

# USER MANUAL

## HAPEX NANO v3.0

### Table of Contents

I.	INTRODUCTION.....	2
II.	TECHNICAL SPECIFICATIONS: .....	2
III.	THE DEVICE .....	3
IV.	THE USER INTERFACE .....	3
A.	Installing the software .....	3
B.	Overview of the user interface .....	4
C.	COMMUNICATION panel: Establishing communication with the device .....	5
D.	DEVICE panel.....	5
E.	CONTROL panel: Start, Stop, Download. ....	5
F.	The NEW MISSION PARAMETER panel .....	6
G.	The STATUS panel .....	6
H.	REAL TIME data panel .....	6
I.	SUMMARY panel .....	6
V.	ZEROING and CALIBRATING the HAPEX.....	7
A.	ZERO .....	7
B.	CALIBRATION.....	7
C.	The reset Button .....	8
D.	A note about time stamps .....	9
E.	Interpreting the data.....	10

## I. INTRODUCTION

The HAPEX Nano is a real time passive Particulate Matter (PM) logger. It uses a light scattering sensor to measure the amount of light reflected by the particulate matter. This logger also senses tiny vibrations which allows it to track when the device is being worn.

The HAPEX Nano was designed specifically to study PM exposure such as that seen in household air pollution linked to the use of dirty fuel for cooking. It is meant to be used along with constant flow pumps and impactors (gravimetric method). Its small size and weight and its long run time allows for work with large sample sizes during long periods of time.

## II. TECHNICAL SPECIFICATIONS:

**Size:** 5cm\*7.5cm\*2.5cm or (2"\*3"\*1")

**Weight:** 100g (3.5 oz.)

**Interval between measures:** 20 seconds (2 seconds in calibration mode)

**Log rate:** 20 seconds to 1 hour (record the average of all sample measured between each log)

**Low Limit of detection (3 sample running average):** 5 µg/m<sup>3</sup>

**Low Limit of detection (individual sample):** 8 µg/m<sup>3</sup>

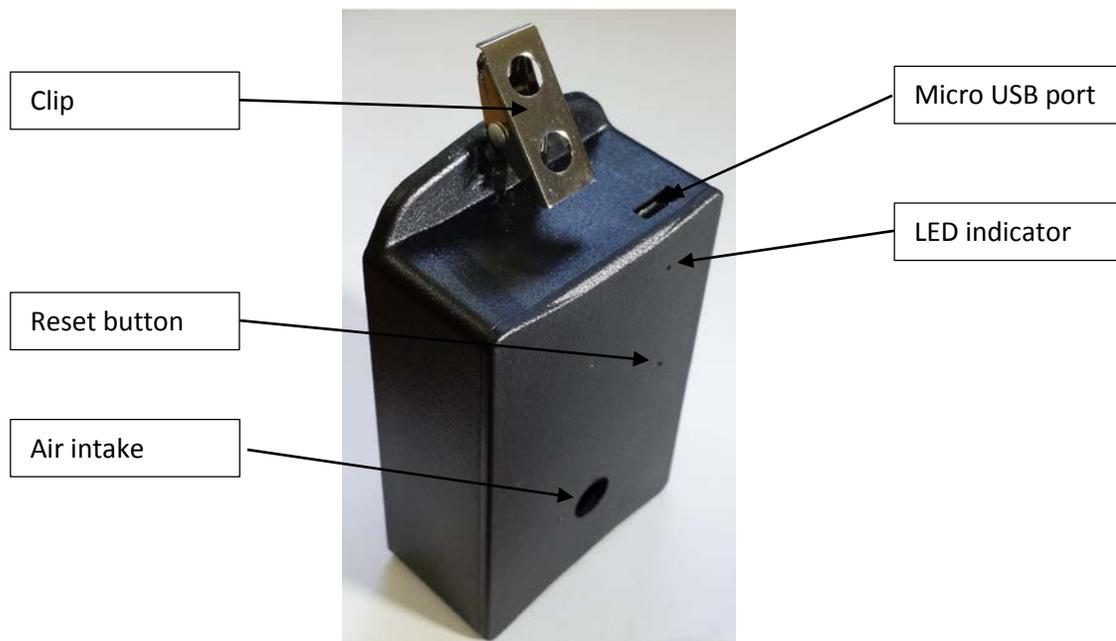
**High Limit of detection (high):** ~150 mg/m<sup>3</sup> (depend on the scattering coefficient)

