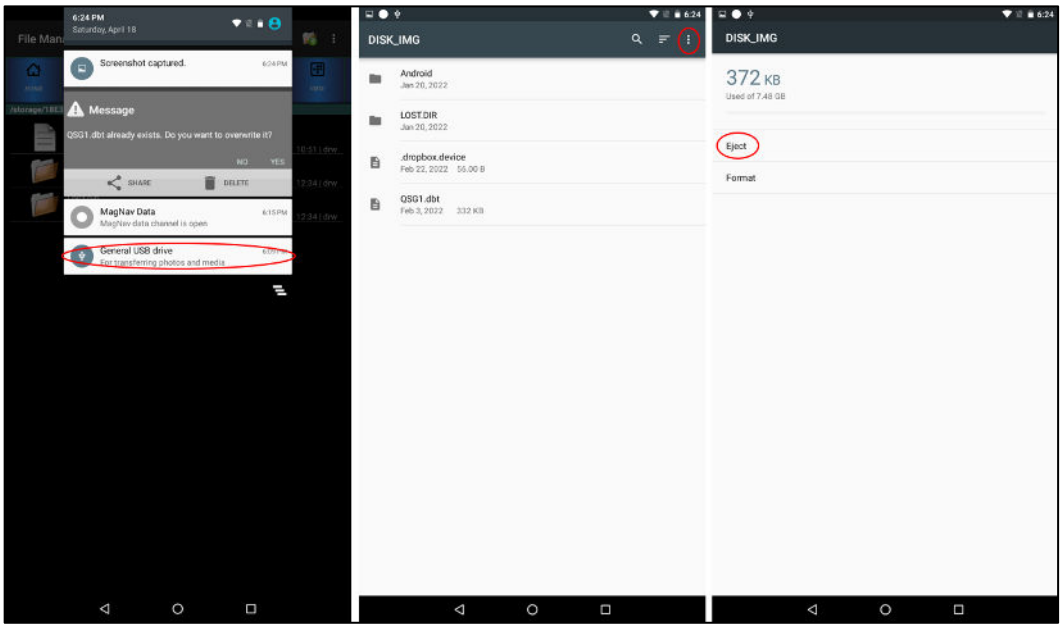
5.1 Download the Project File

Insert a flash drive into the tablet. Press the triangle on the bottom of the screen to return to the App home page. Hold on to the project you want to export until the options appear on the top of the home page. Click EXPORT PROJECT and then select the external drive. Click SELECT on the bottom right to copy the project file (in dbt format) to the flash drive. Note that the app will NOT overwrite the existing project file with the same name. The existing file has to be deleted first in the flash drive.



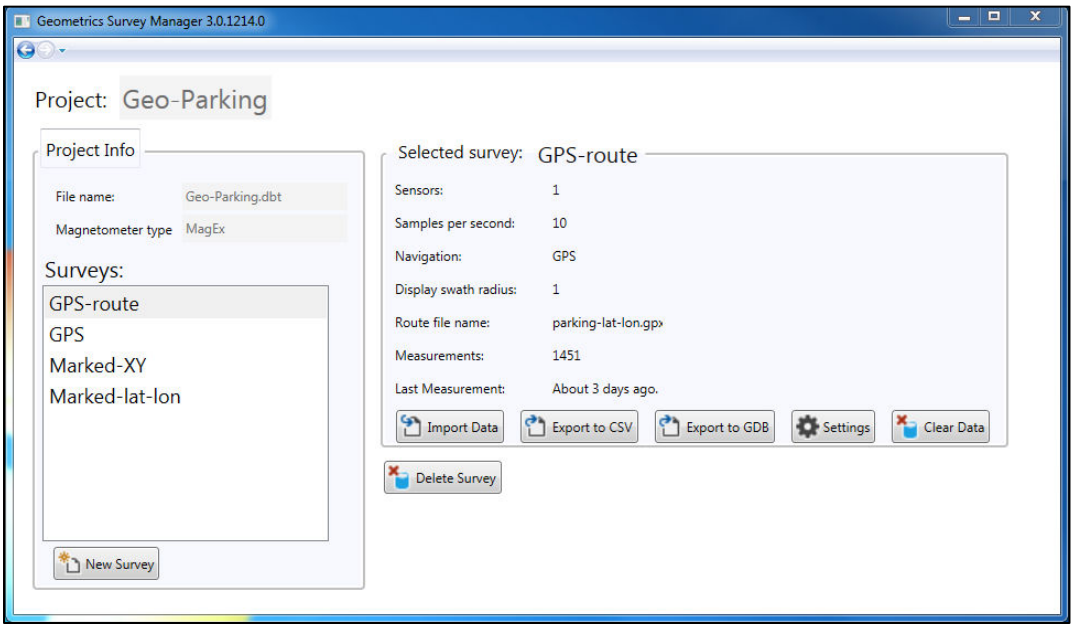
5.2 Eject the Flash Drive

It is very important for you to safely eject your flash drive. Failure to do this will result in corrupted data files! To properly eject your flash drive, swipe down from the top of the tablet's screen and select **General USB Drive**. On the next screen, click the three dots to bring up the menu and select **Settings**. On the last screen, click **Eject**. You may now safely remove your flash drive.



