Caveatron SV User Guide

Software Version: 3.11

Revision: 2024-01-21

Contents

Sidebars

Caveatron Developer: Joe Mitchell

Main Website: www.caveatron.com

Email: info@caveatron.com

Google Groups User Forum: https://groups.google.com/forum/#!forum/caveatron-discuss

Software and Technical Info Github Site: https://github.com/Caveatron

Introduction

The Caveatron SV is a handheld all-in-one electronic device for cave surveying caves or other underground environments. It provides a caver-friendly, self-contained system for recording all station-to-station measurements, entering information such as station names, taking wall position measurements, and reviewing data. The Caveatron is designed to be reasonably lightweight and compact with an environmentally sealed enclosure that contains a rechargeable battery, data storage, and a standard USB port for charging and data download. After returning from the survey, data are downloaded to a computer and the survey data can be used in Walls Cave Mapping Software or Compass Cave Survey Software (after conversion in Caveatron Process software). Point measurements can also be converted to a rudimentary 3D point cloud in Caveatron Process to better visualize passage outlines for map drafting.

DEFINITIONS

Shot – A vector measurement between two station consisting of a distance, azimuth, and inclination

LRUD – Left, right, up, and down distance measurements of the cave walls taken at a station looking along the vector toward the next station.

Points – Single point measurements of the cave walls taken from a station in any direction.

***FROM* Station** - The station from which you are starting a shot, where you hold the Caveatron.

***TO* Station** - The Station which you are targeting in Shot Mode.

Getting to Know the Caveatron SV

EXTERIOR COMPONENTS

Touchscreen Display – All interaction with the Caveatron is done via the touchscreen. It is recessed and covered with a screen protector to reduce the chance of damage. The screen is not resistant to significant impacts, so treat it with care. The screen is less sensitive to touch than most smartphone type screens so needs a heavier touch to activate. Using the tips of your fingers and/or fingernails works best.

Power Button – The button is a momentary press type, so press it once to turn the Caveatron on and again to turn it off. The button must be pressed fairly deeply to activate it which prevents accidentally turning it on or off by bumping the switch. When the system is turned on the display screen turns on. If the display screen is not on, than the system is off.

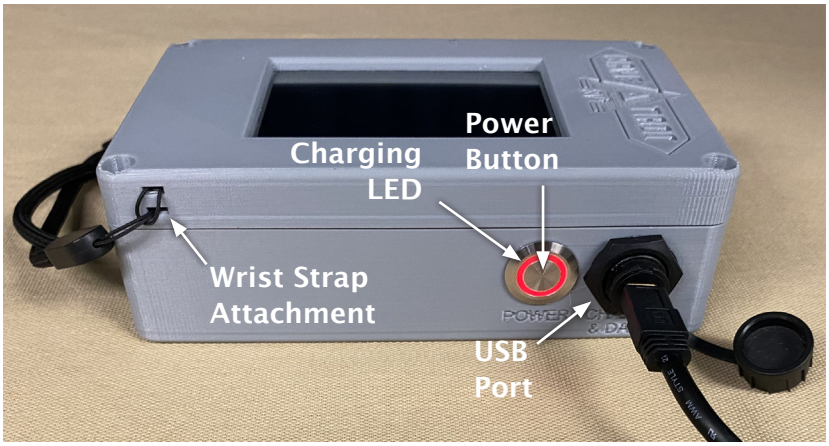
Charging LED Ring – Around the Power Button is a two-color LED ring. When the system is charging, the LED is illuminated red. This is true whether the system is powered on or not. If the system is fully charged and still plugged in to external power, the LED is green. A yellow LED indicates a charging fault but the battery may still be fully charged. If the Caveatron is unplugged the LED is off.

USB port – This port has a USB-micro style connector. The port is used for both charging and data transfer. It can be plugged into any standard USB power adapter or the USB port on a desktop PC to charge. A charge current rating of 1 Amp or greater is preferred. It will charge for a lower current adapter but at a slower rate. For data transfer, the port is connected to a Mac, Windows, or Linux desktop PC. A twist-on dust cap protects the port from dirt and water and should always be closed when not charging or transferring data.

Wrist Strap – A wrist strap can be attached through these slots.

LRF window – The Laser Range Finder (LRF) operates through this small window and its visible beam also serves to point the Caveatron to the station. Do not stare into this window when the laser is operating. Keep the window reasonably clean to avoid blocking the rangefinder. The window is recessed to provide some damage protection.

MAIN INTERIOR COMPONENTS



Laser Range Finder (LRF) – Takes precision distance readings for the station-to-station distance measurements. It uses a red laser that is also used for pointing the Caveatron.

Inertial Measurement Unit (IMU) – Contains an accelerometer, magnetometer, and gyroscope. Together, these sensors provide the orientation of the Caveatron and measure its rotational motion.

Real Time Clock (RTC) – Maintains the date and time and is used to create the survey filenames and log the time of each shot and scan. The RTC is powered by a very small continuous current from the main battery, so would not discharge it for many years.

MicroSD Card – All survey and scan data is stored to files on the microSD card inserted into the main Teensy processor module. The card also holds files used to load and save calibration data. The files on this card are accessed from a computer through the USB Port. The card is formatted in standard FAT32. It could potentially be removed or replaced but afterwards a magnetometer recalibration would be recommended.

Battery – The main battery is a rechargeable lithium-ion battery so care should be taken to avoid damaging it or a fire could result. The battery is charged through the USB port and should take about 2-3 hrs to fully charge.

GPS Module (Optional) – The Caveatron SV can support a GPS module for geolocating cave surveys or performing surface surveys.

Bluetooth Module (Optional) – The Caveatron SV can support a Bluetooth module installed for communicating data to an app on a mobile device (not yet implemented).

Operating Mode and GUI Overview

Main Menu

This screen appears when the Caveatron turns on and provides access to the operating modes, the Survey menu and Utilities Menu

Shot Mode

This mode is used to collect the traditional station-to-station survey measurements of distance, azimuth and inclination. All these measurements are taken in a single step by placing the Caveatron on a station, pointing the Caveatron's laser at the next station and pressing a button.

LRUD Mode

This mode is used to take passage wall distance measurements for a station at right angles to the direction between the current station and the next station. LRUD stands for the four measurements: left, right, up, and down. Values of zero and "passage" for a going passage may also be entered.

Point Mode

This mode is used to take 3D points of the cave walls from a station. These points can be

used to obtain a simple passage outline to aid in map drafting. One way this might be used is to take a number of points vertically along a running profile line between stations for a profile view, horizontally between the stations for a plan view, or as a passage cross section at the station.

Manual Mode

This mode is used to quickly view real-time azimuth and inclination data or acquire a shot that is not stored. A Quickshot mode is also available that arranges multiple successive shots in a list on the screen in a manner similar to a conventional disto.

GPS Mode (if equipped)

Acquires geospatial coordinates from GPS satellites and allows them to be saved to a survey file.

Survey Menu

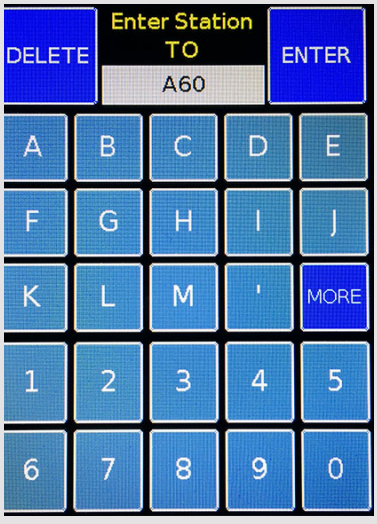
Within the survey menu are functions to setup and start a new survey, review, edit, and delete shot data, view a line plot of the cave, and obtain information about the survey.

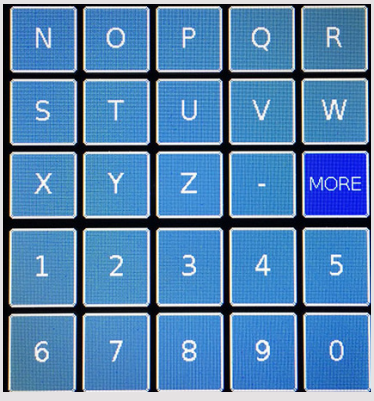
Utilities Menu

This menu contains a variety of controls to adjust settings, connect to a computer over USB to transfer data, calibrate the Caveatron, and view other information about the unit. A list of surveys stored on the SD card can be viewed and previous ones reopened.

KEYPAD USAGE

The keypad is configured to provide the most number of buttons practical for the limited screen size available. The keypad varies depending on the type of data that can be entered, however, in general letters A-M appear on the first page and N-Z appear on a second page. Numerical characters appear on both. The second page is accessed by the **MORE** button (from the second page, pressing the **MORE** button returns to the first page.) At the top right is the **ENTER** button, which is pressed to confirm an entry and move to the next screen. The upper left button appears as a **CANCEL** button when no characters have been entered and exits the current mode. When characters are entered, then the **CANCEL** button changes to **DELETE**, which removes one character at a time when pressed (by deleting all characters, the **CANCEL** button reappears.)





Some variations of the keypad have additional specific buttons for entering special characters, spaces, or common words.

Using the Caveatron SV

PREPARING THE CAVEATRON

Charge the Caveatron by plugging the USB port into any USB adapter. The battery is full when the red light on the power switch button turns green (or turns yellow or off if so configured). A full charge can take up to 3 hrs.

Turn on the Caveatron by pressing the power button fully in and releasing. The screen will show the Main Menu.

STARTING A NEW SURVEY

Go to **Survey ➜ Start new Survey**

Type in the name of the cave and press **ENTER**

Press **ENTER** again to accept the filename and a success message will briefly appear.

A screen appears allowing survey info to be entered, such as the names of the survey team members. This is optional and can be edited later. Press **ENTER** when done.

TAKING A SHOT BETWEEN TWO STATIONS

Choose your station locations in the cave. Altough long shots can speed up a survey they can also make it harder to get acurate readings. Enter Shot Mode by pressing the **SHOT** button. For the first shot, enter the *FROM* Station name and press **ENTER** then enter the *TO* Station name. On subsequent shots, pick one of the options for automatic station names or enter your own station name.

Place the rear bottom left corner of the Caveatron on the station point. If the rear bottom right corner works better, press the button on the screen to select that corner instead. Point

the red laser so that it is hitting the station. Sometimes it can be helpful to place a small flat light colored object (like a plastic card or a survey book) on the station to make it easier to hit and get an accurate reading.