**Maximum mission length:** 450 days.

**Battery run time:** 2 years (3,200,000 samples). Battery life may be extended by plugging an external battery.

**Maximum number of samples recorded:** 11,712

### III. THE DEVICE



### IV. THE USER INTERFACE

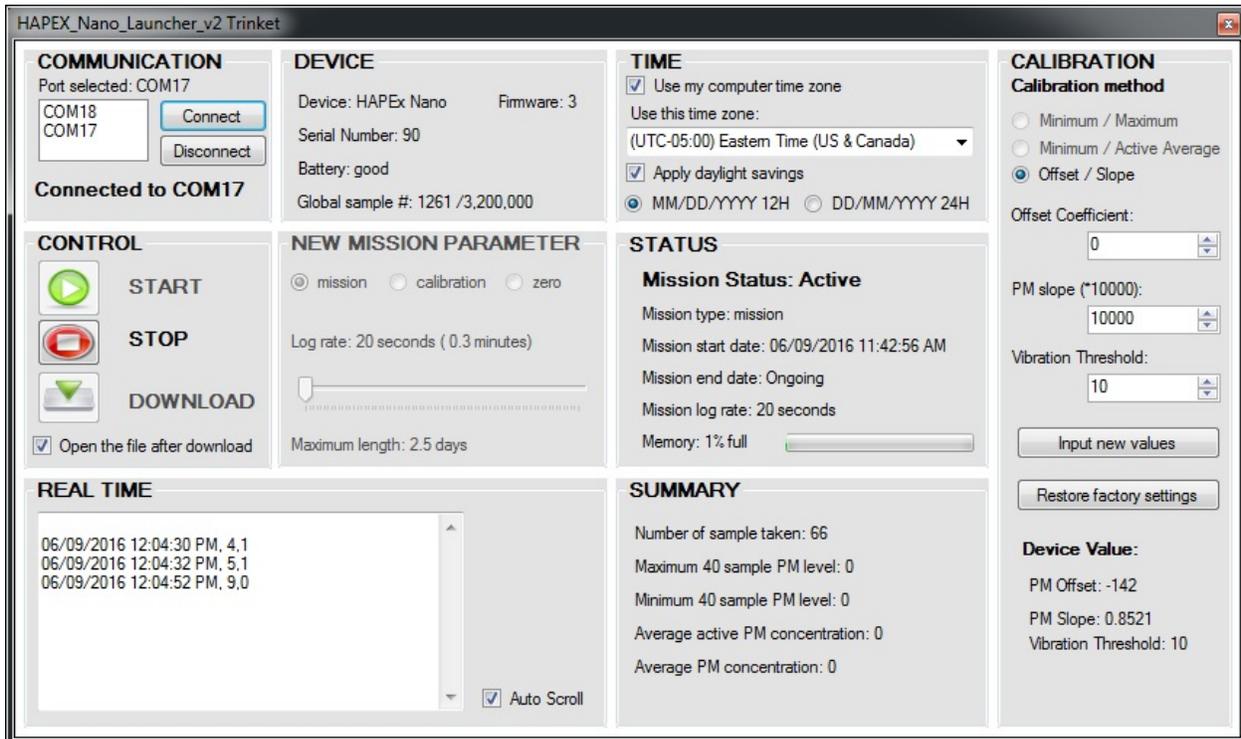
#### A. Installing the software

The HAPEX Nano launcher software is compatible with Windows 7, 8 and 10 (mac OS and linux OS are not supported). To install it just unzip the installation folder and double click on the “setup.exe” file.

