

Cavway X1 User Manual

November 2025 Rev. B

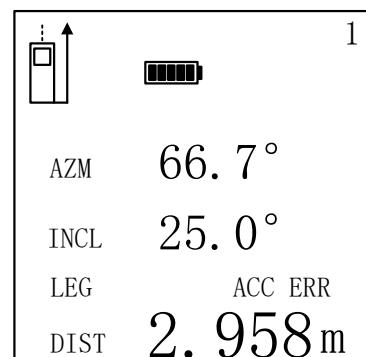
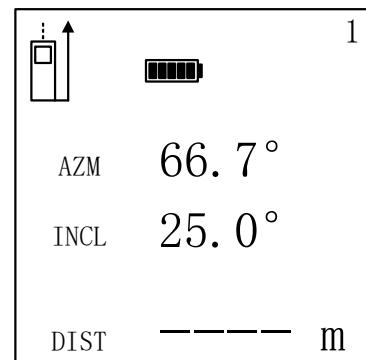
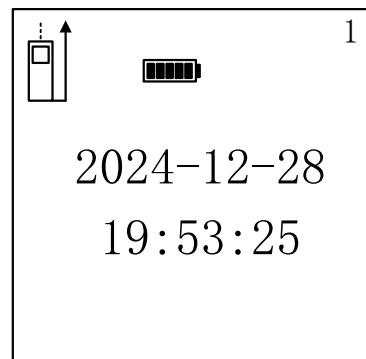
Siwei Tian & Marco Corvi

The Cavway X1 is an integrated electronic device for cave surveying. It has the following features:

- Good ergonomic:
145g weight and 131*55*33 mm size
- High Accuracy (after proper calibration):
Distance < 5mm
Azimuth ~ 0.4° or better
Inclination ~ 0.2°
- IP67 Waterproof and floatable
- Screw holes for tripod mounting, and for a tail.
- USB-C port supporting charging and data transfer.
- Two pairs of triaxial G and M sensors.
- On-board standalone smart calibration.
- Robust anti calibration loss and magnetic interference detection.

There are five buttons:

- Measure: "DIST"
- Left: "<"
- Right: ">"
- Menu / Enter: "M"
- Clear / Off: "CLR"



Power on/off

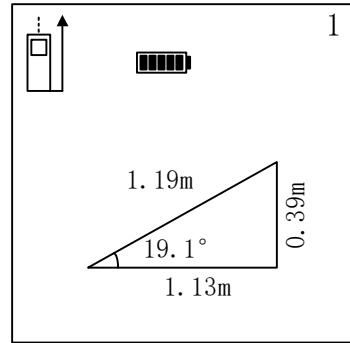
A press on the top button, "DIST", turns the device on. The display shows the date and the time. A long press on the CLR button switches the Cavway X1 off.

To lock and power off the device, press and hold the CLR button while simultaneously pressing the > key. To unlock upon restart, press the M key within 2 seconds.

Measure

Pressing the "DIST" button, the laser turns on and the display shows azimuth and inclination. Pressing it another time the shot measurement is taken: a beep is emitted and the shot data are stored in memory. **Press and hold the DIST button for 2 seconds to trigger a delayed measurement.** The delay time (in seconds) can be set in a menu. If the device detects an error, there is an error warning "ACC ERR" on the display and the beep lasts longer. Whenever three or more consecutive close shots are taken the Cavway X1 emits a double beep and flashes the screen. The word "LEG" is shown on the screen. If "ACC ERR" appears frequently and there is no magnetic interference, check your calibration.

After the measurement is completed, use the < and > keys to view further information associated with the measurement. Available results include error messages and horizontal/vertical components. The error message displays detailed information about sensor accuracy errors. When the "ACC ERROR" prompt appears, this page provides specific details. The horizontal/vertical components page shows the tilt angle of the current measurement, as well as the lengths of the vertical and horizontal projections.



