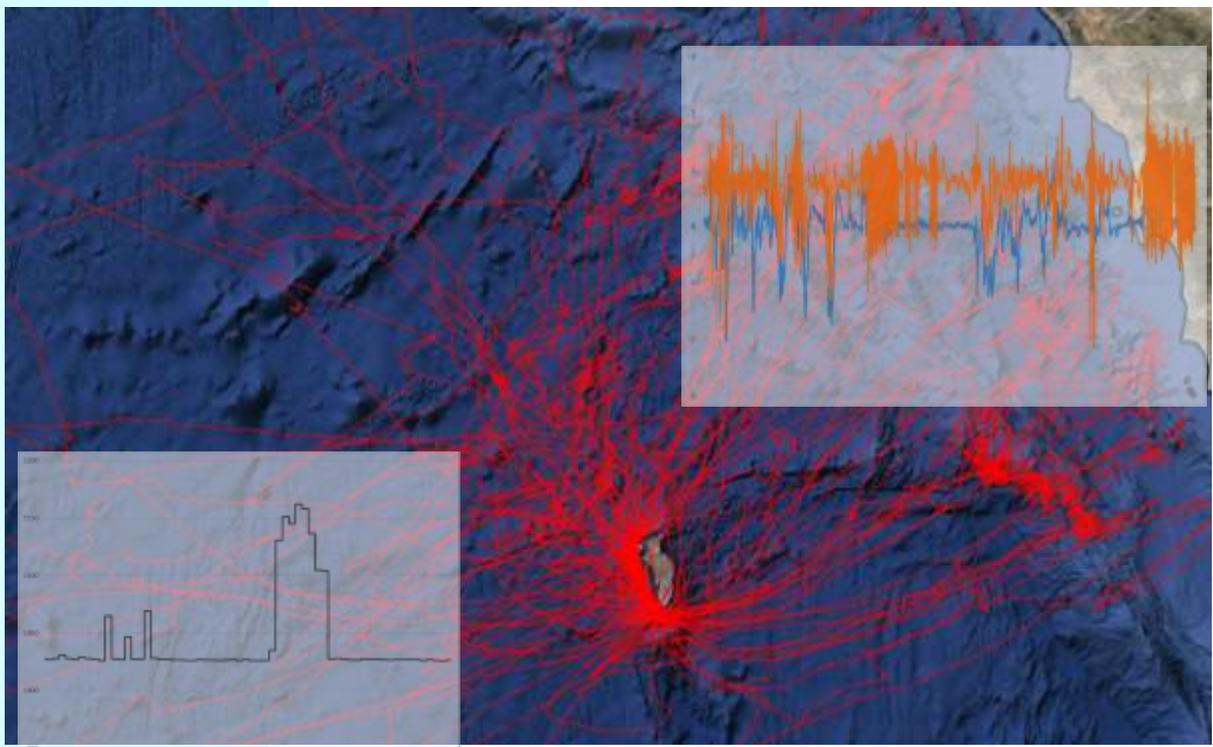# TechnoSmArt

Axy-Trek

Micro GPS and Accelerometer datalogger with temperature and pressure sensors and activity/inactivity logging for tracking free-moving animals

Operating manual

(Version 2.0, June 2018)

www.technosmart.eu

CONTENTS

1. System description

The **Axy-Trek** is a datalogger which includes a GPS, an accelerometer, and different sensors, allowing to measure also temperature and pressure, light or conductivity. It has been especially designed for tracking seabirds but has been successfully used to track terrestrial animals, providing new and interesting information about their movements and behaviour.
Due to its high sensitivity it performs well not only under clear view of the sky, but also under moderate to high coverage such as in wooded or urban areas.
The **Axy-Trek** communicates with a PC by means of a USB cable provided by Technosmart Europe SRL which usually works also as charging cable (unless non-rechargeable batteries are used).

