**Cavway X1 用户手册**

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刺猬（田思维）

Cavway X1是全新一代的洞穴测量集成电子设备，其具有如下特点：

* 较为小巧:

重量仅为145g，且体积仅为131\*55\*33 mm

* 高精度:

距离 < 5mm

航向角 < 0.4°

倾斜角 < 0.2°

* IP67防水
* USB Type C接口，可用于充电和数据下载交互
* 两套传感器，可良好的检测地磁干扰，同时具有较强的抗丢失校准性能

仪器上仅有5个按键:

* 测量: “DIST”
* 左: “<”
* 右: “>”
* 菜单 / 确认: “M”
* 关机 / 取消: “CLR”

**测量模式**

按下顶部的 "DIST" 按钮即可开启设备，屏幕会显示日期和时间。长按 "CLR" 按钮可以关闭 Cavway X1。



按下 "DIST" 按钮后，激光会打开，屏幕显示方位角和倾角。再次按下该按钮后，设备将进行距离测量，并将数据存储在内存中，同时在屏幕上显示测量值。如果在测量中检测到错误（如激光模块无法返回值），屏幕会显示错误警告，并且蜂鸣声会持续更长时间。

当连续进行三次或更多的相似距离测量时，Cavway X1会认为检测到主线，此时机器会发出双声蜂鸣并闪烁屏幕，同时屏幕上会显示“LEG”符号。如果屏幕上显示“ACC ERR”符号，可能是周围存在磁干扰。如果“ACC ERR”频繁出现且确认周围没有磁干扰（如四周有无铁器或磁铁），请检查设备校准情况。

**热键:** 在测量后，长按左键 “<” 2秒显示当前测点的精度错误详情。

长按右键 “>” 2秒提示是否清除所有未通过蓝牙发送的测点数据。

**历史数据模式**

在测量模式中，按下 “<” 或 “>” 按钮，Cavway X1 将进入历史数据模式，屏幕上会显示存储的数据，最新的数据位于顶部。通过 “<” 按钮向上滚动（显示更新的数据），通过 “>” 按钮向下滚动（显示较早的数据）。

屏幕左侧的字符 “E” 表示数据错误，字符 “C” 表示校准数据，加粗的数字表示主线（Leg）。尚未传输的数据右侧会显示一个 “\*”。按下 “M” 按钮可进入测量详情页面。

在测量详情页面，按下 “M” 按钮可循环查看所选数据的详细信息：读数、误差以及 G/M/dip 的值。“<” 和 “>” 按钮可分别查看内存中的上一条或下一条测量数据，而无需切换详情页面。

**热键**: 长按右键 “>” 2秒提示是否清除所有未通过蓝牙发送的测点数据。

**菜单模式**

按菜单按钮 "M" 进入Cavway X1的配置菜单，其有如下的菜单项:

* 校准Calibration
* 清除蓝牙未发送数据Clr. Unsent
* 选项Options
* 信息Information
* 高级菜单Advan. Menu

通过左"<" 和右 ">" 按钮来移动光标，选择菜单后，通过“M”按钮进入子菜单，“CLR”按钮返回上一级菜单。

**校准Calibration**

选择此项菜单进入校准模式，在此模式中，用户可以对仪器进行快速校准。

**清除未发送数据****Clr. Unsent**

该子菜单进入清除蓝牙未发送数据的选项。当选择确认后，将清除所有未发送数据。

**选项Options**

该子菜单完成以下设定 (粗体为默认值)

* 测量参考 (**尾部**, 尾巴, 三脚架, 前部, 自定义)
* 测量防抖延迟 ( **0** 到 9 秒)
* 背光 (0 到 **10**级; 0 为关闭背光, 10 为最大亮度)
* 音量
* 空闲关机时间 (**60**, 120, 180, 240, 300 秒)

左 "<" 和右 ">" 按钮移动光标。“M”按钮更改设定的值，“CLR”按钮返回上一级菜单。

测量参考可选的选项有：

* 尾部: 激光测距的参考点从仪器尾部平面开始计算。
* 尾巴: 激光测距的参考点从仪器尾部安装的可拆卸尾巴开始计算。
* 前部: 激光测距的参考点从仪器前部平面开始计算。
* 三脚架: 激光测距的参考点从三脚架螺丝孔开始计算。
* 自定义: 该选项用于自定义尾巴或加装额外壳子的情况。激光测距的参考点为仪器尾部平面加上自定义的偏移值。例如，该设定为20mm，仪器尾部到激光点的距离为1m，则实际仪器读数为1.02mm。