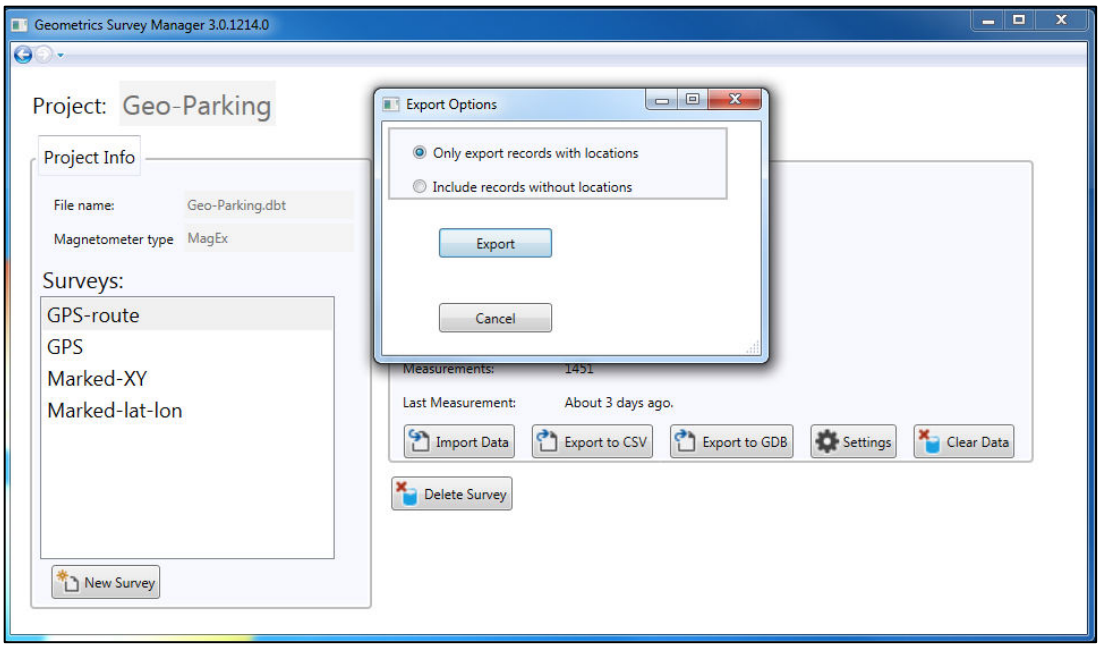
5.3 Export the Survey Data Using the Survey Manager

Transfer the project file in the USB drive to your computer. Open the Survey Manager, click **MagEx** and then **Open Existing MagEx Project**. In the pop-up window, navigate to the folder containing the project file. Select and open the project file (dbt file). The following project information window will appear.



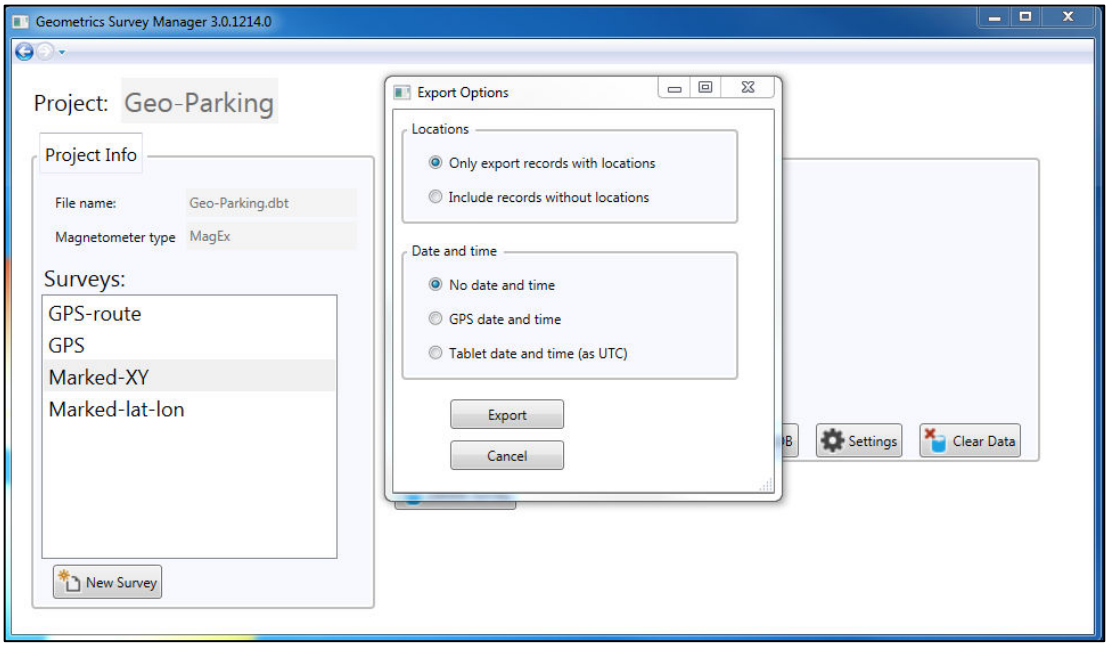
Individual surveys are listed on the left. To export a set of survey data to a csv file, select the survey and click **Export to CSV**. For GPS surveys, there are 2 export options. These are 1). only export records with locations; or 2). Include records without locations.

The first option only exports records with valid GPS signals. If parts of your survey do not receive GPS signals, then the corresponding sections of data will NOT be exported. If you find your file is smaller than expected or have fewer records than expected, then you may have lost the GPS signal during the survey. To check, export your file using the second option to include records without GPS.



For marked surveys, there are more export options. Other than the same two options about locations, there are 3 more options regarding date and time. Location options are similar as for GPS surveys. One

only exports records with locations (within markers). The other includes records without locations (data acquisition enabled but the first marker signal not received yet) as well. If time stamped data points are required, choose **GPS date and time** or **Tablet date and time**.



For users with licenses for GeoSoft software, you may export the data as a GDB file.