1.0 What is what?

The **Axy-Trek** comes in different shapes and sizes, according to battery type and size, antenna model and set of sensors.
The most common version is the one with a pressure sensor and a ceramic antenna, ideal for seabirds (Fig. 1.1). In this version you can find a waterproof connector and on its side the pressure sensor.
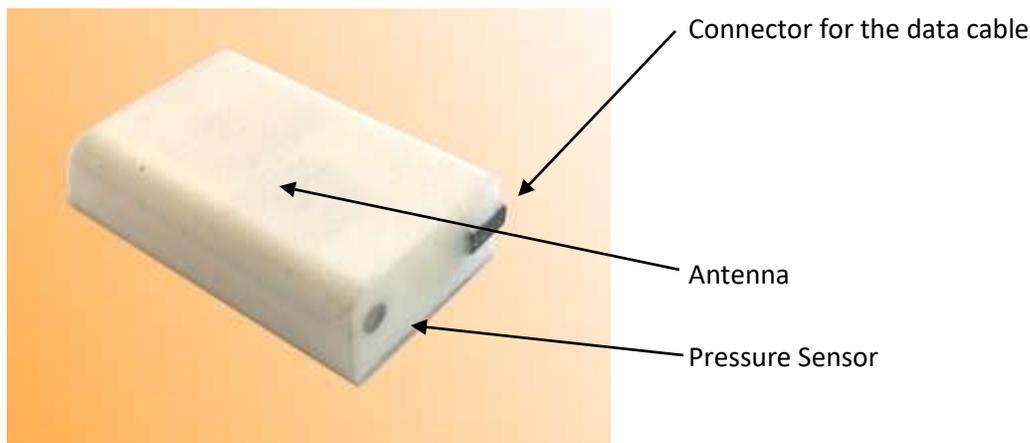

Fig. 1.1 Axy-Trek with ceramic antenna and pressure sensor

The antenna is fully encapsulated in the casing and is on the opposite side of the device with respect to the connector.

In the version with a whip antenna, on the other hand, the pressure sensor is on the same side of the antenna, opposite to the connector (Fig. 1.2).
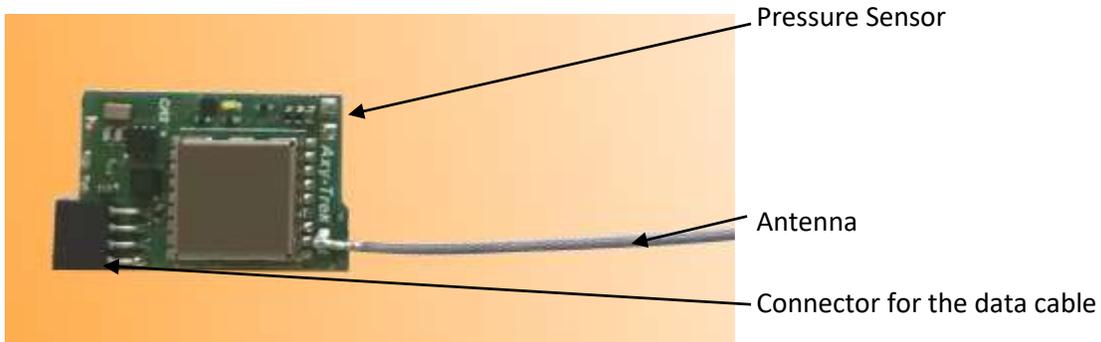
Pressure Sensor

Antenna

Connector for the data cable

Fig. 1.2 Axy trek with whip antenna

1.1 Software and drivers

The *Axy-Trek* works with the software **Axy Manager 2**, created and distributed by Technosmart Europe. It should be downloaded from our website, so please ask for username and password, if you do not have them already.
Please consider that Technosmart is updating both firmware and software regularly, so please contact Carlo at Technosmart (sales.carlo@technosmart.eu) before each field season to know if a new update for your loggers is available.

Axy Manager 2 works only under Windows operating systems, and the minimum operating system required is Windows 7. It can work with Apple computers emulating Windows 10 but it will require some extra configuration. If you are using an Apple device, please contact us.

1.2 Turning on/off the loggers

In order to turn the unit ON, swipe the magnet included in the parcel close to the connector. A white light indicator (LED) will start blinking once per second. During the first 20 seconds of blinking it is possible to connect to the *Axy-Trek*.
After this period the accelerometer will start to record at the frequency you selected (unless a start delay has been set). The GPS will start according to the schedule, and it will blink until it has collected the first GPS position.
Note: You can connect to the unit only in the first 20 seconds. If the GPS is scheduled to start with no delay, the device will continue blinking after the first 20 seconds, but connection will not be possible.
In earlier versions of the *Axy-Trek* all blinking stopped after the first 20 seconds.