Holding the Caveatron as steady as possible, press the **TAKE SHOT** button and continue to hold it steady on the station for approximately the next 3 seconds. You will hear the *Start Tone* followed by three short beeps about 1 second apart. If the shot was successful, this will be followed by the *Success Tone*. If the shot failed, you will hear the *Failed Tone*. The results will be displayed on the screen. Press **DONE** to accept the shot and go back to the Main Menu or **REDO** if you want to take the shot over again.

AUDIO INDICATIONS

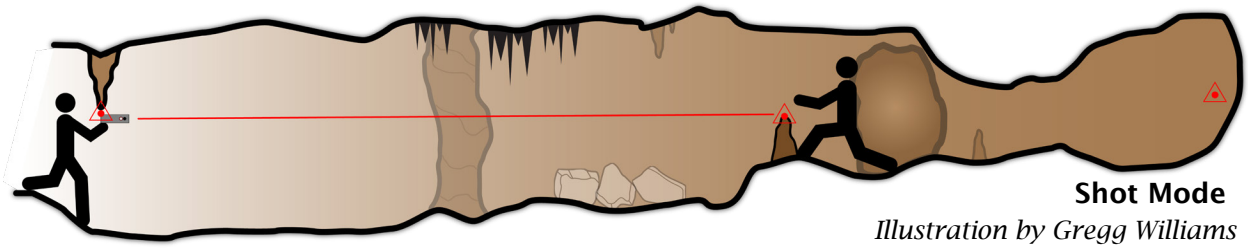
The Caveatron uses audio tones to indicate the status of shots and scans.

LRF Beep (Very short high-pitch) – Indicates that the LRF has obtained a measurement.

Start Tone (0.5 sec high-pitch) – Indicates when a shot starts.

Success Tone (1 sec high-pitch) – Indicates when a shot completes successfully.

Failure Tone (1.5 sec low-pitch) – Indicates that a shot has failed.



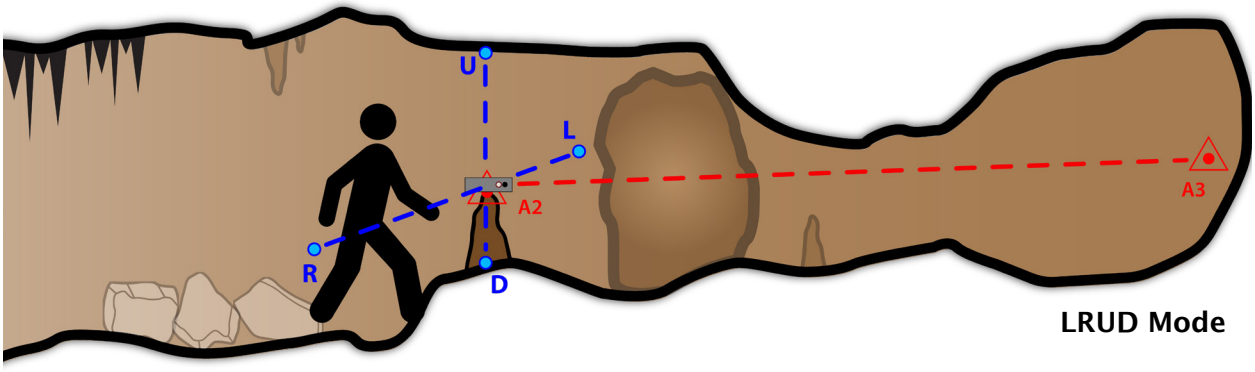
Shot Mode

Illustration by Gregg Williams

Optional: Take a backsight from the *TO* Station back to the *FROM* Station to improve the accuracy of the survey and find errors. Repeat the process above but pick one the brown buttons from the automatic station naming screen when first entering *Shot Mode*. Only take a backsight for a station pair for which you have (or will get) a frontsight as they are processed differently. Backsights improve accuracy, but are not required.

TAKING LRUDS

Go to the station at which you want to measure the left, right, up and down wall distances and press **LRUDs** (this is usually the *FROM* station of the most recent shot). The screen for taking measurements appears immediately unless an LRUD already exists for the most recent shot. Press the **UP**, **DOWN**, **LEFT**, or **RIGHT** button for the measurement you want



LRUD Mode

to take. Place the rear of the Caveatron on the station and point it directly in the selected direction perpendicular to a line toward the next station. Press the **TAKE MEASUREMENT** button. As soon as the measurement is complete it returns to the direction selection screen and the distance value for that direction is displayed.

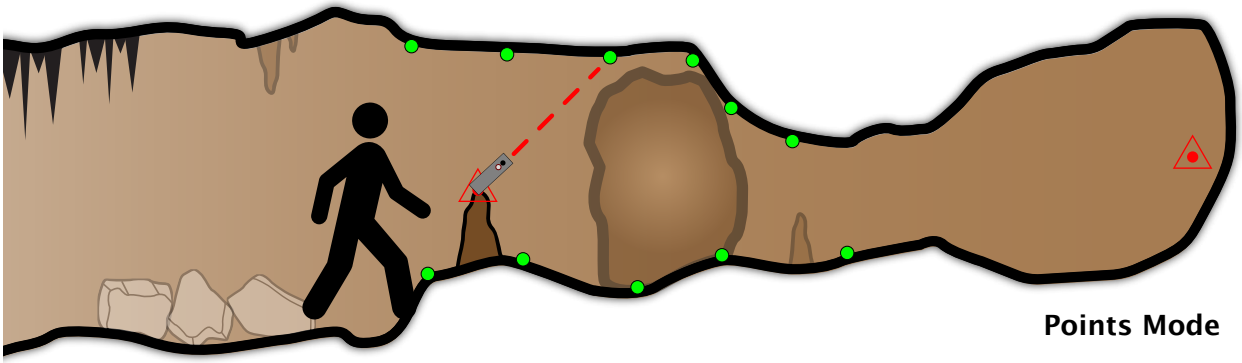
When a direction is selected, rather than taking a measurement, you can alternatively select **Set 0 Distance** if the direction is into a wall, or **Passage/Ignore** if the measurement is down a Passage or you don't want to enter one.

After completing all measurements, press **SAVE & EXIT** to store them or **CANCEL** to exit without saving.

Previous stations or stations with no ongoing survey (such as at the end of a passage) can also be selected for an LRUD from the first LRUD screen by selected **Previous Shots** or **End Stations** , respectively.

TAKING POINT MEASUREMENTS

The Caveatron SV can be used to produce a rough passage outline to aid in map drafting by storing wall points in any direction from a station. From the Main Menu, press the **POINTS** button, enter the station from which you want to record the points, and then the type of points you are taking (**Cross Section**, **Running Profile**, or **Walls** for general passage measurements and to assist with plan views). Separating points by type makes it easier to separate them into different point clouds to assist with map generation. Place the rear of the Caveatron on the station at a position roughly in line with the laser. Point the laser to the point on the wall, ceiling or floor of the passage you want to measure. Tap the **MEASURE POINT** button while holding it steady until you hear the *LRF Beep.* Press and hold the **MEASURE POINT** button for continuous readings. Repeat until all measurements are taken from a given station. After a measurement, you can delete the most recently taken single measurement or set of measurements by pressing the **DELETE LAST READING** button or change the point type for subsequent measurements with **CHANGE TYPE**.



Points Mode

DOWNLOAD AND PROCESS THE DATA

Connect the Caveatron to a computer by the USB port.

Turn on the Caveatron and go to **UTILITIES ➜ SD CARD ➜ USB CONNECT**

The Caveatron will appear as a drive called "Caveatron" with an SD Card folder inside (Windows or Linux) or open the Android File Transfer app (Mac). Each survey is stored in its own folder with the cave name and date the survey was started. Copy the entire folder for that

survey to your computer to download the data.

Turn off the Caveatron to disconnect from the computer.

Process the survey data using a program such as Walls Cave Mapping software or Compass Cave Survey software. To use Compass, the data must be converted using the Caveatron Process software. Point mode measurements are converted to a 3D point cloud also with the Caveatron Process software. Instructions are provided in the manuals accompanying those programs.

UPDATING THE CAVEATRON CALIBRATION

CAUTION: After performing a calibration, you must start a new survey before conducting any new scans, otherwise the scans will not be correctly processed.

Periodically the Caveatron needs recalibration of its compass. Its probably best to do this before each survey trip.

Go to a location far from any buildings, power lines, motors, or metal objects.

Turn on the Caveatron and go to **Utilities ➜ Calibration ➜ Compass Calibration**

Press **Start Calibration**

Rapidly rotate the Caveatron through all possible directions in a sphere around the device as much as possible. This is best done by a combination of turning it more up and down while turning yourself around. A progress bar on the screen will drop toward zero but may jump up again as you cover new angles. When it reaches zero, the Caveatron will beep and is ready for the next step. You do not need to keep rotating more than about 30 sec and can just let it go to zero if it has not already done so.

Press **Continue Calibration** and, at a more medium speed but in the same manner as before, continue to rotate the Caveatron through all possible directions in a sphere as much as possible. A progress bar on the screen will slowly increase toward 100%. Continue rotating the Caveatron as long as it takes for the progress bar to reach 100% at which point the calibration is complete. The last few percent may take longer – try to be sure you hit angles you may have missed previously to get it to reach 100%.

The new calibration values are displayed on the screen. Press **SAVE** to store the new calibration values or **CANCEL** to keep the previous values. After saving, its best to turn the Caveatron off and on before taking any new data.

Main Menu & Utilities Menu

The Main Menu screen appears when the Caveatron SV is turned on. It provides buttons to access the primary operating modes of the Caveatron: Shot, LRUDs, Points, and Manual. In the bottom portion of the screen are button to access the Survey and Utilities menus. The Utilities Menu provides a page with additional functions including Settings, SD Card/USB connection functions, Calibration, the optional GPS menu, and an About screen. At the top of the menu screens is the Status Bar which shows the current time in the upper left (24 hour format), the currently active menu or mode in the center (in most screens), and the battery level indicator in the upper right. The battery indicator fill level decreases as the battery discharges and changes from green to red when it drops below 15% charge remaining. If the battery reaches 2% charge remaining, the battery outline changes from white to red. At the bottom of the display is the Info Bar which displays information or gives prompts related to the current screen. Both the Status Bar and Info Bar are present on most screens.

Shot Mode

Shot Mode is used to acquire and record the cave survey measurements traditionally taken with a tape measure, compass and inclinometer. The Caveatron uses the LRF to acquire and average 3 distance readings and the IMU to acquire and average 75 azimuth and inclination readings. The measurement process takes about 3 seconds. The data is stored to the internal memory card along with the station names and the date and time of the shot.

Either one of the rear bottom corners of the Caveatron enclosure are placed at the starting station or position of the shot. The red laser beam is then used to align the Caveatron to the station or position toward which the shot is be taken.