6.0 Simplified summary of MagEx processes from creating a survey to processing the acquired data.

6.1 Software summary

There are two software programs you will need to use, and your choice of a third program to image the magnetometer data and create a 2-D plan-view map of the survey data. These are as follows: “Survey Manager”, Survey Manager is a Windows program running on your Windows laptop or desktop computer. “MagNav”, MagNav is an android app running on your Andriod tablet. There are a number of magnetometer data imaging software you can use. Examples are Surfer from Golden Software, Magmap and MagPick from Geometrics, Oasis Montage from Seequent-Geosoft, and others.

6.2 Step by step procedures

The projects and surveys can be created on either the Windows laptop With Survey Manager or on the Android tablet with MagNav.

Creating the Survey from MagNav on an Android tablet

1) In general it is more convenient to create the Project and the Survey on the Android tablet. Both the tablet and the PC can recreate the .dbt file that will contain the survey data. The difference is the Android will only create surveys using the GPS for location. Creating a survey using marked positions without GPS can only be done in Survey Manager on the laptop. For detailed information about marks

for navigation see section “3.3 Marked Navigation” in this manual. The use of MagNav on the tablet is described in detail in the “Quick Start Guide”, which is a separate document. A summary of the procedure follows.

2) With the MagEx turned on connect the tablet to the MagEx WiFi. The WiFi is MagEx-***** where “*****” is the MagEx magnetometer serial number.

3) You will see the MagNav Icon on your tablet’s home screen. Double click and open the MagNav app.

Click "Create New Project” and inside the Surveys page click “Create New Survey”. In the pop-up window, set up your survey parameters and click OK. The new survey will appear on your Surveys page. Click the survey name to enter the survey data collection.

4) Click on the new survey to start data collection. In the survey “Navigation” screen click on “Start” to begin data acquisition. This process is described in more detail in sections “MagNav App” and “Starting Your GPS Survey”, sections 8 and 9 of the MagEx quick start guide.

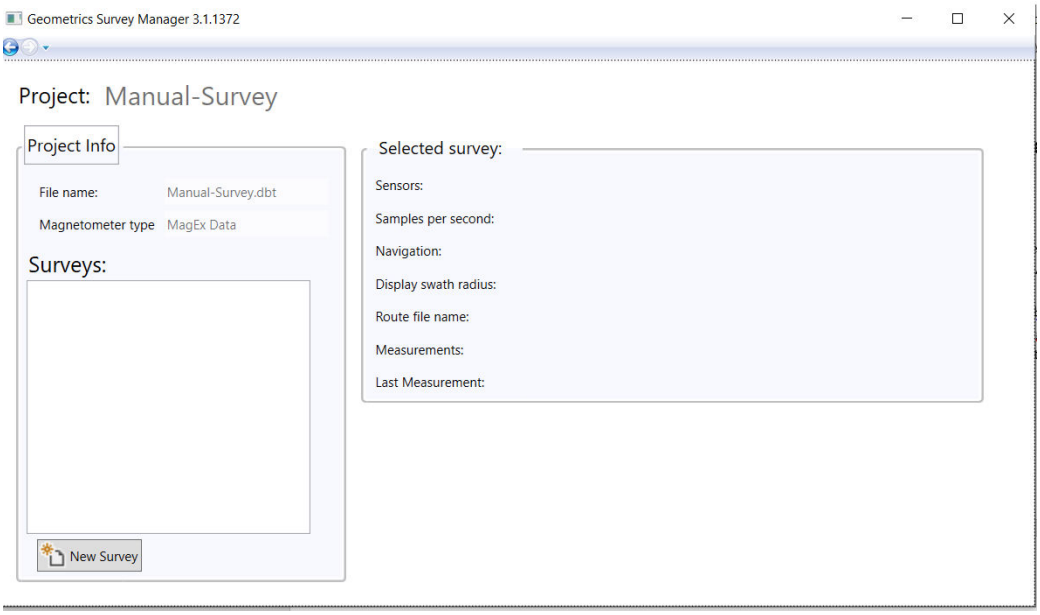
5) After the survey data has been acquired export the survey data to the Survey Manager laptop. Insert a USB drive into the Android tablet.

6) The transfer to the laptop is explained in detail in section 5 of this MagEx User Guide. After the data has been transferred to the Windows computer open Survey Manager. Select “Open Existing MagEx Project”. Navigate to the data folder and select the desired survey .dbt file. From the displayed screen the data can be exported as .CSV files or Geosoft .DGB files. For example, selecting “Export CSV” will display a window to allow you to choose a data folder and give it a unique name. Note that the CVS file, in addition to having columns for Lat, Long, and mag readings also contains columns that are not used with the MagEx, but are part of the MFAM module. These are the readings from an internal Compass and an internal gyroscope-accelerometer. The compass and accelerometer readings are used for airborne and drone borne magnetometers for compensation calculations. They are not needed for the MagEx.