To turn the logger OFF, swipe the magnet close to the connector. The white LED will be on for 1 second. After this second you need to move the magnet away very quickly. Essentially when the LED is on the magnet should be close to the unit, when the LED is off it should be away from it. The switching off is signaled by a long blink followed by fast blinking of the LED.

Note: In the first 20 seconds of blinking the unit will switch off after a single passage of the magnet.

1.3 Connecting to the Axy Manager 2 software

First of all, to be sure that the data cable is properly recognized by the software, click on "Scan ports" on the top left of the software window and select the COM port from the drop-down list. Usually on a Windows 10 system everything should work flawlessly. However, sometimes the data cable might not be recognized and you might read "no COM port available". This issue can be easily solved by downloading and installing the driver "USB Data Cable Driver (FTDI)" from our website, software section.

To connect to **Axy Manager 2** you should first insert the included data cable into the connector. The cable should be inserted with the LEDs on the same side (up) of the LEDs on the device. Inverting the cable will not cause any damage, but you will not be able to communicate with the device.

With the data cable plugged into the computer turn on the logger with the magnet and after 1-2 seconds click on "Connect". As the logger is correctly connected, you should see the main window of the manager populated with different values, such as model type, firmware version, battery level and unit name (Fig. 1.3). You can change unit name as you wish, using alphanumerical characters. At the bottom a memory bar indicates memory occupation, with blue and grey representing used and free space respectively.
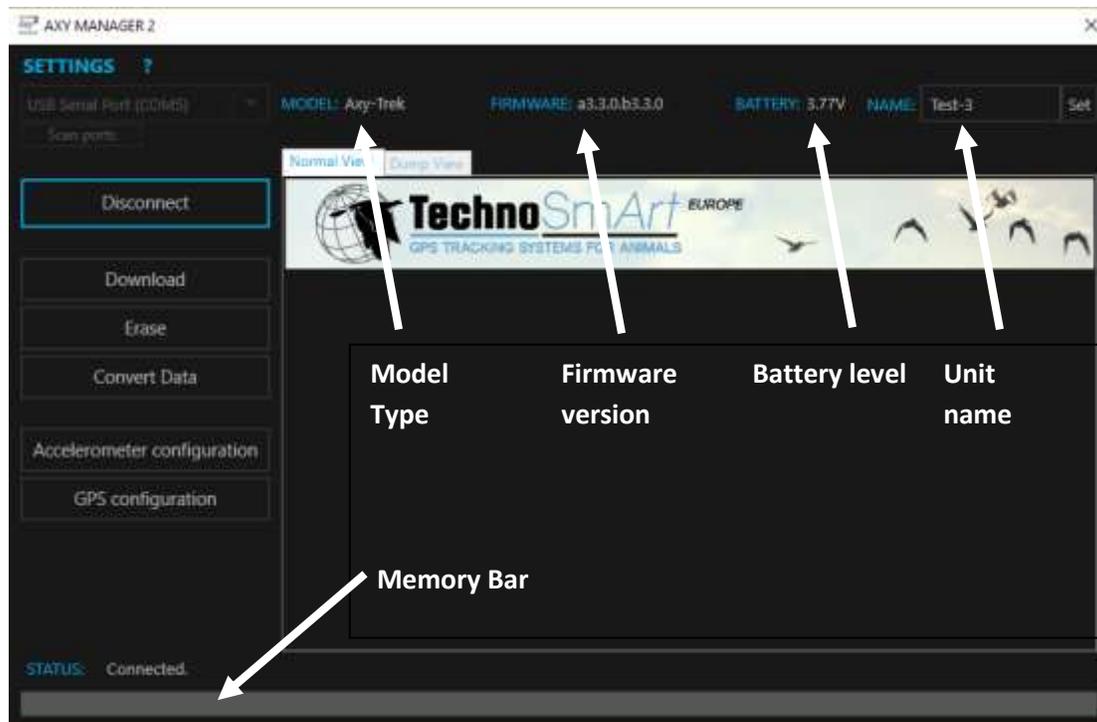

Fig. 1.3 main window of Axy Manager 2

Now you can start to configure your device according to your requirements!