背光设定可以实时调整仪器的背光亮度。当设定为0时，屏幕背光熄灭。

**信息Information**

信息菜单显示仪器的硬件、固件版本号、序列号以及电池电压。Cavway X1采用1800mAh无磁锂电池，充满电后其正常电压约为4.1至4.2V

**高级菜单Advanced Menu**

高级菜单有如下子菜单项

* 测点选项Shot options
* 校准选项Calibration options
* 时间设定Time
* 单位设定Units
* 恢复出厂设置Factory reset

**测点选项Shot options**

测点选项子菜单有如下选项（粗体为默认值）

* 错误检测 (**ON** 或者 OFF)
* 双传感器角度误差 (0.2, 0.3, **0.4**, 0.5, 0.6, 1.0 角度)
* 模值ABS 相对误差限制 (0.5, 0.8, **1.0**, 1.5, 2.0, 3.0 %)
* 磁倾角dip绝对误差限制 (0.5, 0.8, **1.0**, 1.5, 2.0, 3.0 角度)
* 恢复默认值
* 重置统计值

角度误差为两套传感器输出在空间上的角度误差。模值ABS误差为G，M传感器所测量的加速度和地磁矢量模值相对其平均值误差的阈值，单位为百分比。磁倾角Dip绝对误差限制为仪器所测量的磁倾角相对其平均值的误差阈值。

**校准选项****Calibration options**

校准有如下设置菜单 (粗体为默认值)

* 误差检测 (**ON** 或 OFF)
* 组误差百分比 (1, **3**, 4, 5, 6, 8, 10 %)

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.

**时间设定**

时间设定子菜单内，用户可以设定年，月，日，小时，分钟，秒。通过左 "<" 和右 ">" 按钮，用户可以调整每个项的值，“M” 按键可以调整光标到下一个设置项，光标在移动至秒后，自动回到年处。“CLR” 按键保存时间设置。



**单位设定**

目前仅可以设定距离的单位，m（米）或ft（英尺）

航向角，倾斜角的单位目前为角度（°）。

**校准指南**

Cavway X1 使用和Disto X2/XBLE

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. During each group:

1. Fix the rear of the instrument at point A and the laser beam at 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 the distance 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 angular 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 can be accepted and stored. If more than four shots are taken, only the last four will be considered. If an error occurs during a shot, the group can be reset (i.e., all shots cleared). If a shot deviates significantly from the previous shots, it will start a new group. Only groups with four valid shots are saved; otherwise, they are discarded. The group data can be manually reset at any time using the “>” button.

**Calibration Coefficients Computation and Reporting**

Once 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), also known as the "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.