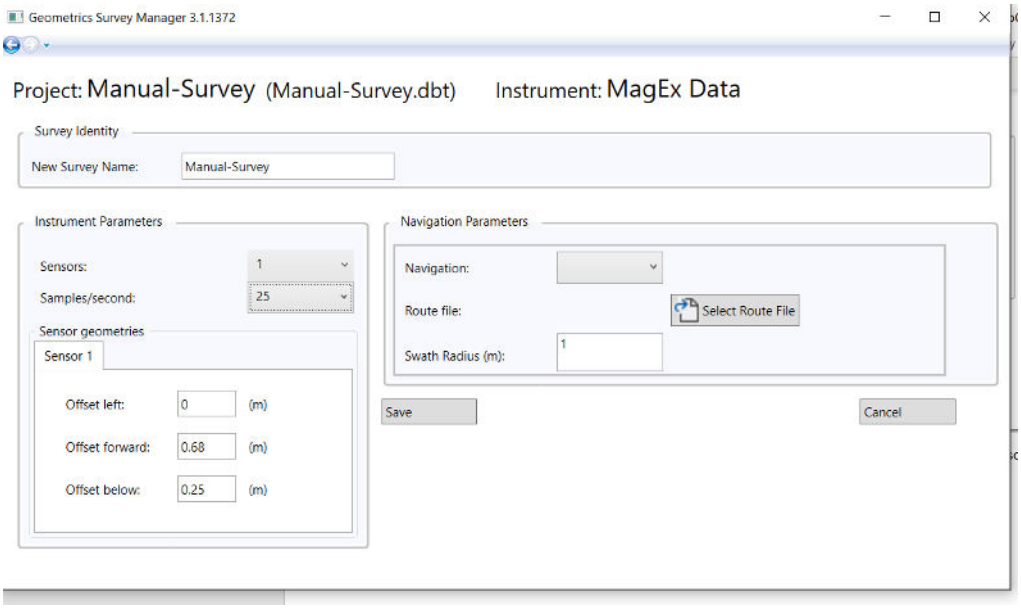
Creating the Survey from Survey Manager on a Windows Laptop

1) Open Survey Manager on your Windows computer. Follow the directions in section 1 of this manual. They are, select “MagEx”. Click “New MagEx Project”. Name and save the new project.

2) You will see the following screen:



Click New Survey to give the survey a name, select navigation mode, and review or change the survey parameters from the screen below.



Click “Save”. The file will be saved in the folder you created for the new survey previously. Details of the setup are given in chapter one of this manual

3) Copy the survey dbt file to a USB drive and insert the USB drive into the USB port on the tablet.

4) Open MagNav on the Android tablet by clicking on the Geometrics icon on the tablet’s home screen. Click on Import Project and select the project dbt file on the USB drive.

5) Turn on the MagEx and connect the tablet to the MagEx WiFi. The WiFi name is MagEx-***** where the "*****" is the serial number of the MagEx magnetometer.

Select the Project name from the Projects screen on MagNav. Click on "Create New Survey" and enter the survey parameters. The survey name will appear on the "Surveys" screen. Click on the new survey to start data collection. In the survey "Navigation" screen click on "Start" to begin data acquisition. This process is described in more detail in sections "MagNav App" and "Starting Your GPS Survey", sections 8 and 9 of the MagEx quick start guide.

6) After the survey data has been acquired export the survey data to the Survey Manager laptop. Insert a USB drive into the Android tablet.

7) Transfer the USB drive with the project to the laptop as explained in detail in section 5 of the MagEx User Guide. Open Survey Manager. Select "Open Existing MagEx Project". Navigate to the data folder and select the desired survey .dbt file. From the displayed screen the data can be exported as .CSV files or Geosoft .DGB files. For example, selecting "Export CSV" will display a window to allow you to chase a data folder and give it a unique name.

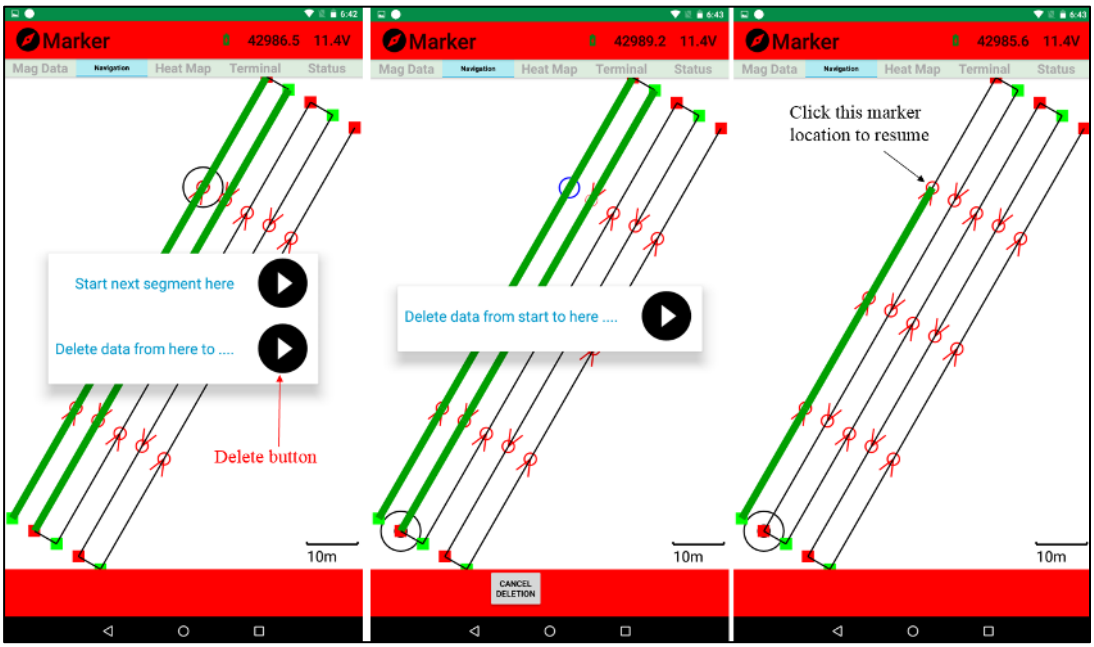
8) Magnetic data processing. For those who use Surfer or Geosoft Oasis you are already familiar with creating 2D maps of the data. There are several commercially available data contouring-mapping on the market. Nearly all data mapping programs will be able to read and plot the ASCII CSV X,Y, and attribute format.