Shot Mode collects both frontsights and backsights for any given vector between two stations. Frontsights are required and form the basis of the survey whereas backsights are op-

tional. Backsights are used to improve the accuracy of the survey and find potential errors. You can also retake (Re-shoot) previous front-sights that are unsatisfactory with the originals replaced by the new ones.

FRONTSIGHTS AND BACKSIGHTS

Do not get confused about the frontsight/backsight terms – they do not refer to a specific survey direction in the cave. In the terminology of the Caveatron, a frontsight is any shot that is the primary (and usually first) measurement between taken between two stations, regardless of the actual direction of the shot relative to the rest of the survey. The backsight is a secondary shot taken in the reverse direction between two stations for which a frontsight exists (or will exist) and is averaged with it. If a backsight exists without a frontsight, that vector will not be counted during data processing and a gap will exist in the survey (though there are ways to work around this in post-processing). Below is an example of how this is intended to work:

- A1-A2 frontsight
- A2-A1 backsight
- A3-A2 frontsight
- A2-A3 backsight
- A3-A4 frontsight

Note that A2-A3 was taken "backwards" in relation to the other two shots but it is a frontsight because it was the first shot taken between these two stations. The actual direction relative to other stations has nothing to do with the frontsight/backsight terms – only that the backsight is in the opposite direction of the frontsight for a given vector.

Here is an example of what NOT to do:

- A1-A2 frontsight
- A3-A2 backsight
- A3-A4 frontsight

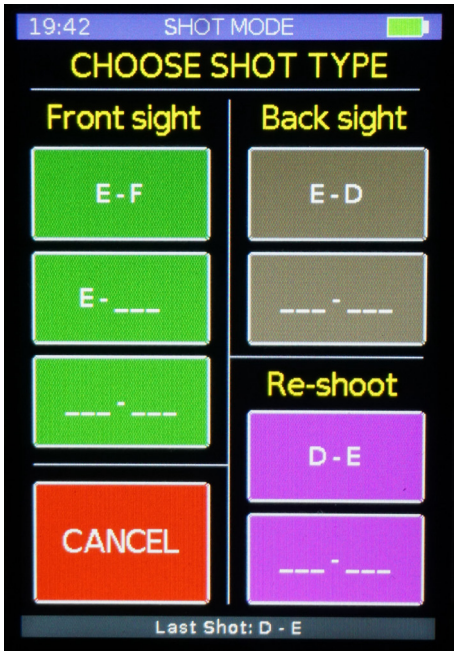
A3-A2 should have been taken as a frontsight and since no frontsight exists for this shot, a gap exists in the survey in the Caveatron's displays in the Survey menu and will exist in the Caveatron Processing software for post-processing. (It can however be used as a frontsight when processing the scan data if the survey file is processed in Walls software first.)

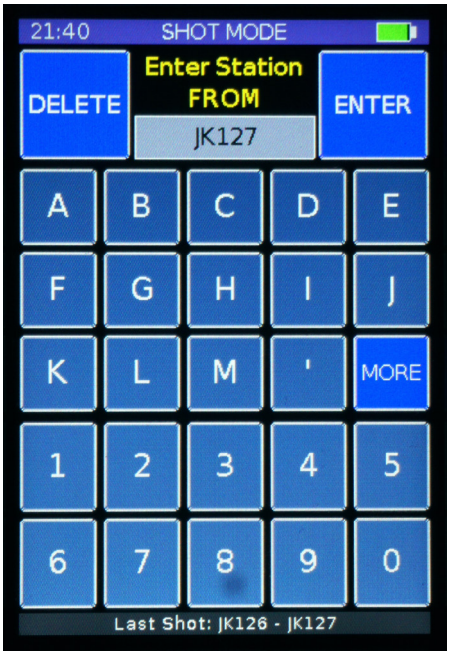
OBTAINING A SHOT

When starting Shot Mode, the user is presented with a series of screens to enter the names of the *FROM* station and *TO* station. The station entry screens provide a alphanumerical keypad to enter in the station names and a box into which the station name appears as typed (usage of the keypad is described in the sidebar on p. 7). A station name can be up to 7 characters in length.

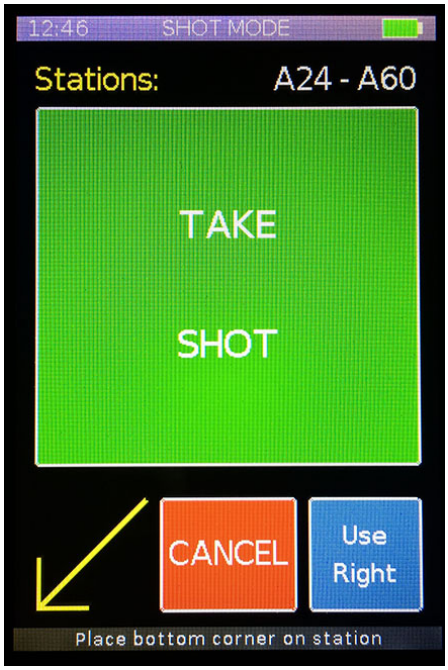
During the first shot of a survey, the *FROM* and *TO* station entry screens are presented successively for entering the station names. The second and subsequent shots in a survey bring up a different initial screen when entering Shot Mode – a station name shortcut screen. The Caveatron attempts to predict the station names for the next shot and several options are presented. If the shot is going to be a frontsight, one of the three green buttons at the top is selected. If the shot is going to be a backsight, then one of the two brown buttons at the bot-

tom is selected. Each of these buttons provides different naming options. The first is a fully predicted option and selecting it skips both cave name entry screens and takes you directly to the screen for taking the shot. The options with '__' allow you to enter a different station name and for either one or both the *FROM* and *TO* stations. The purple Re-shoot buttons are for quickly retaking previous frontsight shots to fix errors. The Caveatron will search for any set of Re-shoot station names you enter and select them if they are found or alert you if they are not. Note that Re-shoot is for front-sights only. If you need to retake a backsights, you will need to delete it from **View/Edit Shots** in the Survey Menu and then take a new one the normal way.

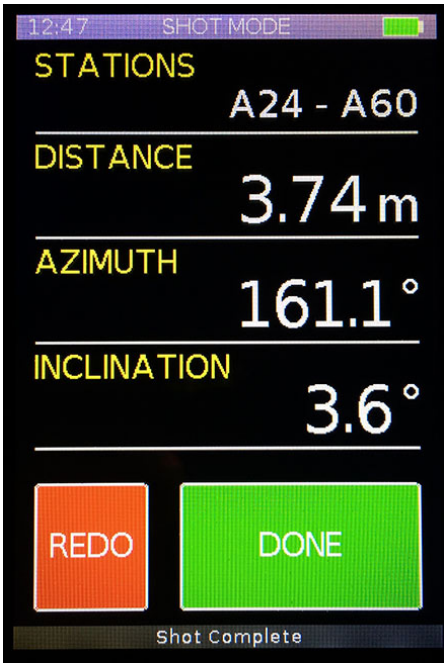




After completing station name entry, the Shot screen appears. The red laser automatically turns on and the Caveatron is placed on the station point. The Caveatron is placed on the *FROM* station so that either the left rear bottom corner or right rear bottom corner touch the station. The default is the left rear bottom corner and is indicated by an arrow in the lower left corner of the screen pointed in that direction. If you use the right rear bottom corner, tap the **Use Right** button to switch to that corner and the arrow changes location (You can then tap **Use Left** to switch back to the original corner). The Caveatron can shoot any inclination up to +/- 90 degrees without any issue. However, be sure the roll angle of the Caveatron (its tilt angle left to right) is relatively level. If this angle exceeds 30 degrees in either direction, the shot will fail. The Caveatron can be held upside down to take a shot without any issues as sometimes using the ceiling is more convenient. Again, just be sure that the roll angle is relatively level near 180 degrees (between 150 - 210 degrees) as with the upright orientation.



When you are ready, press the large green **Take Shot** button to take the readings. This takes about 3 seconds and the Caveatron needs to be held steadily on the target station to get an accurate result. Be especially careful when hitting the button, that you don't tap so hard that it knocks it off alignment. It is best to brace the Caveatron against the station with one hand and hit the button with the other to keep it steady. Keep your eyes on the position of the laser during the shot to keep it in position.



During the shot, you will first hear various audio indications as described in the sidebar on p. 8. After pressing, **Take Shot**, the *Start Tone* will be heard, which will be followed by three *LRF Beeps* – each one indicating a successful distance reading. If the shot is successful, the *Success Tone* will follow at the end. If the shot fails, then the *Failed Tone* will be heard and an error message will display on the screen. The most common error is that the Caveatron is suddenly moved during the measurement resulting in inconsistent values. An error might also happen if the magnetic field around it changed such as from a headlamp suddenly being too close to it.

When the shot is successful, the distance azimuth and inclination readings are displayed on the screen along with the station names. The **DONE** button at the bottom saves the data to the Survey (*.SRV*) file on the memory card. If you do not like the reading and want to take the shot over again, tap **REDO**. This takes you directly back to the **Take Shot** button and retains the station names as well as remembering which corner was used.

POST–SHOT MESSAGES

If there is an error in the shot, the type of error (no LRF return, azimuth shift, etc.) will be displayed. You can hit **DONE** to exit and no data is saved or hit **REDO** to go directly back to the Take Shot button to try the measurement again.

Another alert that may appear after taking a shot is a magnetic anomaly detection. This can occur if the Caveatron is too close to an object that generates a strong magnetic field such as iron objects (like a cave gate), rocks with a high ferromagnetic content, or even your headlamp (especially the battery). This often results in an erroneous azimuth reading. The Caveatron still saves these shots as normal but you should consider re-taking the shot or at a minimum doing a back-sight to double check it. If the alert continues to occur, even after you have ensured any magnetic sources such as your headlamp are not near the Caveatron, then try moving the station to a different location. Note that the threshold values that generate the alert can be set in the Settings Menu and they might vary at your location from the defaults. Check the Settings section for more information.

If you are obtaining a backsight, a different screen is displayed after taking the shot that shows the error between the the backsight and the matching frontsight. The distance, azimuth and inclination of each are shown along with the error in degrees or meters. The error is colored green or red (the cutoff values are in the table below) so that you can quickly check

if there is a problem with one of your shots. The colors are for display only and do not affect anything about the operation of the Caveatron or what is saved.