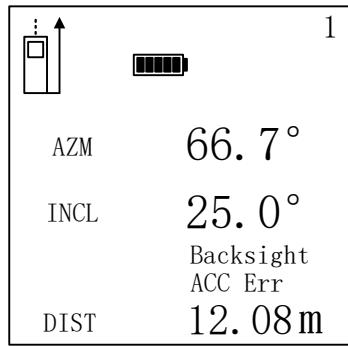
Hotkey:

Long press ">" opens a confirmation dialog to clear the transfer flag of unsent shots.

Special shot marking

In measurement mode, pressing the "M" button while the laser is on allows the Cavway X1 to assign a special mark to the shot (leg or splay). The corresponding mark will be displayed on the screen. The five available marks are:

- No Mark
- Feature
- Ridge
- Backsight
- Generic



Pressing "M" button repeatedly cycles through these values.

Memory mode

Pressing the "<" or the ">" button the Cavway X1 enters the memory mode: data in memory are shown on the display. The most recent data on the top. It is possible to scroll up ("<" button - more recent data) and down (">" button - older data) in the list.

The character 'E' on the left indicates a data with accuracy error. The character 'C' denotes a calibration data. The lines in bold indicate a leg. The data that have not been transferred have a '*' on the right. Data with special marks are indicated with "_". Pressing "M" button enters the shot detail page.

SHOT # 1		
DIST	AZM°	INCL°
2. 95	66. 7	24. 6
E 5. 26	163. 8	22. 2*
E 1. 58	293. 0	7. 3_
C 0. 00	294. 7	8. 3
C 0. 00	297. 5	7. 6

On the shot detail page, the "M" button cycles through the info of the highlighted data: readings, errors, and G/M/dip values. The "<" and ">" buttons move to the previous and next shot in memory, respectively, without changing info-page.

SHOT # 1 *	SHOT # 1 *	SHOT # 1 *
DIST: 1.65m Q: 5	absM Error absM1: 0.9822 absM2: 1.0284 Dip Error Err1: 1.9° Err2: 0.9°	absG: 0.988g absM: 53.74uT Dip: 56.9°
AZM: 23.5°	< >:Prev/Next shot	< >:Prev/Next shot
INCL: 1.7°	M:Next page	M:Next page
2024-12-18 20:33		
Accuracy Error		
< >:Prev/Next shot		
M:Next page		

Menu mode

Pressing the "M" button opens the configuration menu of the Cavway X1:

- Calibration
- Clr. Unsent
- Options
- Information
- Advan. Menu

The "<" and ">" buttons move through the choices. You select a choice with the "M" button. A press of the "CLR" button returns to normal mode.

Calibration
Clr. Unsent
Options
Information
Advan. Menu

< >:Prev/Next
M:Enter

Calibration

With this menu the device enters the calibration mode, which is used to calibrate the Cavway X1.

Clr. Unsent

This menu clears the flag of the data that have not been transmitted yet. There is a confirmation question.

**Clear unsent
Shots?**

M:Confirm
CLR:Cancel

Options

The options are (bold values are the default)

- Reference (**rear**, tail, tripod, front, custom)
- Shot Delay (from **0** to 9 second)
- Backlight (0 to **10**; 0 no backlight, 10 max brightness)
- Beep (**ON** or OFF)
- Idle time-off (**60**, 120, 180, 240, 300 seconds)

The "<" and ">" buttons move through the options. The value of each setting is adjusted with the "M" button, cycling through the available values. The "CLR" button goes back to the main menu.

The possible values for the reference are

- Rear: the distance is measured from the rear end of the

> Ref.	Rear
Shot delay:	0s
Backlight:	10
Beep:	ON
IdleOff:	60s

< >:Prev/Next
M:Ad. just CLR:Back

instrument

- Tail: the distance is measured from the tail on the rear of the instrument.
- Front: the distance is measured from the front end of the instrument
- Tripod: the distance is measured from the point of attach of a tripod. The laser axis is 18.6 mm above the center of the tripod screw hole.
- Custom: this choice is for a custom tail. The laser reading is taken from the rear end of the instrument, but the distance has an additional value specified (in mm). For instance, if the custom value is 20 mm and the reading is 1 m the distance is 1.02 m.