7.0 Appendix

7.1 Delete Data in Marked Surveys

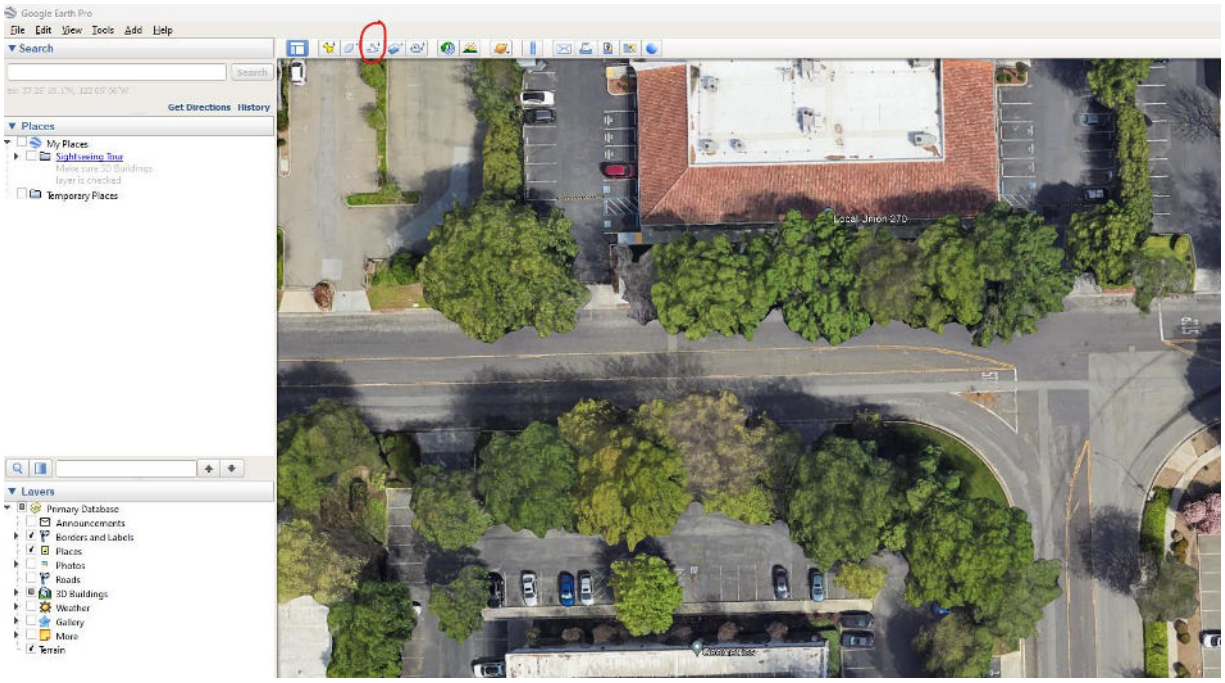
In certain cases, users may need to delete one or more data segments. Users may do this only while the MagEx is connected to the tablet.

To delete a segment, choose one end of the data to be removed and use your finger to hold that marker point. A popup window will appear. Click the **Delete data from here to ….** button. Then locate and press the other end of the data segment to be removed. Hold that point until a second popup window appears. Click the **Delete data from start to here….** button. The deleted data segment will NOT be covered by solid green lines anymore. To resume data acquisition, click the marker at the end of the solid green line.

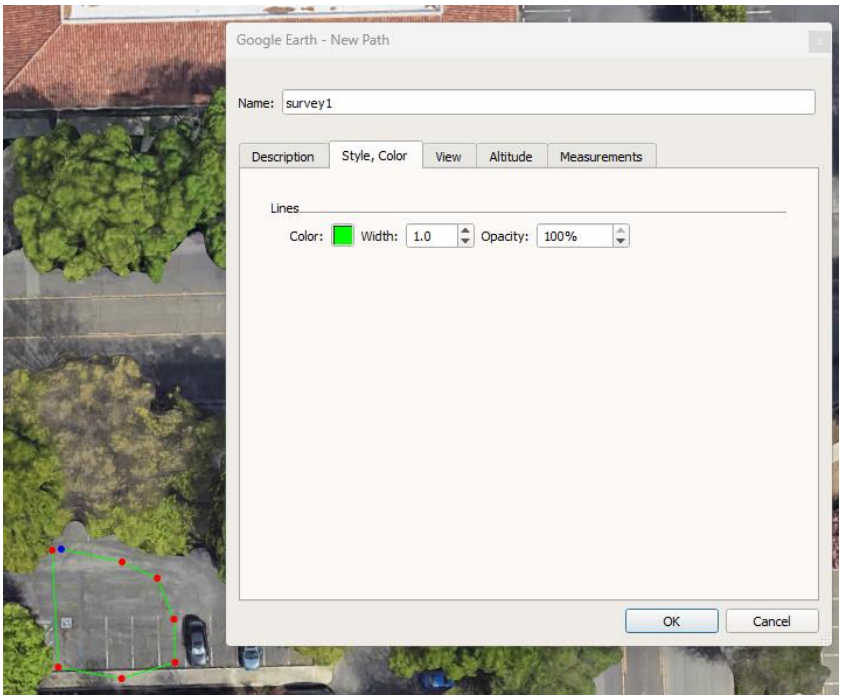

Marker
42986.5 11.4V
Mag Data
Navigation
Heat Map
Terminal
Status
Start next segment here
Delete data from here to ....
Delete button
10m
Marker
42989.2 11.4V
Delete data from start to here ....
CANCEL DELETION
10m
Marker
42985.6 11.4V
Click this marker location to resume
10m