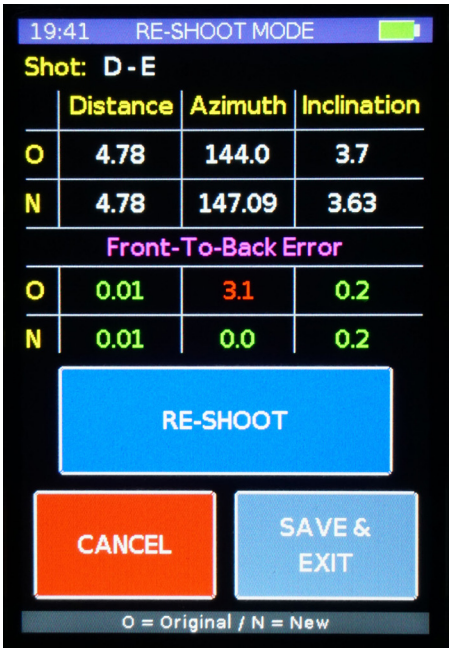
Red/Green Cutoff Values for Frontsight/ Backsight Error

Distance	Azimuth	Inclination
0.05 m	2.5˚	2.0˚

RE-TAKING SHOTS

If after taking a backsight, you determine that the frontsight is probably faulty, you can quickly retake it from the initial shot selection screen when starting Shot Mode. The most recent shot is displayed but you can also enter another station pair. The Caveatron tries to find the station pair. If they are not found, an error message is shown. If a match is found, a screen appears that shows a table with the shot data and the front/back errors for each measurement (colored according to the table above). The row labeled **"O"** is the error between the original front/back pair whereas the row labeled **"N"** is the error with the newly retaken front shot (initially blank until the new shot is taken).

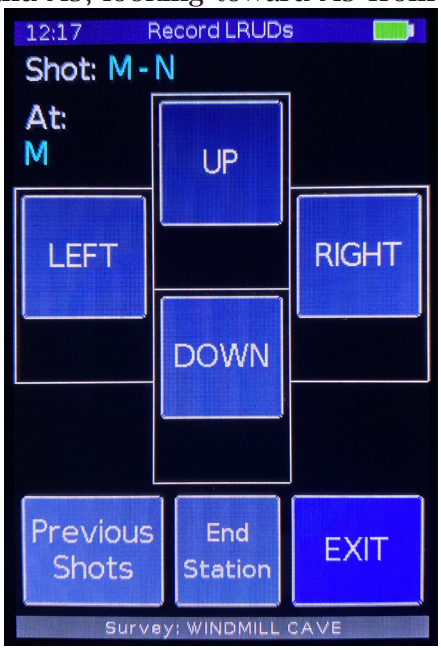
Press **RE-SHOOT** to go to the standard shot screen and retake the shot as usual. Afterwards, the Caveatron returns to this screen with the values and the error for the new shot displayed. If you want to try again, you can press **RE-SHOOT** and take it yet again. Once you are satisfied, press the **SAVE & EXIT** button to delete the original shot in the survey file and store the re-taken shot. If you press **CANCEL,** the original shot is not changed.



LRUD Mode

LRUD (left, right, up, and down) measurements are commonly used in cave survey to provide passage dimension information which assists in map drafting and visualization in cave survey software. Both of the cave mapping software programs supported by the Caveatron (Walls and Compass) can use LRUD data to produce rudimentary 3D views of cave passages in addition to the line plot.

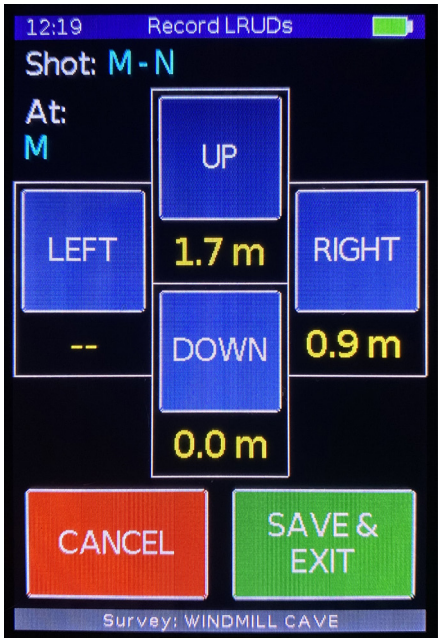
LRUD mode provides a way to collect the LRUD measurements and integrate them directly into the survey file for use in Walls or Compass. LRUD measurements assume a "To" LRUD format where the LRUD orientation is looking toward the next station. For example, as shown in the illustration on pg. 8, if you take a shot from station A2 to A3, then the "Left" measurement for A2 is 90˚ to the left of a line drawn between A2 and A3, looking toward A3 from A2. (This is in contrast to the "From" LRUD format where you use the line coming from the previous station for the reference direction). The final end station in a survey line must be treated differently since it has no "To" station. In this case use to line from the previous station as reference. The end station LRUDs are handled with special notation in both Walls and Compass software so must be selected as such when taking them on the Caveatron SV.



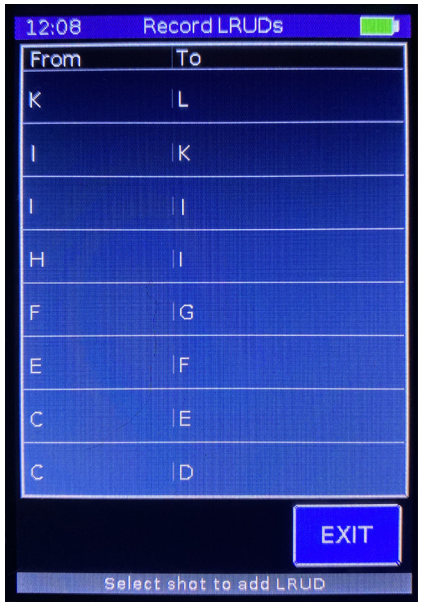
When starting LRUD mode after taking a shot, the user is shown the main LRUD screen with the current shot and *FROM* station (labeled "At"), where the LRUD is to be taken, and a set of buttons for **LEFT**, **RIGHT**, **UP**, and **DOWN**. Selection the direction for the LRUD measurement turns on the red laser and brings up a screen with a large **TAKE MEASUREMENT** button. At the bottom of this screen are additional options for **Set 0 Distance** and **Passage/Ignore**. **Set 0 Distance** would be selected if the station is directly on the wall, floor or ceiling and the direction of that LRUD measurement would have no distance. The Passage/Ignore button is used if the LRUD is at an intersection with a passage going off indefinitely in the LRUD direction. You can also use this button if you prefer not to take an LRUD measurement in this direction. Note that when saving the LRUDs, any direction for which no entry has been made will be assumed to be **Passage/Ignore**.

To take an LRUD measurement, the Caveatron's laser is pointed in the direction for that LRUD, as described above, and the **TAKE MEASUREMENT** button is pressed. This initiates a quick distance measurement – no azimuth or inclination readings are obtained. The usual *Success* or *Failure tones* are emitted depending on the results of the measurement. The display then returns to the main LRUD screen but now shows the result of the distance measurement in meters below the button for that direction. **Set**

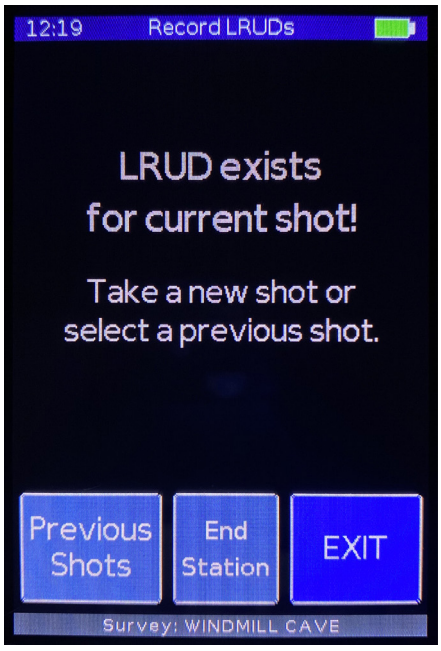
0 Distance is shown as "0.0" and **Passage/Ignore** is shown as "—". If you wish to change the measurement for a particular direction, press the direction button and re-take it. To save the measurements and return to the Main Menu, press **SAVE & EXIT**. Note that no measurements are stored until the **SAVE & EXIT** button is pressed. Turning off the Caveatron while in LRUD mode or pressing **CANCEL** from the main LRUD screen will lose the measurements taken for that station. After pressing **SAVE & EXIT**, the LRUDs for that station cannot be changed onboard the Caveatron, so be sure they are satisfactory first.



When starting LRUD mode, the Caveatron SV assumes you want to take them for the most recent shot. You can add them later to previous shots from the main LRUD screen by pressing the **Previous Shots** button. This brings up a list of the 8 most recent shots that do not have LRUDs, showing the From and To station names. Tap the row of the shot for which you want to add an LRUD to and the main LRUD screen reappears, now selected for that shot. The measurements are then recorded in the same way and, when completed, stored with the selected shot by pressing the SAVE & EXIT button.



LRUDs for stations at the end of a survey line are similarly recorded by selecting **End Station** from the main LRUD screen. A list of the 8 most recent stations without end LRUDs is shown and tapping on a row selects that station. The LRUD measurements are then acquired in the same manner as before.



If you start LRUD mode and most recent shot already has an LRUD or no shots have yet been taken, then a message appears that an LRUD already exists. You can select **Previous Shot** or **End Station** to choose another shot to add an LRUD, or **CANCEL** and take a new shot.

There is a method to remove or change an existing LRUD for a shot. This is done by going to **Survey → View/Edit Shots**, select the shot you want to change and tap it to bring up the context menu. Tap **FRONT<>BACK** which changes it to a backsight and removes the LRUD. Tap **FRONT<>BACK** a second time to change it back to a frontsight. If the shot is one of the most recent 8 without an LRUD, you can then go back to LRUD mode and select **Previous Shots** to add new LRUD measurements. End Station LRUDs cannot be deleted onboard. All measurements can be edited later in Walls or Compass software.