The backlight of the display changes accordingly to the setting while it is adjusted. The value '0' is a completely dark screen.

Information

The information menu displays the hardware version, the firmware version, the serial number, and the battery charge. Cavway X1 adopt a 1800mAh non-magnetic battery, which is three times that of the DistoX2.

Cavway X1

Hardware: 1.0
Firmware: 1.0.0
Serial: 0001
Battery: 4.18V

CLR:Back

Advanced Menu

The advanced menu has

- Shot options
- Calibration options
- Time
- Units
- Factory reset

Shot Options
Cal. Options
Time
Units
Fact. Reset

< >:Prev/Next
M:Enter

Shot options

The shot accuracy options are (bold values are the default):

- Error detection (**ON** or OFF)
- Angle difference (0.2, 0.3, **0.4**, 0.5, 0.6, 1.0 degrees)
- absG and absM error limit (0.5, 0.8, **1.0**, 1.5, 2.0, 3.0 percent)
- Dip error limit (0.5, 0.8, **1.0**, 1.5, 2.0, 3.0 degrees)
- Reset to default values
- Reset the statistics

> Err Detect: ON
Angle Diff: 0.4°
ABS Lim: 1.0%
dip Lim: 1.0°
Reset Default
Reset Statistic
< >:Prev/Next
M:Adjust CLR:Back

The angle difference is the difference between the device directions measured by the two pairs of G-M sensors. The absolute (ABS) error limit refers to the maximum deviation between the magnetic field intensity and gravitational acceleration magnitude obtained by two sets of G-M sensors relative to their mean values. The dip limit is the difference between the G-M

angles measured by the two pairs of GM sensors.

Calibration options

The calibration options are (bold values are the default)

- Error detection (**ON** or OFF)
- Group limit angle (1, **3**, 4, 5, 6, 8, 10 percent)

The group limit angle is the threshold for the automatic detection of the shots of a group. The Cavway X1 automatically detects when the user starts a new group after completing one. To complete a group the user must take four or more shots in the same direction, rotating the device by 90 degrees each time. If more than four shots are taken only the last four are considered for the group. When a group is completed the Cavway X1 emits a double beep.

> Err Detect:	ON
Grp Limit:	3%

< >:Prev/Next
M:Adjust CLR:Back

Time

With the time menu the user can set year, month, day, hour, minute, and seconds. The values are adjusted with the "<" and ">" buttons. The "M" button moves to the next value: from "year" to "month", from "month" to "day" and so on. After "seconds" it goes back to "year". The "Back" (CLR) button saves the time.

> Year:	2024
Month:	12
Day:	18
Hour:	22
Min:	21
Sec:	55

< >:Adjust
M:Next CLR:Save

Units

The only units choice is for the distance: m (meter) or ft (feet).

The angles are always in decimal degrees.

> Length:	m
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< >:Prev/Next
M:Adjust CLR:Back

Calibration

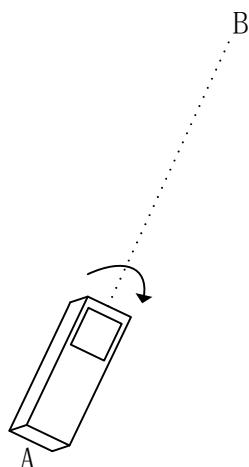
The Cavway X1 utilizes the same calibration method as the Disto X2/XBLE, with additional features for calibration assistance and error detection. Notably, the Cavway X1 can be calibrated independently without the need for an app on smartphones or tablets. To initiate calibration mode, navigate to the menu and select "Calibration".