7.2 Create and load a Google Earth KML file into MagNav to guide your survey

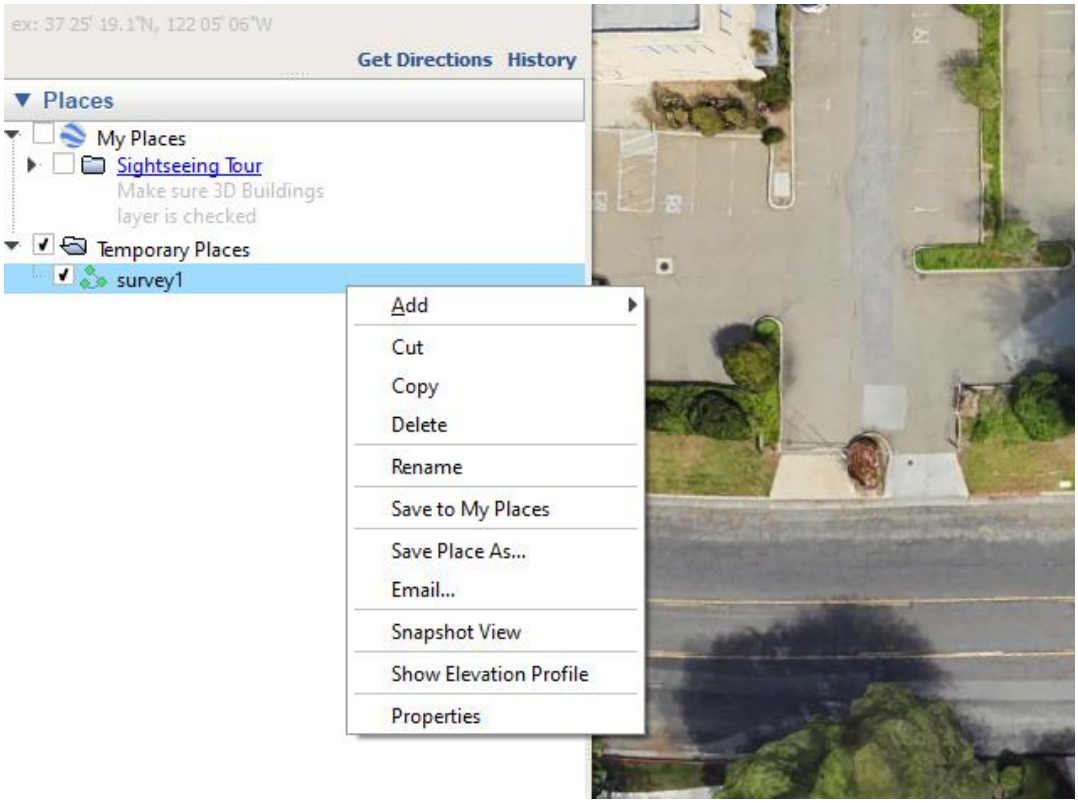
1. Open Google Earth Pro. Navigate to your survey area and click “Add Path”.



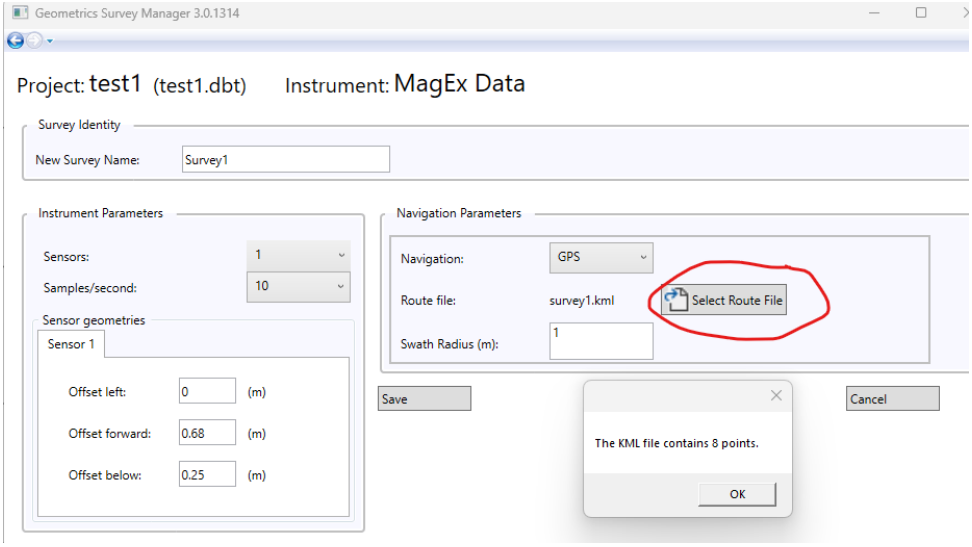
2. Move your cursor and left click to define the outline of your survey area. You can rename your path name and click OK.