2. GPS Configuration

When the GPS configuration window will open, it will show the last settings used for the GPS, not those present on the logger. To read those, please click on "Read settings".
To upload the settings to the GPS, please click on "Send settings".
You can also save the schedule and open the schedule by clicking on "File" on the top left of the GPS configuration window.

2.1 GPS working mode

There are six *working modes* characterized by different power consumption, accuracy, and recording intervals. Specifically:

1) **CONTINUOUS:** this mode provides the most accurate locations; positions are recorded at 1 fix/sec. However, this is also the most power-draining mode: consumption is about 20 mA.

2) **OFF:** when the module is turned OFF it enters a "sleep" condition in which its consumption is dramatically reduced to near zero (27 µA). No positions are stored; however, the unit is ready to enter another mode, following the schedule.

3) **Short periods:** this mode is suitable for intervals between 1 fix/sec and 1 fix/5 seconds. Positions are computed in a shorter time than in *continuous mode*, allowing energy to be saved but causing lower accuracy. Battery consumption is not constant and depends on satellite visibility. In areas with lower satellite visibility these modes might switch to *continuous mode* automatically and thus increase consumption.
Fix rate is not constant either, as if the GPS needs to go into *continuous mode* because of bad reception, data will be saved at 1Hz frequency. If set to 1 fix/sec (200 mms ON) the module will store data like in *continuous mode,* but power consumption and precision are lower (<9 mA).

4) **Long periods:** this mode allows for intervals ranging between 10 seconds and 20 minutes between fixes when low power consumption is required. The module remains in a sleep condition (OFF) until a programmed acquisition occurs. The acquisition usually requires between 1 to 10 seconds according to time interval and satellite visibility and power consumption is 4-14 mA depending on the interval between fixes.

5) **Very long periods:** this mode is similar to the previous one but has longer intervals, ranging between 30 min and 12 h, and is ideal for applications requiring very low power consumption.

6) **MultiFix:** this mode has been especially designed for applications that require very accurate positions. It takes 5, 10 or 15 fixes instead of 1 and by this increases

considerably the accuracy of the fix. While taking 1 fix every 10 minutes provides an accuracy of around 30 meters, for example, collecting 15 fixes every 10 minutes and averaging the last 5 fixes of the bout can provide an accuracy of only 2m in ideal conditions. This mode has a higher power consumption compared to its single fix relatives.

7) **Subsecond**: not yet implemented on **Axy-Trek**.

2.2 GPS time schedule

The **Axy-Trek** GPS can be programmed to switch between different working modes during the day, at defined hours. There are five recording intervals available during the day. For example, it is possible to configure the unit to collect data in *continuous mode* from 00:00 to 10:00, to stay *OFF* until midday, then to store 1 fix/h from 12:00 to 18:00, and finally to be *OFF* again from 18:00 to 24:00.

Important: the GPS works in UTC time, not local time, so check your time zone before setting the schedule!

Moreover, it is possible to program the unit also on a weekly basis, to perform a different task on specific days of the week and to repeat the task the week after.

If the weekly schedule is selected, seven tables, one for each day, are proposed. To manage the settings of a particular day, select the table relative to that day and perform the changes. Settings can be copied to the following day to facilitate the programming. Consider that the working day 1 is the day you turn on the device in UTC. So be careful if you turn it on around midnight in UTC time.

2.3 GPS acquisition settings

In the main GPS configuration window, you can click on the "Settings" tab to access advanced GPS settings and the configuration of the analog sensor (see below, par. 2.6 Analog sensor)

How does the GPS work, exactly?

When you turn on the device the GPS will start to search for satellites after 20 seconds. This acquisition phase has been set, as a default, to be no longer than 300 secs (5 mins, *Acquisition ON time*). In general, only 50 seconds are needed to acquire the signal and compute the first position. If a fix is not obtained within the *Acquisition ON Time*, the GPS module ends the search for satellites and enters a very low power state, the *Acquisition OFF Time*, which lasts by default 1800 secs (30 mins), before trying again to acquire the signal.