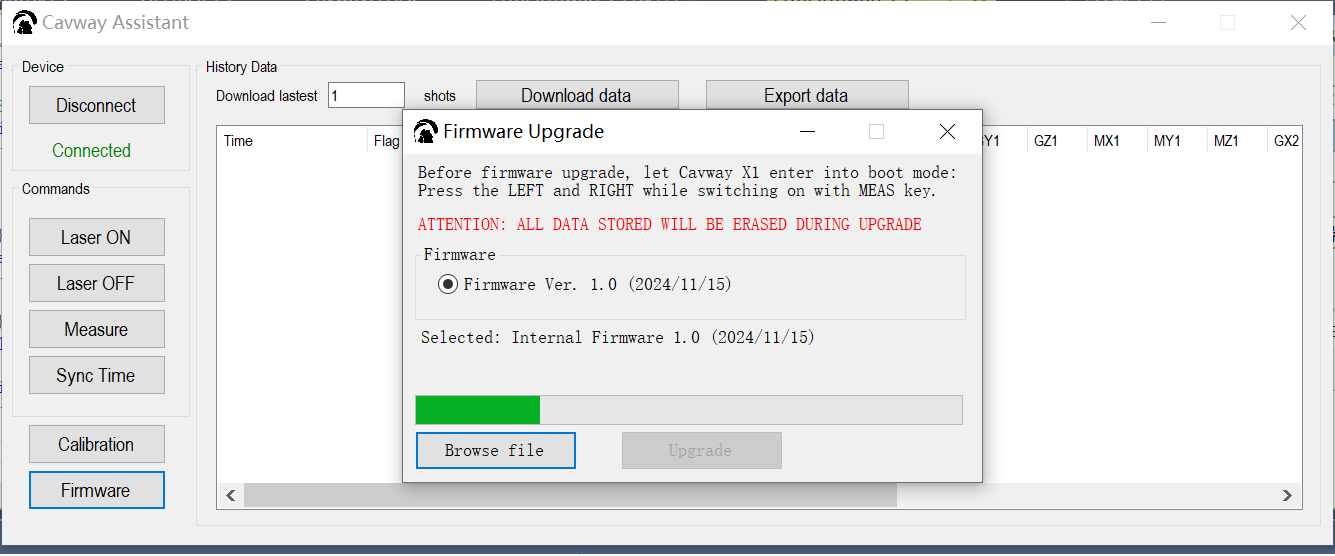
**Firmware upgrade**

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, and keep 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.

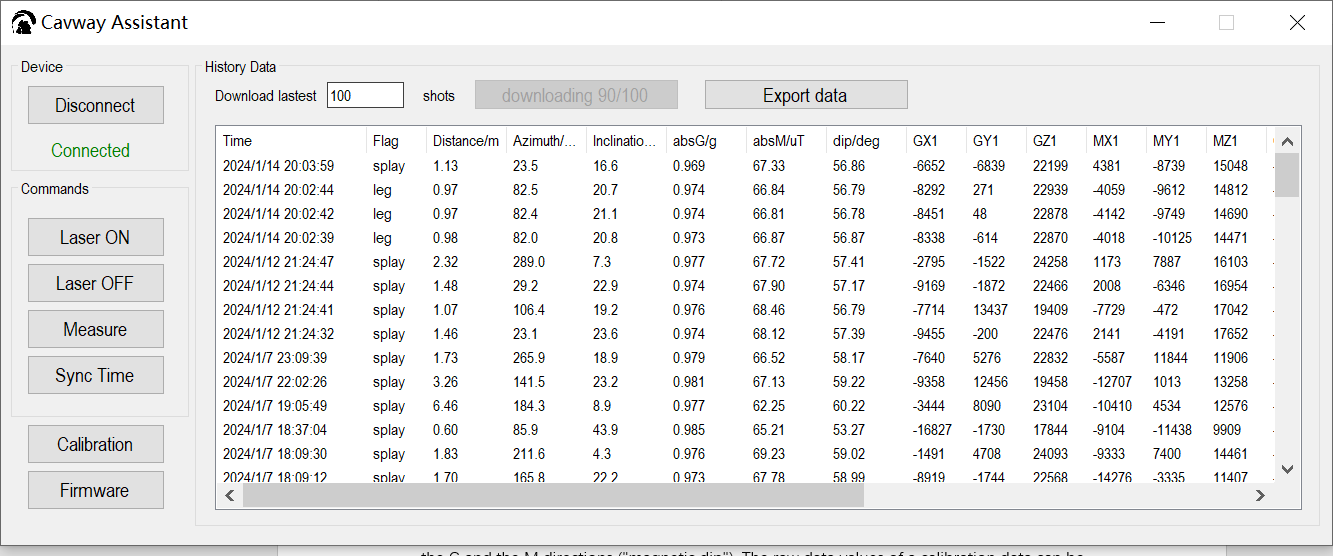
WARNING: All data stored will be erased during firmware upgrades including the calibration and history data.



**Cavway Assistant**

All history data stored can be downloaded by Cavway Assistant. Data downloaded is 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](https://www.google.com/search?sca_esv=963e6bd44828a6b7&sxsrf=ADLYWIIteROwLb4N3uSO_b9ud6EQ4C7pyw:1734533237611&q=coefficients&spell=1&sa=X&ved=2ahUKEwijkOrrx7GKAxU9IjQIHbC6OqwQkeECKAB6BAgcEAE) parameters of the 2 sets of sensors. “Save Coeffs” button stores them in local disk (.coe format). Calibration [coefficients](https://www.google.com/search?sca_esv=963e6bd44828a6b7&sxsrf=ADLYWIIteROwLb4N3uSO_b9ud6EQ4C7pyw:1734533237611&q=coefficients&spell=1&sa=X&ved=2ahUKEwijkOrrx7GKAxU9IjQIHbC6OqwQkeECKAB6BAgcEAE) parameters can be loaded from local disk and uploaded to device.