3. Select the new path created and right click it. In the pop-up menu, click “Save Place As” to save it as a kml file.

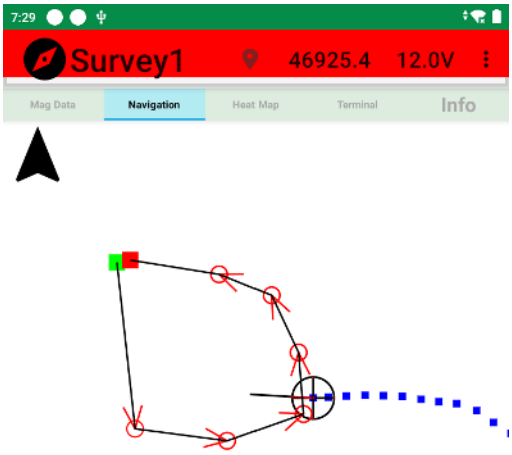


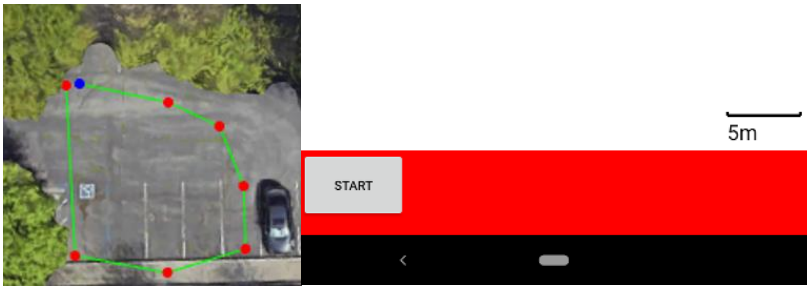
4. Open the Survey Manager. Load an existing project or create a new project. Inside the project, create a new survey. Set up other preferred parameters. Click “Select Route File” and load the saved kml file. Make sure to click “Save” before exiting.



5. Plug in a USB drive and copy the project (.dbt file) to the USB.

6. Eject the USB from your computer to make sure it can be safely removed.
7. Turn on the instrument and the Getac tablet. Make sure the wifi is connected.
8. Plug the USB drive into the Getac tablet.
9. Open the MagNav app. Click “Import Project” to load the project (.dbt file) from the USB.
10. Enter the project and enter the survey. On the Navigation page, the path created in Google Earth will be displayed, which can be served as guidelines or outlines for GPS surveys. Marker points can be created similarly for marked surveys.





7.3 How to set up NTRIP Base Station for GPS RTK

What Does the GPS Need to Get RTK Accuracy?

First the GPS must be capable of generating RTK data. A RTK capable GPS uses a much different method to calculate position compared to a non-RTK GPS. In addition, you need a surveyed in place base station to send correction data to the roving GPS to compensate for variable atmospheric delays in the satellite's transmission path. One way to do this is setup your own base station with each survey site. Another way is to use an established network of base stations that can broadcast the corrections via the internet and cellular phone network.

What is NTRIP?

NTRIP is an acronym for "Networked Transport of RTCM via Internet Protocol". NTRIP allows base station correction data from a nearby base station to be accessed via the internet and sent to the roving GPS. Many base stations exist which run continuously and broadcast their base station data to a caster which can redirect it to the roving GPS via the cellular network.

Getting a NTRIP Account and Sign In Credentials:

To access the network of NTRIP data feeds you will need to get an account with a username and password. Some NTRIP networks will give free accounts for engineering development, personal use, and or educational use. One such network is run by UNAVCO (you can look up other providers by visiting https://ntrip-list.com/). To get an account you will need to email them at:

rtgps@unavco.org

There are some restrictions on commercial use of the data, and some attribution requirements for any published data using NTRIP data feeds. It may take a few weeks for the account request to be processed.

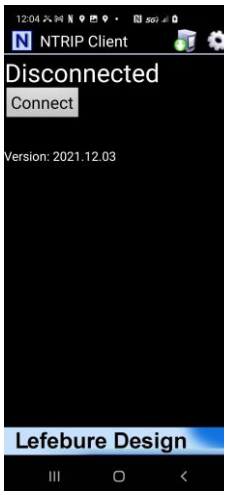
The UNAVCO networked base stations are mostly concentrated on the western United States, but they do have stations elsewhere as well. An internet search for UNAVCO base station sites will bring up a map of base station locations. You'll need to have a base station within 15 kilometers or so from your survey site.

Using an Android Cell Phone as a NTRIP Client:

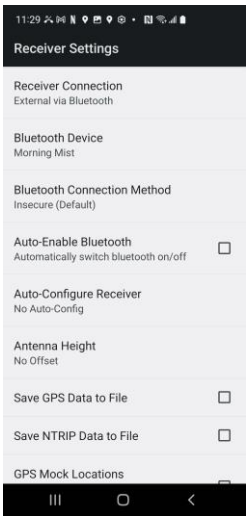
To get NTRIP correction data to the MagArrow/MagEx magnetometer we will use an NTRIP client app running on an android cell phone. One very good (and free) app is called "NTRIP Client" by Lefebure Design which may be found in the google Play Store. It allows you to connect to your NTRIP caster account using your name and password credentials. Through the app you can select a base station close to you and receive the correction data via the cellular network. The app will then redirect that correction data to the MagArrow/MagEx via a Bluetooth link.

Using NTRIP Client by Lefebure Design:

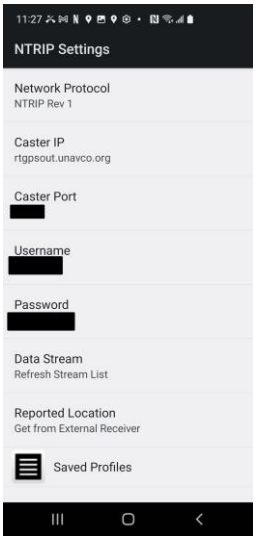
1) Installing the app: In the google play store search for "NTRIP Client" and select and install the Lefebure version. Install the app.
2) Pairing the Android Bluetooth with the MagArrow/MagEx: To get the correction data from the phone to the MagArrow/MagEx you will need to pair the phone and MagArrow/MagEx Bluetooth connections. On the phone go to the Bluetooth settings and scan for the MagArrow/MagEx Bluetooth name which will be the last 8 digits of the MagArrow/MagEx serial number. Select it and allow it to pair up. The opening screen of the app is shown on the right.
3) NTRIP Client Settings: Launch the NTRIP Client app. In the upper right corner tap the gear (settings) icon to go into the setup menu.
    a. Display setting: Leave all the items at their default setting.
    b. Receiver Settings: Click on this item and then select "Bluetooth Device". This will show all the paired Bluetooth devices on your phone. Select the MagArrow/MagEx Bluetooth device which you paired to above. Leave all the other settings at their default setting. In the example screen shot the Bluetooth device is "Morning Mist" which isn't standard. Normally it will be the last 8 digits of your MagArrow/MagEx serial number.
    c. NTRIP Settings: This is where you put in your account name, password. When you get an NTRIP account there will be instructions on how to set this page up. The only other thing you will need to change once the NTRIP account is set up is the "Data Stream" setting. This is where you select the base station correction source which is usually letters and numbers. Be sure to do this part right. You want to get the base station ID from the map of base stations close to you and select the closest base station. If you put in the wrong base station code here you won't get good results, and it may be difficult to figure out why. In the screen shot at the right we have selected "SLAC_RTCM3" which is located at the Stanford Linear Accelerator in northern California.
    d. The Help ICON in the Settings Section: If you want detailed information on what all the setting do (like all the ones we left at their default setting) this will outline what they all do, and when they might need to be changed.