Note: Depending on the GSV settings (see below, par. 2.5 GSV thresholds), if GPS signal is low (for example the animal is in a burrow), the GPS might recognize very quickly that it will not take a position and will go to sleep after 20 seconds, to save battery. Therefore, in case of no sky visibility the GPS will not consider the *Acquisition ON Time* but will go to sleep after 20 seconds.

When a good position is finally computed, *Axy-Trek* starts the execution of the programmed schedule and will continue with it, unless the satellite signal is lost, in which case a new acquisition cycle is performed.

Both *Acquisition ON* and *OFF Time* are configurable by the user. However, consider that you should NEVER configure the *Acquisition ON Time* to be lower than 120 seconds.

Note 1: In this phase the accelerometer is recording anyway, even if no GPS fix has been recorded.

Note 2: It is very important for animals dwelling in burrows or being underwater frequently (penguins, cormorants etc.) to set up a proper *Acquisition OFF Time*. A too short period will cause high battery consumption because of repeated tries to obtain the fix. However, a too long period will cause the GPS to go to sleep most of the time if the animal is frequently underground (or under water), producing very limited fixes. If you are in doubt, contact us for further information and advice!

2.4 Delayed start

The *Axy-Trek* offers two options to delay the start of the recording.

The "minute" option works BEFORE the first fix. Thus, when you set a number of minutes and turn on the device, it will blink the first 20 seconds (the communication period) and then turn the LED off for the time set in start delay.

After this time has elapsed, the logger will start the acquisition phase as described in the previous chapter.

The "date" option works AFTER the first fix has been taken. Thus, when you turn the logger on it will take the first fix to set the actual date and time. After the first fix has been taken, the logger goes into a deep sleep phase, and turns on at midnight of the set day.

Note that in both cases the accelerometer will be off for all the delayed time.

2.5 GSV thresholds

The *Axy-Trek* uses a particular characteristic of GPS satellites, called GSV, in order to reduce power consumption when tracking animals that are often in dens or burrows. The GSV can be considered as the "strength" of satellite reception.

When trying to take a fix, the logger checks satellite strength (GSV value) and number after 20 and 40 seconds. If the GSV values (and number of satellites in view) are below the GSV Sum 1st or 2nd, at the given time, the logger will go into sleep mode, while if above it will continue looking for satellites. Clearly if the logger manages to take the fix before 20 seconds it will never check the GSV value.

The GSV is particularly convenient with animals living in burrows or dens as it allows to save battery by sensibly shortening the satellite searching time when the animal is in the den. Practically it avoids the logger to waste battery when reception is very bad.

The correct settings for the GSV values for "standard" species, living in a fairly open environment are

Satellites: 2

GSV Sum: 40
GSV Sum 1st: 20
GSV Sum 2nd: 40

Special Case 1: Forest species

If the species you are studying dwells in particularly closed environments (a forest or bush area) the logger might have difficulties in getting fixes as the GSV values might be too demanding. In these cases, please try lowering the GSV settings until you find what works best. In some case you might even need to set all values to 0 and use the "movement threshold" to save battery when the animal is stationary, instead.

Special case 2: Penguins and diving animals

In case you are studying species that spend most of their time underwater like penguins or seals, you should configure the *Acquisition OFF Time* and the GSV values in a special way. The *Acquisition OFF Time* should be set to 1, so that the logger will try to take a fix right after it goes into sleep mode. In this way, the logger is always ready to take fixes, when the animal comes out on the water surface. All GSV thresholds in this case should be lowered to 0, practically inactivating the GSV check.

To save battery when the animal is diving, you should use either the water switch or the analog sensor (see below, par. 2.6 Analog sensor).

If you are uncertain of the best settings for your loggers, please contact us and we will be very happy to help you!

2.6 Analog sensor

In **Axy-Trek** a number of different analog sensors could be added to the default ones. For example, you could add a light sensor or a conductivity sensor or a salt water switch.

All these work with an analog digital converter and are set in the advanced settings of the GPS configuration.

The analog sensor can disable the GPS if the value is above or below a certain threshold.

Note that the analog sensor output is not the real value of light (in lux) or conductivity, but rather the result of a comparison. Therefore, some calculation will be needed to extract the real value of light or conductivity you are interested in. This will be explained to you when you will purchase the loggers, but do not hesitate to contact us in case of doubts.