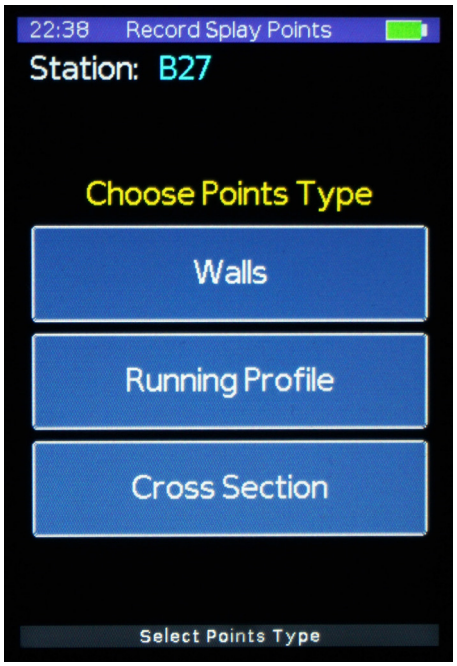
Points Mode

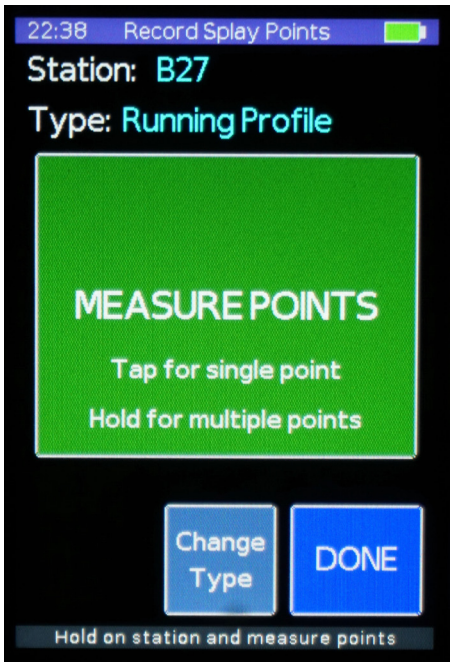
Points Mode is provides a means to take rudimentary LIDAR-like measurements that can be used to produce a very simple point cloud of an area. Each point is taken manually while located at a station. One possible application for this mode is to take data to assist with map drafting. For example, profile data could be collected by taking a series of points vertically across the ceiling and along the floor in a line between two stations. Cross-sections or plan view data could be obtained in a similar manner. This data can then be converted into a point cloud, oriented into the correct perspective, and imported into an illustration program for map drafting. The drafted passage outlines can then be drawn with greater accuracy as they are based on actual data.

When starting Points Mode, a station entry screen appears to enter the station name from which the points will be taken. The most recent *FROM* station is automatically pre-filled but an alphanumeric keypad is presented which can be used to enter a different station (see Keypad Usage sidebar on p. 7). Pressing **ENTER** accepts the station name and moves to the next screen or press **CANCEL** (which appears after deleting the characters) to quit Points Mode and return to the Main Menu.

In the next screen, the Points Type is selected, which can be useful when extracting them for later use in assisting with map drafting. **Walls** type points are general purpose though primarily intended for measuring the Walls for a plan view in a map. In this case, the points would be taken in a rough plane above the floor at locations that best illustrate the shape of the passage or room and locations of major objects like rocks or formations. **Running Profile** type points are taken along the ceiling and floor in a line between two stations and form the basis for a profile view in a map. Finally, **Cross Section** type points are taken in a loop around the passage perpendicular to the direction of the passage to show a section of the passage shape at the station location.

After selecting the Point Type, the measurement screen is shown which lists the selected sta-





tion name and the current point type. Point the laser toward the point you want to measure and press the **MEASURE POINT** button. You can take either single point measurements by tapping the button or holding it to get continuous points. For each point the *LRF Beep* is heard and the laser blinks. After the final point, the measurement screen reappears and the most recent distance (Di), azimuth (Az) and inclination (In) measurements are displayed below the **MEASURE POINT** button. Additional points can be taken by pointing the laser to the next location to measure and pressing or holding the **MEASURE POINT** again. This can be repeated for as many points as you want to take from that station. If a measurement is taken in error or the measurement result was unsatisfactory, press **Delete Last Reading** to delete the most recent single measurement or set of continuous measurements.

Readings are stored immediately into the *.CVP* file which is converted to point clouds with Caveatron Process software. Separate point clouds can be generated for each point type. The *.CVP* file is plain text with the file described in the sidebar below.

From the measurement screen, the Point Type can be changed at any time by pressing the **CHANGE TYPE** button. Press **DONE** to return to the main menu.

CAVEATRON POINTS FILE (.CVP) FORMAT

A *.CVP* file is in a plain text format with a header and sets of point measurements grouped by station. Each station can have any number of point sets and each point set can have any number of point measurements.

Header – 4 lines followed by two blank lines

```
;CAVEATRON SPLAY POINTS FILE
;Serial Number: xxxxx - Firmware version: 3.xx
;Cave Name
;Survey Date: xx/xx/xxxx        (Date is month/day/year format)
```

Point set subheader – 3 lines. Each point set is separated by one blank line

```
#Station: x        (Station name, up to 7 char)
#Type: W           (Point set type – 'W' for Walls, 'P' for Profile, 'C' for Cross Section)
#Time: xx:xx:xx    (Time point set was started in hour:minute:second format)
```

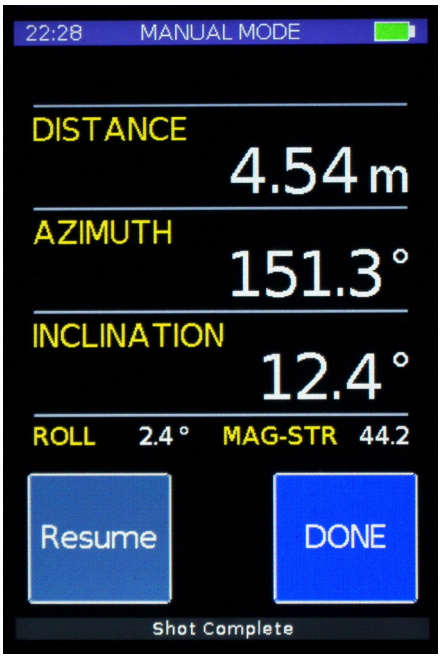
Point measurements – 1 per line with each value comma separated.

```
distance,azimuth,inclination,roll
```

EXAMPLE:

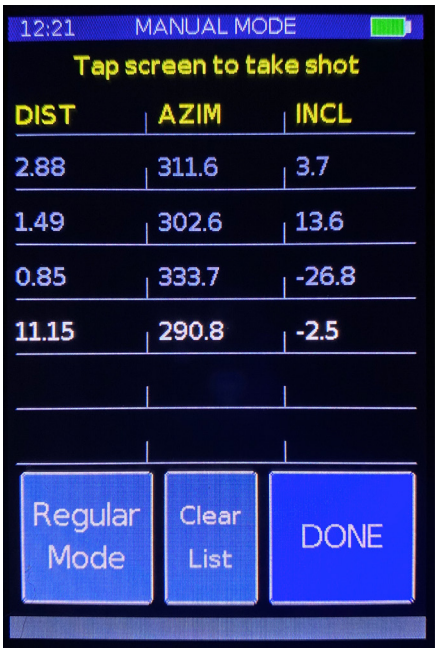
```
;CAVEATRON SPLAY POINTS FILE
;Serial Number: XX001 - Firmware version: 2.20
;BIG CAVE
;Survey Date: 04/25/2021


#Station: 1
#Type: W
#Time: 16:46:24
2.68,208.7,30.7,-2.0
1.80,203.3,50.5,-6.4
```

Manual Mode



Manual Mode allows a quick check or measurement of angles and distances without having to enter station names. This mode is for viewing measurements only and does not record any data.

Manual Mode for the Caveatron SV has two modes. In regular mode, a screen appears that shows live azimuth, inclination, and roll angle values and the red laser turns on. (The distance is not displayed live and requires a shot to obtain it.) The magnetic strength is also shown which can help with setting the magnetic anomaly detection thresholds. You can immediately view the actual pointing angle of the laser from the on-screen numbers (relative to a marked point on the rear of the Caveatron in line with the laser). By tapping anywhere in the middle portion of the screen, a shot is taken in the same way as a shot is taken in Shot Mode (an average of 75 angle readings and 3 distance readings). Note that the zero point for a shot in Manual Mode is a point on the rear of the enclosure in line with the laser, not one of the corners. The readings from this shot are displayed in the screen. Press **Resume** to restart the live view.



The second mode is Quick Shot mode which is selected by the **Quick Shot Mode** button at the bottom of the live view. In this mode, you can take shots rapidly and display each shot in a list of distance, azimuth, and inclination. This provides a mode similar to how a conventional laser disto operates. Tap the central portion of the screen to take the shot. Hold the Caveatron steady during the measurement which lasts about 1 second. You will hear the *Start Tone* when the measurement starts followed by an *LRF Beep* and then the *Success Tone* if the measurement succeeds. If the measurement fails, then the *Failed Tone* will be heard and an error message displayed. The shot results are shown in the list. As subsequent shots are taken, the next shot result appears below the previous one. The most recent shot is always shown in white text with the previous shots shown in gray text. If the number of shots exceeds the length of the list, the latest measure returns to the top of the list.

At the bottom of the Quick Shot mode screen is a **Regular Mode** button to change to back to regular manual mode, and a **Clear List** button to remove all values from the list.

Pressing **DONE** exits Manual Mode and returns to the Main Menu. The Caveatron remembers whether regular or Quick Shot mode was last used and returns to that mode when Manual Mode is next used.

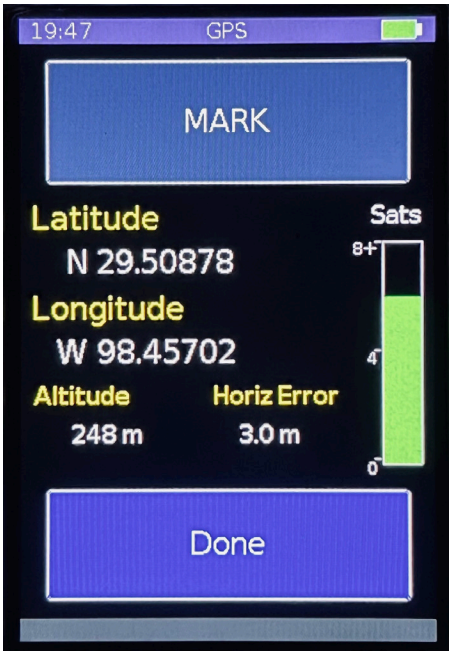
GPS Mode (if equipped)

GPS Mode allows you to geo-spatially locate a cave survey or get precise surface feature locations. GPS Mode requires the installation of an optional GPS module, otherwise the Mode is not available. GPS Mode is found in the Utilities Menu.

When starting GPS mode, the GPS module is powered up. It will take some time to acquire a satellite lock unless the Caveatron has had a recent GPS lock. It may take up to 10 minutes to acquire a fresh lock depending on the surrounding terrain and satellite positions. If the Caveatron has had a satellite lock in the previous 3 days, the predicted satellite positions are stored for much faster acquisition, usually within 30 seconds depending on the surroundings. It is recommended that the Caveatron be set outside in GPS Mode until a satellite lock is obtained a day or two prior to a planned survey to update the satellite information for fast acquisition.

The GPS Mode screen is shown below. The bar on the right shows the number of satellites in view. When the bar is yellow, it is still acquiring the location. When the bar is green, the a location lock has been obtained. The coordinates are shown in decimal latitude and longitude with the elevation shown in meters. These values update once per second. Also shown is the horizontal position error in meters which is useful to determine the accuracy of the coordinates.