Calibration process

Calibration involves taking groups of four shots that cover all directions. During each group:

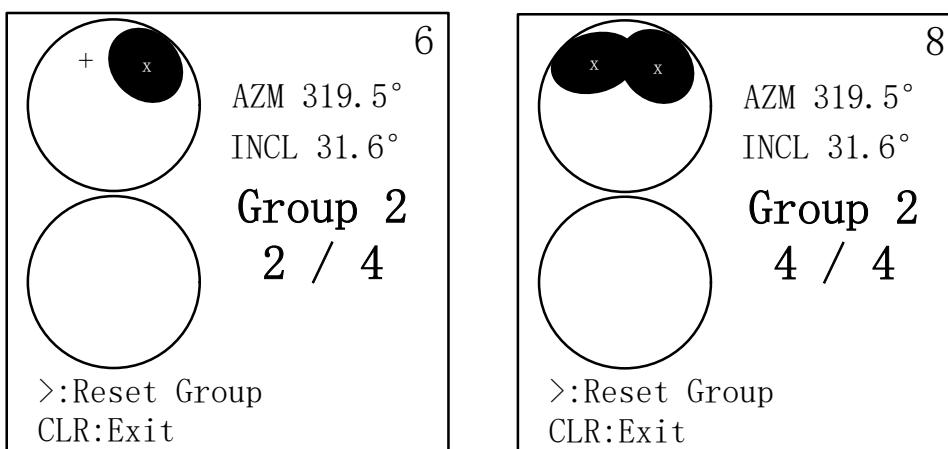
1. Fix the rear of the instrument at point A and point the laser beam on point B.
2. Take the first calibration shot, then rotate the device by 90 degrees and take the next shot.
3. Repeat until four shots are taken.

While the distance between points A and B is not recorded, it is recommended that it exceeds 5 meters for optimal accuracy. After completing one group of shots, change to a new direction and begin a new group.



Display features

The display provides a visual map of the 3D directions covered by the calibration groups. Two circles represent the upward and downward hemispheres. The directions that are "covered" by the calibration shots are dark. The directions of the groups already taken are shown with a 'x' and that of the group that is being taken with a '+'. A good calibration should darken both circles entirely, requiring at least 14 groups of shots.



Group Management

The display also shows:

- The total number of groups completed.
- The number of shots in the current group.

When a group contains four valid shots, it is complete and it is stored when a new group is started, or before the computation of the calibration. If more than four shots are taken, only the last four are considered. If an error occurs taking a shot, the group can be reset (i.e., all

shots cleared) by pressing the “>” button. If a shot deviates significantly from the previous shots, a new group is started with that shot. If the previous shots do not form a complete group, they are discarded.

There is a limit of 25 groups. When the limit is reached no more groups can be taken.

Calibration Coefficients Computation and Reporting

When more than eight complete groups have been captured, the calibration process can be computed by pressing the "M" button. This action generates a detailed calibration report for each sensor pair, which includes:

- Average Error: The mean angular error across the shots in the group.
- Standard Deviation: A measure of the variability in the angular errors.
- Maximum Error: The largest observed angular error.

The error of a shot is defined as the angular difference between the recorded data and the average direction of the shot group after the calibration is applied.

The report also provides:

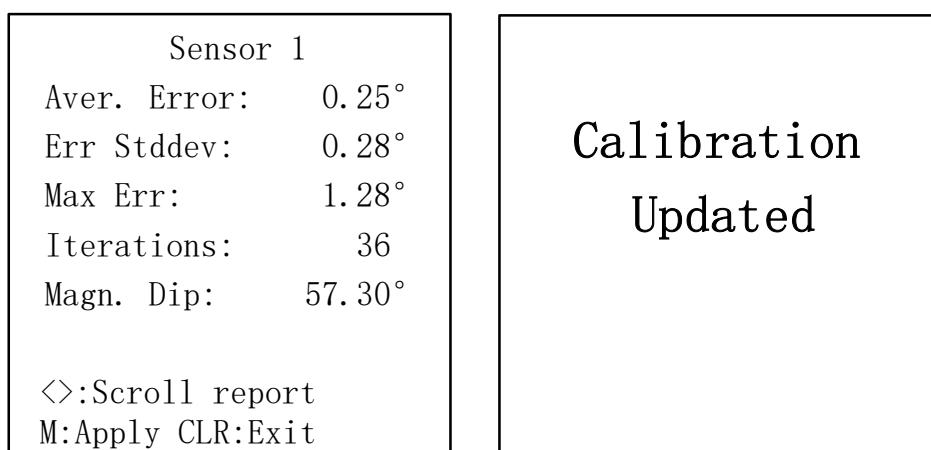
- The number of iterations performed during the computation.
- The angle between the gravitational direction (G) and the magnetic direction (M), ("magnetic dip.")

The raw data from calibration shots can be viewed in the memory dialog for further analysis or review.

After the calibration coefficients are computed, the user has the option to:

1. Apply the Coefficients: Press the "M" button to put the computed calibration into use.
2. Discard the Coefficients: Press the "CLR" button to discard the calibration and return to the main calibration interface.

After discarding or applying the calibration, users can choose to continue capturing additional groups of shots to further refine the process.

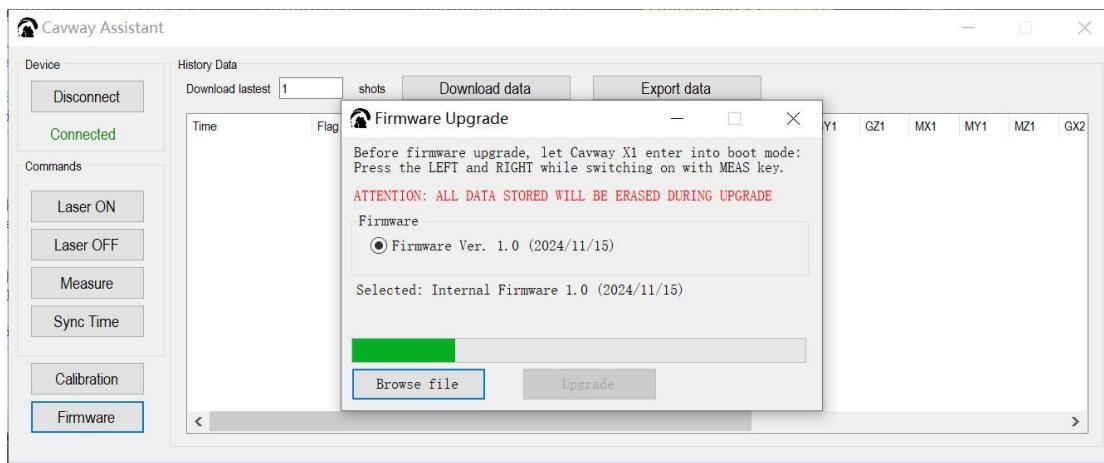
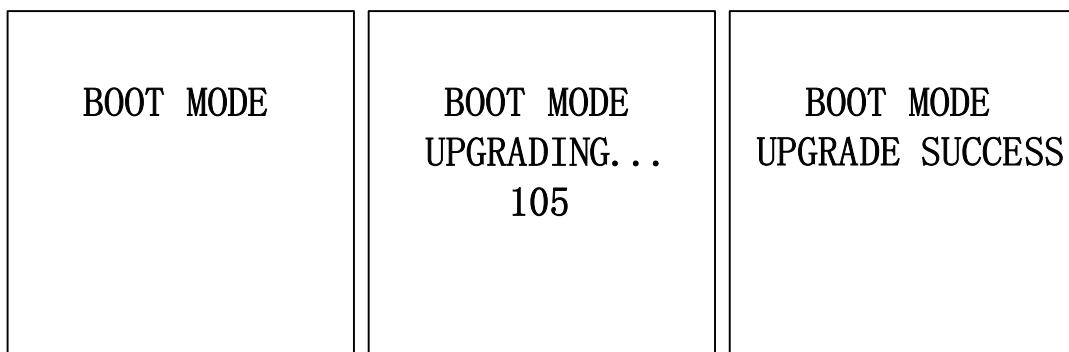


Firmware upgrade

WARNING: All data stored will be erased during firmware upgrades including the calibration and history data.