To determine the threshold you should use to stop the logger, you should simulate the environmental condition your logger is going to face, while enabling the logging of the analog sensor. Once you obtain these values, you can determine easily which value should be used as threshold to deactivate the GPS.

Once you determine this value (the raw one) you can select "stop GPS if <" or ">" (click on the symbol "<" to change it) and type the correct value. Now the analog sensor will stop the GPS once the sensor is above or below the chosen threshold.

3. Accelerometer configuration

The accelerometer configuration window will allow you to configure the accelerometer, the pressure/temperature sensors and also the activity/inactivity pattern. Furthermore, here you have also the possibility to activate the water switch to disable the GPS during long dives.

To send the accelerometer configuration, please click on the button "send configuration" at the bottom of the window.

Note: The values you see in the accelerometer configuration window are those found in the connected datalogger, not those used the last time, contrary to what happens for the GPS configuration.

3.1 Sample rate, G Fullscale and Resolution

Rate of sampling is usually the first thing to set when using an accelerometer.

Sampling frequency is the number of acceleration data the logger is taking every second. The frequency goes from 1 per second to 100 per second. This rate does not affect battery usage but only memory, so please make sure you have enough free space to save as much data as you wish (refer to us to know how long you can record).

The G Fullscale is the maximum value of acceleration you can record. So if you select 2, any movement with an acceleration above 2 is going to be saturated at 2.

We suggest using 2 only for very slow moving animals. In most cases 4 or 8 is to be preferred. For example, a seabird flying requires at least 4 but is preferable to use 8, so as for swimming penguins.

A plunge diving bird like a gannet/booby requires even 16g not to saturate the acceleration during the dive.

A medium sized mammal usually requires around 4g but again 8g might be better.

The best way to act, if possible, is to deploy the first device at 16g, check the maximum value of acceleration and then select the lowest G range possible which does not saturate the values. You could clearly always select 16g but remember that the lower the G range value is, the higher the resolution in acceleration will be.

There is also the option to increase the resolution of the data, from 8 to 10bits. Practically, with 10 bits you have 4 times higher resolution than at 8 bits. So if for example the fullscale 16g (ranging from -16g to +16g) is divided in 256 values at 8 bits, it will be divided in 1024 values at 10bits, increasing the resolution substantially. However, it will occupy 1/3 more memory. If memory is not limiting in your case, use 10 bits to have higher resolution.

3.2 Temperature and depth logging

The *Axy-Trek* can be configured to have a pressure and temperature sensor. Unfortunately, the temperature sensor is only available together with the pressure sensor.

This can be of two different types: a "Water sensor" which can withstand pressures up to 30 bars (300m underwater), and an "Air sensor" which can withstand only 10m depth but has a

much higher resolution in air (about 20cm). This second pressure sensor can be used therefore as an altimeter with very high resolution.

If you check the "Enable" option, the logger will record pressure and temperature data with the frequency selected in the box on the right ("1" means 1 per second, "2" means one every 2 seconds).

Note: The logger has no way of knowing if the pressure sensor is present but broken or not present at all. In either case if you enable the logging the logger will not start and will make a double blink once per second instead. In this case, if you don't have the pressure sensor, disable the logging. If you have it, it is unfortunately broken.

3.3 Movement threshold

The accelerometer on board allows to turn on/off the GPS when the animal is not active above a certain user-defined threshold.

In case you do not wish to use a movement threshold, set the left pane at 0, and the GPS will always be on.

The movement threshold calculates the mathematical module of the acceleration and checks if this is distant from 1 by a certain amount of g.

In the left pane of the "Movement threshold" section you will select how distant the module should be from 1 to activate the GPS. For example, if you select 2g (G fullscale) and 4 as movement threshold you will read a 0.0625g on the right. This means that the logger will turn on the GPS if the module of acceleration is above 1.0625g or below 0.9375g for a given amount of time (selected in seconds in the right pane). If you select 4g as fullscale this value doubles, so you might need to halve the movement threshold in order to keep the same amount of movement.

Usually 0.0625 is a good value to distinguish activity from inactivity for most animals. However, you could always deploy a first device without movement threshold and calculate the module of the acceleration during the activity periods.