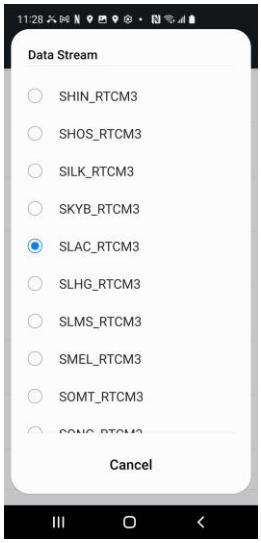
Opening Screen



Selecting the Bluetooth Device



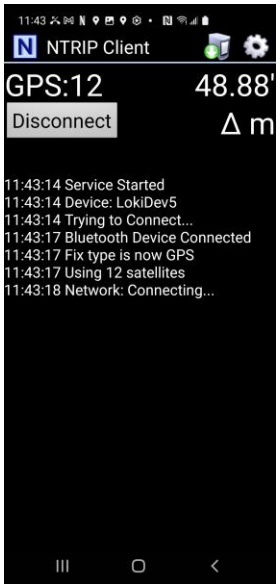
NTRIP Settings Page



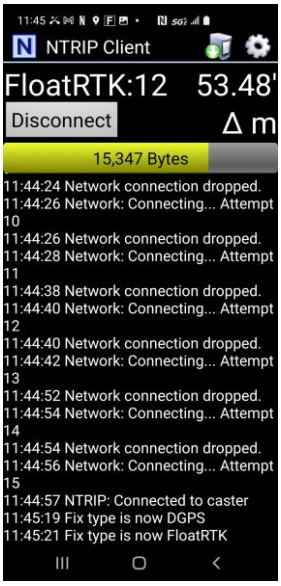
Selecting the Base Station Data

Connecting to the MagArrow/MagEx (Send RTCM Correction Data):

1) Once the setup in the Lefebure NTRIP Client app is finished return to the main menu and tap the "Connect"
2) The app will connect to the MagArrow/MagEx via a Bluetooth connection and start to send correction data. A horizontal progress bar will display the number of correction bytes sent to the MagArrow/MagEx GPS module. It may take a few minutes for the GPS to find a RTK solution. In the first screen shot on the right you can see the Bluetooth connection and the Network connection to the NTRIP Caster. In the second screenshot note that the network connection is broken. This is a common problem where the NTRIP is started indoors with a good WiFi connection to the internet. But when walking outdoors the WiFi connection weakens and stops giving the errors you see. To solve this, turn your WiFi off to force the Android phone to use the cellular connection to the internet.



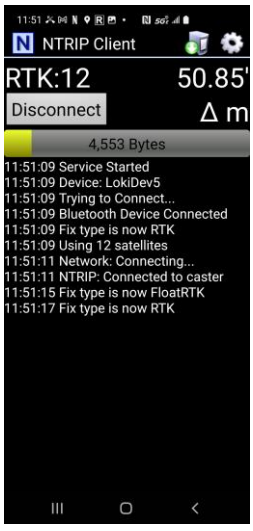
"Connect"



Don't forget to turn off WiFi!

Displaying RTK Status:

1) The MagArrow/MagEx will output RMC and GGA NMEA string backs to the NTRIP Client app via the same Bluetooth link. The app will parse these strings to determine RTK Status and display it on the app screen. In the screen shot at the right you can see that it went to Float RTK mode, then Fixed RTK mode. Here is a description of the various GPS fix modes:
    a. Standard GPS: The reported location is based on time-of-flight measurements from different satellites broadcasting a pseudocode at a 1MHz repetition rate (a wavelength of ~300 meters). Using time and phase information from the pseudocode the GPS uses triangulation to get your position. Error in location is caused by how closely the time and phase information from the pseudocodes can be resolved, and from uncertainties in time caused by atmospheric delays.
    b. Differential Correction (DGPS): Using the stationary base station data (which experiences exactly the same atmospheric delays, and is located in a precisely known location), the atmospheric uncertainties can be removed. This improves the GPS location accuracy.
    c. RTK Float and RTK Fixed: Using the phase of the GPS carrier frequency to measure time of flight (instead the broadcast pseudocode) the position accuracy can be greatly improved to less than a few centimeters. Beside the phase difference between the carriers from different satellites the GPS also needs the integer number of wavelengths back to each of the satellites. There are several possibilities for each satellite with a 20-centimeter wavelength inside a 3 meter sphere of uncertainty. The GPS searches for a position solution that triangulates to the same



Don't forget to turn off WiFi!

fixed position using the carrier phase from several satellites. If a complete solution is found the position is labeled “Fixed”. If only a partial solution can be found the position is labeled “Float”. Float positions can sometimes be very accurate, and sometimes not.