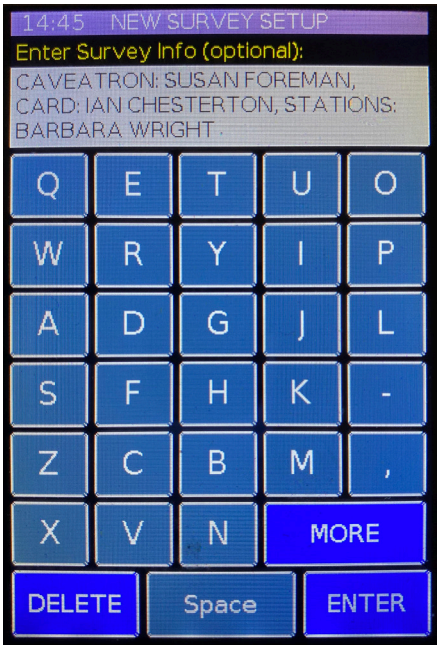
Pressing the **MARK** button brings up the normal station entry screen, where a station code can be assigned to the coordinate. This would normally be the code for the survey station at the cave entrance. After pressing **Enter** the GPS coordinate is saved to the current survey file as a fixed point. In Walls, a fixed point is defined by the prefix #FIX and includes a station name, and an absolute X, Y, and Z coordinate, which in this case are the readings from the GPS. The #FIX statement also includes horizontal and vertical error which are included in the saved data along with a timestamp. There is no limit to the number of fixed points that cave be saved, just be sure to give them different codes to avoid confusion.



Survey Menu

The Survey Menu provides functions for viewing survey and scan data, performing some limited editing, and for creating new surveys.

SETTING UP A NEW SURVEY



Before starting a survey, the survey files need to be created and initialized. This is done by selecting the **NEW SURVEY SETUP** button, which brings up a keypad to type in the name of the cave. Shortcuts are provided for the words “Cave” and “Pit”. The name entered here is also used for the folder name in which the survey’s files are stored. If you want to cancel creating a new survey, press delete repeatedly to remove all the text, after which it will turn back into the **CANCEL** button.

After entering the cave name, press **ENTER** and the next screen appears showing the automatically generated base filename for all the files. It must be 8 characters and uses the first 4 characters of the cave name, the 2 digit month, and 2 digit date. Press **ENTER** to accept the default name or change it to any to any combination of numbers and characters you want. Once the base filename is entered, the files are created for the survey on the internal micro SD card and initialized with headers and starting values. A message box will briefly appear to inform you that the files were successfully created.

The next screen that appears is for entering survey information such as the names of the team members, conditions or other info about the cave. This information is optional. The screen shows a QWERTY-like keypad and a text entry box. This box is limited to 84 characters. Numbers and special characters can be found by tapping the **MORE** button. A second tap of the **MORE** button brings back the letters. Press **ENTER** to save the info which will appear near the top of the *.SRV* survey file when viewed in Walls Cave Mapping software. The info can be viewed and edited later from within the survey statistics page or added from there if you don’t want to do it at this time.

VIEWING A LINE PLOT

The line plot shows the shot vectors taken in the current survey. This is useful for getting a sense of the direction and interconnection of the passages and where additional survey may need to be performed. The plot shows stations as yellow squares and the shot vectors between stations as cyan lines. The stations are labeled with their names, though some labels are not shown if stations are too close together. The line plot also shows the most recent station as a larger green triangle and any duplicate stations

(such as loop closures) are shown as red squares. Note that loops are not actively closed in this plot which allows you to see how good the closure is by how close the closure points are to each other. The plot may be viewed from three possible directions which are selected by tapping the indicated button: **PLAN** View from above, **PROFILE** view from the south, and **PROFILE** View from the east. The plot automatically scales to encompass the entire survey and a scale bar shows the current scale. There is also an option to **TOGGLE LABELS** on or off. If there is more than one group of unconnected shots, a **TOGGLE GROUP** button will be available to switch between them. Up to 120 shot vectors can be displayed. If a survey has more than that, the newest ones are not shown.

The line plot viewer also has a zoom and pan mode to get a more detailed view of part of the survey. Tap on the line plot display box to enter pan/zoom mode. The buttons at the bottom now change to include a **ZOOM IN** and **ZOOM OUT** button. When zoomed in, you can pan the view by tapping near the edge of the plot box in the direction you want to pan. The **RESET VIEW** button restores the fully zoomed out view and **EXIT ZOOM/PAN** mode returns to the initial line plot screen.

VIEWING AND EDITING SURVEY DATA

This function lists the shots taken during the current survey and provides options to edit them and add notes. This list shows the *FROM* and *TO* station names and the three vector measurements. Shots in white text are front sights while those in tan text are back sights. Fixed points acquired by GPS mode are also displayed in purple text with the coordinates and elevation. This list is sorted backwards in time so that the most recent shot is first. Eight shots are shown per page and pages are stepped through by pressing the **NEXT** button at the bottom to go to the next page or the **PREV** button to go to the previous page. The current page number and total number of pages is also shown. A maximum of 12 pages of shots can be viewed. If a survey has more shots than that, the earliest shots in the survey cannot be viewed or edited on board the Caveatron.

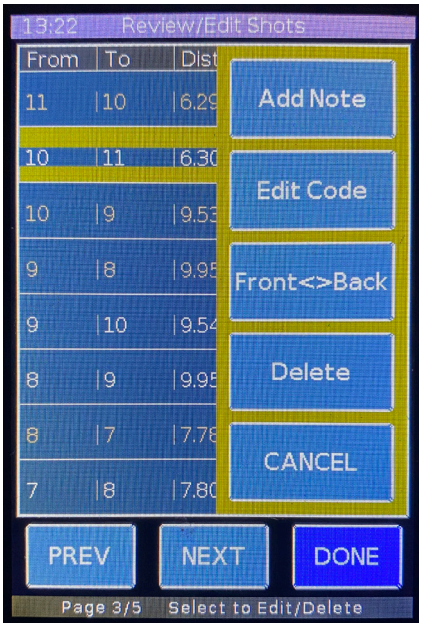
Tapping on one of the shots or a fixed GPS point brings up a contextual menu with several

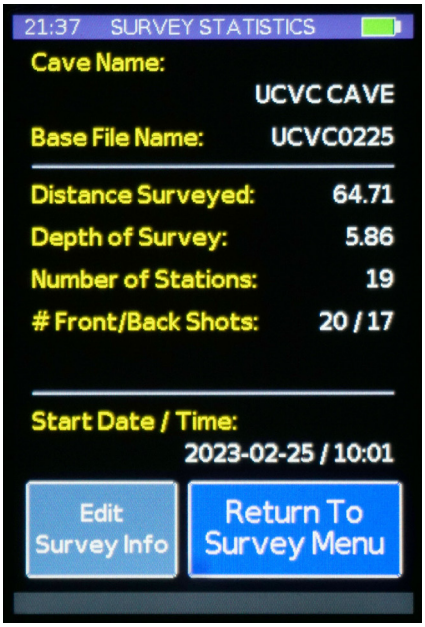
options for editing it. **ADD NOTE** displays a screen with a QWERTY-like keypad and a text box to enter to note for that shot with information such as a description of the area, whether formations are present, if the station corresponds to a previous survey station, etc. Up to 81 characters can be entered and the note is stored in the survey file and is displayed in the Walls Cave Mapping software. Press **ENTER** to save it and exit. If you select **ADD NOTE** to a shot for which a note is already entered, the note is displayed in the text box and can be edited. To leave the note unchanged, press **ENTER** or press **DELETE** until the **CANCEL** button appears. **ADD NOTE** is not available for fixed GPS points.

The **EDIT NAME** menu option allows you to change the **FROM** or **TO** station names or the fixed point name in the event they were entered incorrectly or need to be changed. A box appears to select the FROM or TO station and then the station code entry screen appears with the current station name entered in the text box. After changing it, press **ENTER** to accept the new name. To leave it unchanged press **ENTER** or **DELETE** repeatedly until it turns into the **CANCEL** button.

The **FRONT<>BACK** menu option changes a front-sight into a back-sight or vice versa. Note that changing a frontsight with an LRUD to a backsight will remove the LRUD data for that shot. The is not applicable to fixed points.

The **DELETE** menu option will completely remove the shot or fixed GPS point from the *.SRV* file survey file along with any note entered for it. A dialog box appears to confirm that you really want to delete it before doing so.



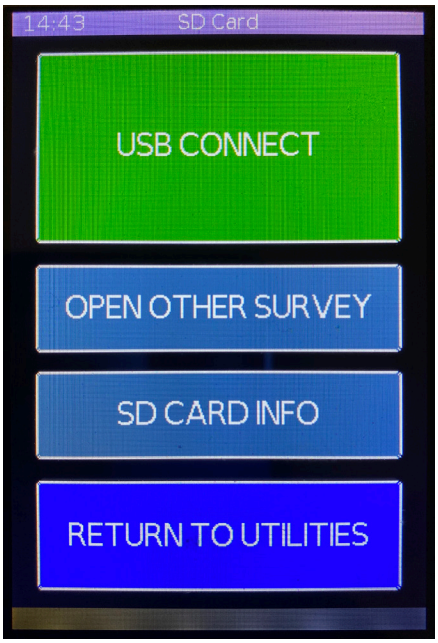


VIEWING SURVEY STATISTICS

This function lists statistics for the current survey including the cave name, file name, the distance surveyed, the surveyed depth, the number of stations, number of frontsight/backsight shots, and the date and time that the survey was started.

At the bottom of the page, the **EDIT SURVEY INFO** allows you to view or edit the survey info that was entered when setting up the survey or adding info if it was not entered at that time. After editing or entering new info, press **ENTER** to accept. To leave the info unchanged, press **ENTER** or press **DELETE** until the **CANCEL** button appears.

Transferring Files with a Computer



The Caveatron uses the Media Transfer Protocol (MTP) to allow computers to connect, view, transfer, and delete files. The MTP protocol is primarily used by Android devices so its level of support varying by computer operating system (see sidebar below). The connection is not normally active and is initiated by selecting a menu item in the Caveatron GUI after which the connection is automatically established.

To connect to the Caveatron to a computer, perform the following steps:

- Plug a USB to USB-micro cable into the Caveatron and computer.
- Be sure the computer is awake.
- Turn on the Caveatron.
- Go to **UTILITIES ➜ SD CARD** and press the **USB CONNECT** button.

Depending on the operating system, different actions will occur:

Windows: The Caveatron will appear as a mounted drive called “Caveatron”. Opening it reveals an SD card folder containing the files on the Caveatron. You can browse, copy and delete files and folders like a normal USB drive.