3.4 Water-switch

The *Axy-Trek* has two possibilities to disable the GPS when an animal is underwater. One is the analog sensor with a conductivity sensor installed, as described previously. The default option, however, uses the pressure sensor, instead. Therefore it can be used only if a pressure sensor is present on the device.

If you enable the water-switch, the logger will calculate the pressure from the pressure sensor once per second and check if the animal is above or below 6m depth. If the animal is below 6 meters, the GPS is automatically disabled. If the animal is above, the GPS is activated.

4. File download and data conversion

Once you successfully retrieve your device after deployment, you will need to download and convert your data.

To download the data click on the "Download" button after having connected to the device (as described in par. 1.3 Connecting to the Axy Manager 2 software). A new window will open which will prompt you about file name and directory to save the file. The default name for the file is the name of the device set in "Device name" on the top right of the main window.

The button "Erase" will erase the memory of the datalogger.

<u>Note:</u> **If you erase the memory by mistake, turn off the logger immediately and send it to us, we can retrieve the data.**

4.1 Conversion preferences

Once you download the data, an .ard file is created, which can be converted to more useful formats.

In the conversion panel you have a number of options about the conversion format (date format, time format etc.). By default, pressure data is expressed in millibars, but in the case of a "Water" pressure sensor (see par. 3.2) it can be converted to meters under sea surface. For this conversion, the value of air pressure at sea level must be provided. This can be done by calculating median pressure in millibars from the data at hand. When dealing with animals that do not perform very deep dives, a slight error in air pressure at sea level might produce very inaccurate pressure values, therefore this method is not recommended.

Setting the "Start time" on the bottom right is not necessary if the **Axy-Trek** has successfully taken a GPS fix, as usual. It is only used as starting date-time in case the GPS has failed to take any position.

The files obtained from the conversion of the .ard file are:
- **text with all data (acceleration, GPS, and all other available sensors)** (.csv),
- **text with only GPS data** (.txt, optional)
- **kml with only GPS data** (.kml, optional)

Binary is the more compressed format containing all GPS data. Data in binary format are not to be viewed or edited with other software, as it is a proprietary format, but is very useful to store data on computers given its reduced size. Binary files can be converted with **Axy-Manager 2** into one of the other formats according to the parameters selected in the converting option panel.

Text .csv are text files, suitable for editing the data with *Excel, Word,* and importing into common software like R.

Specifically, from left to right the columns of the .csv indicate:
   1.   TagID: the name of the tag set in the main window.

2. Timestamp: the date and time as selected in the conversion panel.
3. X: acceleration x axis.
4. Y: acceleration Y axis.
5. Z: acceleration Z axis.
6. Activity: whether the animal was above or below the movement threshold and above or below the 6m threshold in depth.
7. Pressure: the pressure in mbar or depth.
8. Temperature: in Celsius degrees.
9. Location-lat: latitude (degrees, minutes & decimal).
10. Location-lon: longitude (degrees, minutes & decimal).
11. Height-above-msl: altitude (meters above Mean Sea Level).
12. Ground speed: real time speed of the device in km/h.
13. Satellite count: number of satellites used to take the fix.
14. Hdop: value of horizontal dilution of precision for that fix (to determine accuracy, lower values have higher accuracy).
15. Maximum-signal-strength: the value of satellite reception power, the highest the value the best the satellite reception. This is the GSV value.
16. Sensor raw: this is the value obtained from the analog sensor.
17. Battery Voltage: the voltage of the battery (if the option "Report battery informations" in the conversion settings is checked).

If the option "Fill empty fields with last known values" in the conversion settings is unchecked, cell values in the .csv file will be filled only for variables which are actually collecting data. This is relevant when using sensors at different frequencies. For example, if the accelerometer is working at 25 Hz and the GPS at 1 Hz, unchecking this setting will produce a .csv table that for each full line of data is followed by 24 lines with acceleration data and blank cells in every other column. Selecting the checkbox will instead copy every other cell value along the remaining 24 lines.

Text with only GPS data: this is the .txt file, which contains only GPS positions and everything related to them, such as speed, altitude, HDOP etc.