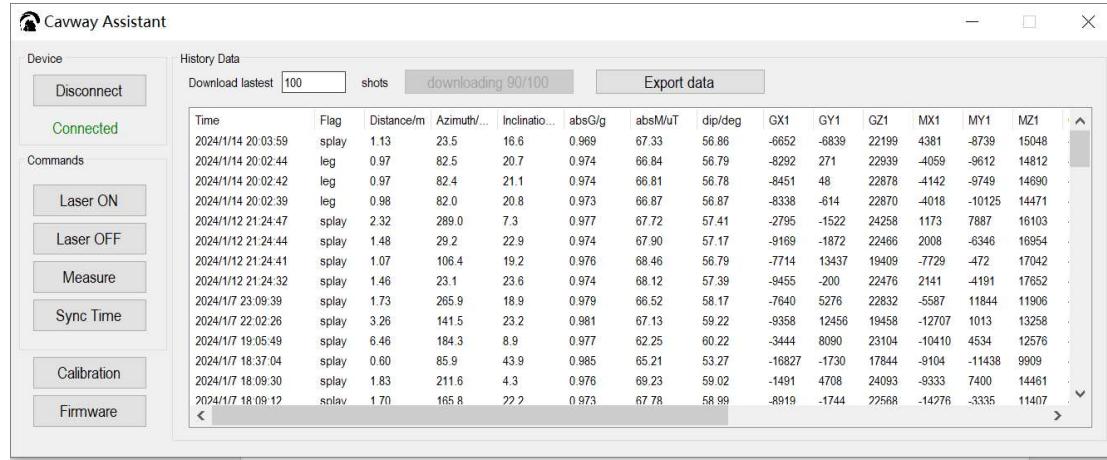
The upload of a new firmware can be done with the Windows program Cavway Assistant.

- Open the Cavway Assistant on the PC
- Connect the Cavway X1 to the PC with a USB cable, with the Cavway X1 off
- Turn on the Cavway X1 in boot mode: press the '<' and '>' buttons simultaneously, hold them and press the 'DIST' button.
- Click the 'Connect' button on the Cavway Assistant. You might have to click it a few times before the program is connected to the Cavway, and the button displays "Disconnect".
- When the program shows that it is connected to the Cavway X1, click the 'Firmware' button. In the coming dialog you can open a firmware file from the PC or use the file bundled in the program.
- Press the 'Upgrade' button and wait for the upload to finish. The firmware upload process is shown also on the Cavway X1 display.
- When finished the Cavway Assistant reports whether the upload was complete ("Success") or not. A successful message also shown on the Cavway X1 display.
- After the program shows "Success" shutdown the Cavway X1 pressing and holding the 'CLR' button.
- Turn it on in normal mode by pressing the 'DIST' button.



Cavway Assistant

All history data stored can be downloaded by Cavway Assistant. The downloaded data are shown in a form including the Distance, Azimuth, Inclinations, absG, absM, dip and the RAW data of 2 sets of sensors. By “Export data” button, the data can be export to csv format.



Calibration data can be downloaded and stored locally.

The “Download Coeffs” button downloads and displays the calibration coefficients parameters of the 2 sets of sensors. The “Save Coeffs” button stores them in local disk (.coe format). Calibration coefficients parameters can be loaded from local disk and uploaded to device, with the "Load Coeffs" and the "Upload Coeffs", respectively.