Mac: Open the Android File Transfer app and it will connect to the Caveatron as “Caveatron” (the app may also open automatically depending on how it is configured). It provides a window to browse, copy, and delete files and folders.

Linux: The Caveatron will appear as a mounted drive called “Caveatron MTP Disk” or similar. Opening it reveals an SD card directory containing the files on the Caveatron. You can browse, copy and delete files and folders like a normal USB drive.

After completing the file transfer, you will have to turn off the Caveatron before using it for any other function.

OPERATING SYSTEM MTP SUPPORT

Windows: MTP is natively supported by the operating system. Nothing further is required.

Mac OS: MTP is not natively supported and no free system-wide drivers are known to exist. The only free software currently known to work is an app called Android File Transfer, which contains its own MTP drivers. Android File Transfer can be downloaded from here: https://www.android.com/filetransfer/

Linux: Some recent distributions include built-in MTP support. For others, libmtp can be installed to provide support. Information can be found at: http://libmtp.sourceforge.net/

FILE STORAGE AND TYPES

Files used by the Caveatron SV are in plain text format and can be viewed in any text editor program. Several different files are generated for each survey. All the files for a particular survey are stored within a single folder titled with the name of the cave followed by the date in YY-MM-DD format. Spaces are converted to underscore characters. The files inside the folder have names that are 8 characters in length and all have the same base name with the 4 letters that are entered when setting up the survey and 4 numbers forming the date in MMDD format. Each file has a different extension depending on the type described below. An example would look like this:

Folder: LIMESTONE_ROCK_CAVE_20-12-06

Files:
LIME1206.SRV
LIME1206.CVP
LIME1206.IMU
LIME1206.LOG
LIME1206.DAT

It is possible to have more than one set of survey files within a single folder, so long as they have different base file names. This can be done if the same cave name is used to create a new survey on the same date. Or if no cave name is entered when creating a new survey then the current cave name and folder are used. In those cases a different first four letters would need to be entered for the base file name. The Caveatron will not allow you to overwrite any existing files. A list of other surveys on the SD card can be viewed within the **SD CARD** utility and re-opened as the current survey, so long as a valid .DAT file is present for that survey.

The different file types are:

Survey file (.SRV) – contains the station-to-station shot vector data from Shot mode, LRUD measurements, and GPS coordinates. This file is in Walls survey format and can be opened in Walls or by the Caveatron Process software. The format of this file can be found in the manual for Walls software.

Points file (.CVP) – contains the wall point measurements obtained in Point Mode. This file is in a custom plain text format (outlined on p. 24) that is converted to an X,Y,Z point cloud by the Caveatron Process software.

IMU calibration file (.IMU) – contains calibration data. The format of this file is described in detail in the “Caveatron Setup & Calibration Instructions” document. The file is used to save existing calibration parameters stored on the Caveatron and load new calibration parameters from a computer to the Caveatron.

Log file (.LOG) – contains internal logged information about the Caveatron state useful for debugging and raw sensor data from shots which may be useful if you had a calibration error. This file does not normally need to be used.

Settings file (.DAT) – contains information about the survey used by the Caveatron to maintain an internal list of shots, scans and other info about the survey. This file is not used outside the Caveatron and should not be edited.

Settings

The Caveatron has several settings that can be adjusted to select your preferred operating parameters. The specific settings shown will differ depending on the hardware in your Caveatron. These settings are retained after powering off and on the unit. After changing settings, its best to re-boot the Caveatron to ensure they are applied.

When opening a setting, a list of settings are shown with radio buttons or a check box to the right. The radio button next to the currently active setting is filled with a green dot. Tap any other radio button to select a new setting. For check boxes, the setting is active if filled with a green square. Tap the square to enable or disable. The new settings are not applied until the **SAVE** button is selected. To return to the previous menu without making any changes, press **CANCEL.**

AUTO POWER OFF

The Caveatron will automatically turn off to save battery life when in the Main Menu screen or in the Utilities Menu screen. This setting adjusts the time until it turns off from the last touchscreen press and can be set to 1, 2, or 5 minutes. It can also be set to NEVER to prevent auto power off from activating.

LCD DIMMING

Certain Caveatron hardware configurations support adjusting the screen brightness. Reducing the screen brightness adds significantly to the battery life.

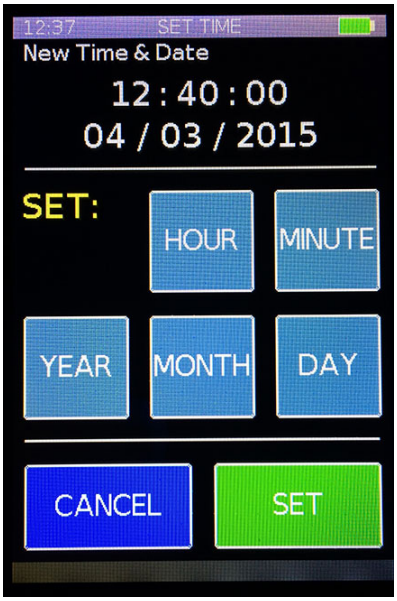
LCD Brightness
The screen brightness can be changed between 100%, 50%, 25%, and 12%.

LCD Dimming
The screen can be set to automatically dim after 1 minute of inactivity. After the screen dims, tapping it anywhere restores it to the set brightness level. The auto-dimming level is equivalent to 6% brightness. Auto-dimming can also be turned off.

SETTING THE DATE AND TIME

The internal clock can be set by going to **UTILITIES ➜ SETTINGS ➜ SET DATE & TIME**. A screen appears that shows the current date and time. The time is displayed in a 24 hr format. Select one of the buttons below to adjust the Year, Month, Date, Hour or Minute. Pressing one of these brings up a numerical keypad to enter a new value. After entering a new value, press **ENTER** to set the new value or press **CANCEL** to avoid changing any

values. (See Keypad Usage sidebar on p. 7) After entering the new value, it returns to the main Set Date and Time screen which shows the new value. Additional adjustments can now be made to other values as needed. When done, press the **SET** button to set the clock the new time. **CANCEL** exits with out saving the new time.



Note that currently, daylight savings time is not automatically set, so the hour will have to be manually adjusted in the spring and fall.

MAGNETIC ANOMALY

These settings pertain to the detection of magnetic anomalies that can affect the compass azimuth readings. A checkbox allows you to enable or disable an audio alert if an anomaly is detected (a text alert is still displayed on screen in any case). The number boxes at the bottom allow you to set the upper and lower thresholds for the detection which may differ in different regions of the world. If the magnetic strength is outside of this threshold range, it triggers an anomaly alert. Use the **UP** and **DN** buttons beside the number box to increase or decrease the value. To help you set the values, you can use Manual Mode which shows the magnetic strength (MAG-STR) at the bottom. Take the Caveatron to an outside location away from any magnetic objects and turn it to various orientations, taking note of the highest and lowest MAG-STR values. Then take it indoor near objects that have stronger magnetic fields (like metal objects or object with motors, like refrigerators) and note the change in MAG-STR. Set the thresholds so that normal readings (like the ones you obtained outside) are between these limits but so that you can detect the anomalous values from placing the Caveatron near magnetic objects. You can adjust the thresholds at any time and they do not affect anything but when you get an alert.

Calibration

Detailed instructions for setting up and calibrating the Caveatron are provided in the “Caveatron Setup & Calibration Instructions” document along with instructions on how to use the calibration functions. Most of the calibrations need only to be done one time when the Caveatron is first assembled. The only calibration that should have to be performed on a regular basis is the User Compass Calibration, and those instructions are repeated in this section.

COMPASS CALIBRATION

The magnetometer sensor used for the compass drifts over the course of several days so needs occasional recalibration. Ideally, this should be done before each trip into a cave to get the best results.

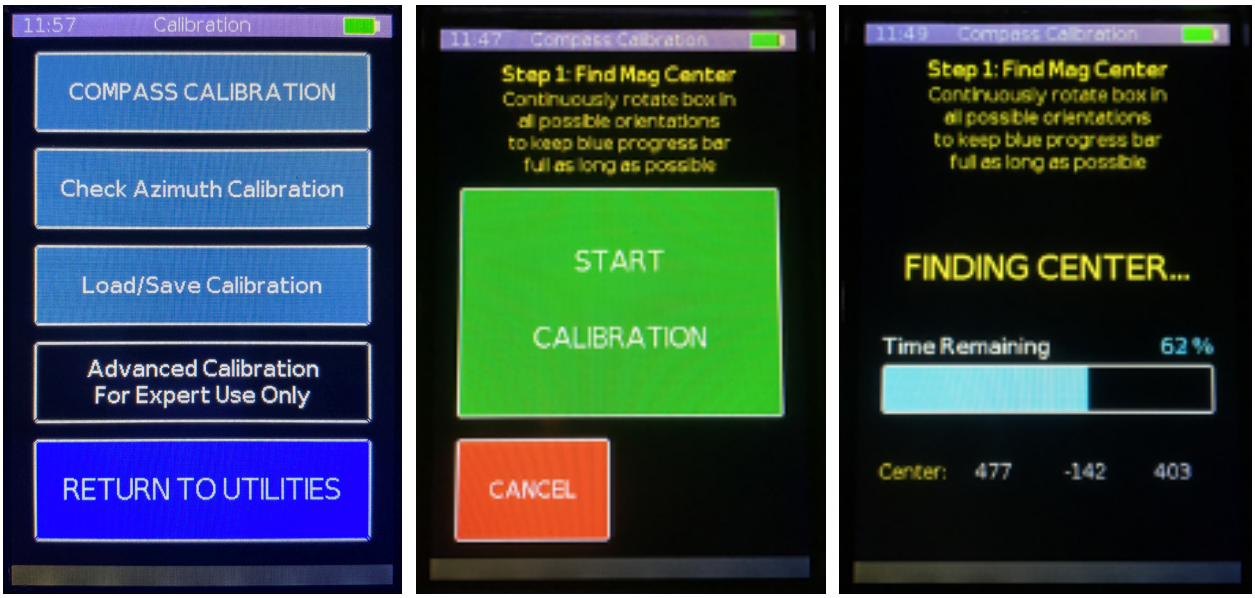
This calibration is simple to perform and the steps are described below. First find an area