Kml file: this is a file which can be opened on Google Earth to quickly view your position data. Fixes are shown as single points on the map (markers) and connected with a line to show the trajectory. The markers are coloured from red to blue, with increasing speed, and bear information about altitude and time.

Note: All text files can be separated by either a comma, a semicolon or a tab. This can be selected in the settings of the main window of **Axy Manager 2.** There you can select "CSV separator" and determine how the columns are going to be separated.

4.2 Movebank Compatibility

As all Technosmart Europe dataloggers, **Axy-Trek** files can be imported into Movebank. You can import either the .csv or the .txt file. Consider however that .csv files are usually very large and therefore their importation can be very time consuming.

To create the files compatible to Movebank, please press the button "Movebank Compatibility" in the converting window (on top of the window).

5. Re-charging the batteries

Batteries can be recharged using the provided USB data cable.

IMPORTANT: Only LiPo batteries can be recharged. If you use a thionyl battery (those rounded like an AA battery) with a recharging cable, even if only for communicating, the battery MIGHT EXPLODE, representing a major hazard!!! **BE VERY CAREFUL!** If we gave you a cable that has a charger and you wish to use your GPS with thionyl batteries let us know and we will provide you a new cable without the charging electronics!

6. Troubleshooting

Although Technosmart Europe has always tried to provide the best devices possible, sometimes you might encounter some issue in the working of the **Axy-Trek**. These might be caused by hardware faults, software faults, or wrong settings by the user.

Here we will analyse the most common issues:

6.1 Software issues

1. ***No Com port in the Com list***: Probably the data cable has not been recognized properly by the computer. To solve this issue, install the driver "USB Data Cable Driver (FTDI)" which can be downloaded from our website, software section.

2. ***Unit not ready while connecting***: First of all be sure you are turning on the device properly and you are trying to connect in the first 30 seconds of blinking. If so, maybe the connector is a little bit loose. Try moving the connector a little bit, in order to improve the contact between the cable and the device. Let us know if that was the problem. If the problem persists, contact sales.carlo@technosmart.eu

3. ***The software crashes during GPS or Accelerometer configuration:*** There might be some mismatch between the firmware on the device and the software version. Please check that you have the latest software version installed. Check on our support page for updates.

4. ***Software crashes during downloading or conversion:*** Please contact us and let us know where exactly the software crashed (right at the beginning, at the end, always at the same point, or randomly), and we will try to solve the issue.

If the issue is during the conversion, please send us the .ard file so that we can check if everything is correct in the data.

If the issue is at the end of the downloading (while writing the .ard file), please select in the main program settings "keep MDP file after downloading" and send it to us.

5. **The downloaded file is different every time:** this issue has happened with Apple computers emulating Windows10 OS. In this case, in the main program settings select "Download speed" and then 1MBaud.

6.2 Hardware issues

These issues are recognized by a different blinking, or no blinking at all when you swipe the magnet. Most of them could be serious and we might need to replace the device, unfortunately. Some of them, however, can be fixed by the user as well.

1. **The logger does not blink at all:** This is the biggest problem, clearly. In the best case the battery is so discharged that it does not manage to power up the logger. Try first to recharge the battery for about one hour and see if this solves the problem. If not, contact us, and we will replace the logger.

2. **When starting, the logger makes a very strange blinking, and/or turns off immediately:** this is usually due to a low battery level. Try to recharge the battery first and let us know if this does not solve the issue.

3. **Upon starting the logger does a double blink once per second:** This might mean two things: low battery (but enough to start the logger) or no functioning pressure sensor. First of all, recharge the battery and see if this solves the problem. If not, the problem is due to a nonfunctioning or absent pressure sensor. If you do not have the pressure sensor, just uncheck "Temperature and depth sensor" in the accelerometer configuration. If you do have a pressure sensor, it is probably broken and this usually cannot be repaired. The good thing is that the data can be downloaded and most of it should be onboard. Contact us for the replacement of the logger. You can still use the logger with the pressure sensor disabled.

4. **The device when turned on has the white led turned on, which turns off after about 1 minute:** It has entered a bootloader mode, which is a special mode which usually reverts automatically. This happens when you touch the connector or plug in the cable right after turning on the logger. If this happens systematically without you touching the connector, we might need to replace the logger.

Axy-Trek data-logger – Operating Manual

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