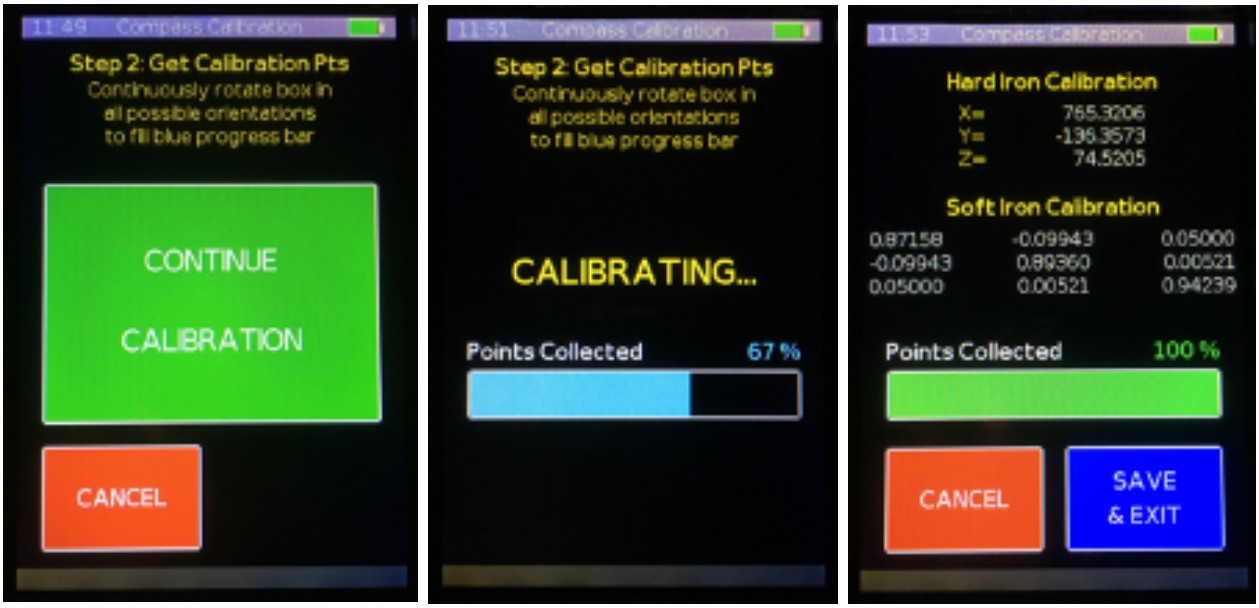
well away from any buildings or major power lines. Be especially careful to stay far away from any motors such as compressors used in HVAC systems. Remember that roads and sidewalks are not good choices as they often contain rebar.

Under the **CALIBRATION** menu, select the **COMPASS CALIBRATION** function. There are two steps – first determining the approximate center of rotation of the calibration sphere and then calculating the coefficients. Both steps are done in approximately the same way. Hold the Caveatron out in front of you and when you are ready, press **START CALIBRATION** for Step #1 or **CONTINUE CALIBRATION** for Step #2. Continuously rotate the unit in all orientations so that each side points in every direction at some point. One way to do this is to spin the unit several times on one axis while you turn yourself around in a gradual complete 360º rotation and then switch to each of the other two rotation axes while you continue to turn around. Oftentimes the more upward pointed and downward pointed directions get missed, so you may need to spin and rotate the unit in these directions a few more times to complete the calibration. A progress bar is shown on the screen to indicate how many of the required points have been acquired. The unit intelligently acquires points to ensure that a relatively uniform distribution of points are collected around a sphere. If you were to just hold it in one or a few directions, the calibration would never complete as there would be an insufficient distribution of points.

Detailed instructions for setting up and calibrating the Caveatron are provided in the "Caveatron Setup & Calibration Instructions" document along with instructions on how to use the calibration functions. Most of the calibrations need only to be done one time when the Caveatron is first assembled. The only calibration that should have to be performed on a regular basis is the User Compass Calibration, and those instructions are repeated in this section.

In Step #1, the goal is to keep the progress bar as full as possible as long as possible while enough points are gathered to get an accurate center position for the magnetic sphere. If you hold it still, the progress bar drops rapidly, but as you spin the Caveatron to different angles, it will jump back up to full. The longer you keep it full, the more accurate the result. Eventually you will have gathered points from every direction and the progress bar will reach zero, completing step #1.



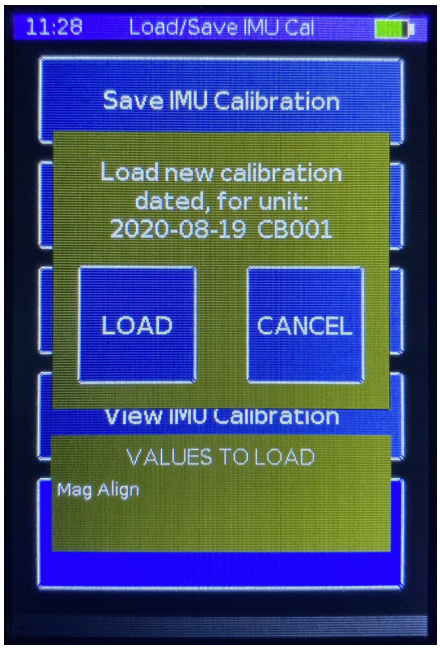


In Step #2, the goal it to fill the progress bar to full. As you spin to different angles and new data points are collected, it will gradually fill up. Spin the Caveatron as before. The last few percent may be a bit more difficult to get as you have to find the angles and orientations of the unit you have not yet covered.

Once the calibration is complete, the coefficients are immediately calculated and displayed on the screen. If you are satisfied, press **SAVE & EXIT** and they are stored in the EPROM as the new Hard/Soft iron calibration parameters for that LIDAR configuration. They can be updated at any time by repeating the Compass Calibration. Note if you do not press **SAVE & EXIT**, the new coefficients are not stored and the existing coefficients remain in memory.

SAVE CALIBRATION PARAMETERS

This function saves the current calibration parameters to a file named “Cal_save.imu”, in the root of the SD card (not in a folder). This file can be downloaded to a computer by the normal file transfer process over USB. This file can also be reloaded if you take a new calibration that is unsatisfactory.



LOAD PREVIOUS CALIBRATION PARAMETERS

This function loads a previously saved calibration file (with the name “Cal_save.imu”.) All current calibration parameters are overwritten by the values in this file and a warning screen gives you the option to proceed or cancel. When selecting to proceed, wait several seconds until a message appears that the loading is complete. The Caveatron should be rebooted after performing this function to ensure the new parameters are applied.

LOAD NEW CALIBRATION PARAMETERS

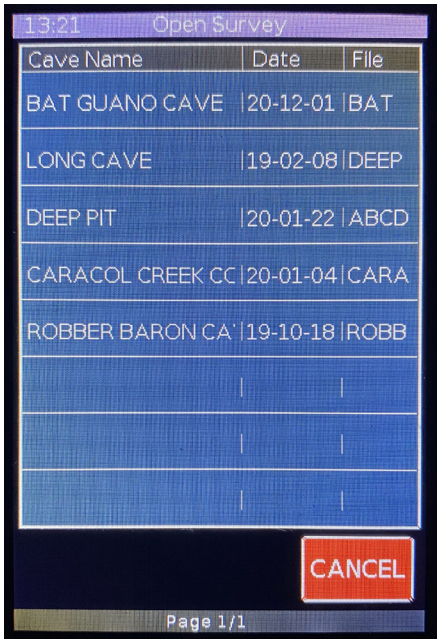
This function loads a subset of calibration parameters from a file named “Cal_new.imu” that a user uploads to

the Caveatron SD card by the file transfer process over USB. This file must be placed in the root of the SD card (not in a folder). This is a special version of an IMU file that can contains a subset of the calibration parameters. If only one type of calibration parameter needs to be changed (for example, the magnetometer offsets), you would only place those parameters in this file and, when load, only those values are changed. A detailed description of the file format of a Cal_new.imu file can be found in the "Caveatron Setup & Calibration Instructions" document.

When running this function, a message appears showing the types of calibration parameters found in the file which will be overwritten and the date in the *.IMU* file to confirm that these are the correct parameters to load. After hitting **OK**, wait several seconds until a message appears that the loading is complete. The Caveatron should be rebooted after performing this function to ensure the new parameters are applied.

Other Utilities

REOPENING A PREVIOUS SURVEY



UTILITIES ➜ SD CARD ➜ OPEN OTHER SURVEY. A previously created survey can be reopened to continue adding shots and scans to it. A list of the surveys saved on the SD card is shown (up to a maximum of 32). Eight surveys are shown per page with the cave name, the survey start date, and the 4 letters used in the base file name. Move between pages by tapping **NEXT** or **PREV** or press **CANCEL** to exit. Tap on the survey's entry to open it and make it the current survey. A message box will briefly appear to confirm that the survey has been opened.

SD CARD INFO

UTILITIES ➜ SD CARD ➜ SD CARD INFO. This shows information about the SD card including its format, size, available space, and number of files.

ABOUT SCREEN

UTILITIES ➜ ABOUT This screen shows the current software revision installed and the serial number of the Caveatron (if applicable).

Theory of Operation

The Caveatron SV's measurement ability is based on three key components – a Laser Rangefinder (LRF), a magnetometer, and an accelerometer. A red laser built into the LRF provides a pointing reference direction along which all the sensors are calibrated.

The LRF produces a series of short laser pulses to measure the length of time it takes for the pulse to return from its target to compute the distance. The LRFs available for use with the Caveatron all have a small spot size, which allows it to be precisely pointed when taking measurements. To achieve its accuracy, the LRF must average a large number of points internally, limiting how often it can obtain a reading.

The magnetometer provides a measurement of the yaw angle of the Caveatron relative to magnetic north by measuring the Earth's magnetic field. As such, all readings by the Caveatron are not relative to true north, however they can be converted in the post-processing software by entering the magnetic declination of your location. Unfortunately, magnetometers can be affected by many other things than the Earth's magnetic field, yielding false readings. These can include ferromagnetic materials, such as iron and some steels, and electromagnetic currents from electricity and motors. In buildings it is difficult to get reliable magnetometer readings as there are many sources of magnetic fields such as refrigerators, heating/cooling systems, wiring in the walls, or rebar in concrete. Fortunately, caves do not usually contain anything that would affect the magnetometer, however there are some exceptions, such as cave gates and your helmet light. As such, the Caveatron should be kept away from gates as much as possible and you should not place your headlamp or battery pack directly next to the Caveatron. Some types of caves such as lava tubes may be located in rock containing ferromagnetic materials, but the effect of this has not been tested. Magnetometers are prone to internal drift so need to be re-calibrated on a regular basis.

The accelerometer provides the tilt and roll angle of the Caveatron relative to Earth's gravity. As such, down is always a known direction. Accelerometers are also affected by movements so have the ability to be used to estimate how far and in what direction something has moved. However, the effect of gravity and the effect of movement cannot be readily separated without the use of a gyroscope. Accelerometers are fairly stable so do not need regular recalibration.