MS Windows will automatically install the .NET framework 4.5 if it is not already on your PC (internet connection needed).

The communication cable is not just a classic USB cable. It has a FTDI chip inside and requires a driver that is automatically installed by MS Windows.

## B. Overview of the user interface



The user interface consists of one page divided in 9 modules:

- “Communication”: establishes the communication with the device hooked to the computer.
- “Device”: presents basic information about the device like its serial number, type, firmware version and battery level.
- “Time”: this module allow the user to set the time zone it want the time stamps displayed in and to choose the way date and time is displayed.
- “Control”: start/stop a mission and download the data.
- “New Mission Parameter”: sets the log rate and total length of a new mission or puts the device in calibration/zero mode
- “Status”: presents the status of the mission: ongoing/completed, start and stop date, log rate and state of the memory
- “Real time”: this window displays the data in real time after each new measurement when the HAPEX is connected to the computer.
- “Summary”: this module displays simple metrics like number of samples taken, minimum and maximum and average.
- “Calibration” this module allows changes to the calibration value stored inside the HAPEX to make sure that each device has the same sensitivity.

### C. COMMUNICATION panel: Establishing communication with the device

Use the communication cable to connect the HAPEX Nano to a USB port of your PC. A virtual port is created for each device connected to your computer.

The list of virtual ports available is displayed and refreshes regularly. Click on the right port and then press “connect”. The software will attempt to establish communication with the device. Once communication is established the other modules become available.

If you unplug the device and plug another one, you may press the “connect” button again to update the information displayed. A connection attempt is made automatically every 4 seconds.

If you want to free the port for other use without closing the application you can just press the “disconnect” button.

### D. DEVICE panel

This module displays basic information about the device connected: its type, the firmware version, the unique serial number, the battery level and the total number of sample taken.

The battery level information is based on the actual voltage measurement provided by the battery. It indicates if the battery level is high, moderate or low.

The total number of sample taken is a more precise indication of the remaining power available. HAPEX Nano is rated for 3,200,000 measurement. This is based on the average power consumption per measurement and the capacity of the battery. Factors like temperature may influence the actual number of sample that may be taken.

### E. CONTROL panel: Start, Stop, Download.

To **launch** a new mission simply click the start button. The mission logging rate can be changed by the sliding scale to the right. The total mission length is automatically displayed based on the log rate. The memory is erased before launching a new mission so be sure to download the information that is on the device first. The mission cannot be paused: once it is stopped a click on start will start a new mission, not resume the existing one.

**NB:** Even with longer logging rate the device always takes one measurement per 20 seconds. It then logs the average of those measurements based on the log rate. For example if the log rate is one minute, it will take one measure every 20 seconds and log the average of the last 3 samples every minute.

Once the mission is started, only the STOP button is enabled.

To **stop** a mission simply click on the STOP button. Once the mission is stopped the START and the DOWNLOAD button become available again. The status of the mission is also updated in the “Status” panel.

To **download** the data to your computer click the DOWNLOAD button. A progress bar appear to show the download. Most of the time the downloading process will be almost instantaneous. It can take up to a

couple of seconds when the memory is full. If the progress bar does freezes, cancel the download and try again.

A window will open for the user to input the file name and location. By default a HAPEX Nano folder is created in “My Documents” and a file name is generated with the serial number of the device and the date and time. The file created is a “.csv” file. These files can be opened by any table management software (including MS Excel).

The check box “Open file after Download” uses the default software to open the csv file after the download. You can change which software is associated to the csv file within MS Windows control panel.

#### F. The NEW MISSION PARAMETER panel

This panel sets the type of mission can be done and the log rate.

##### Mission type:

- mission: this is the classic mission mode that should be used by default. The sampling is fixed at 20 seconds and the logging can be changed to have mission last up to a 190 days.
- calibration: in this mode the HAPEX take one measurement every 2 seconds and log every measurement in its memory. So the memory will be full in about 6.5 hours. This mode is useful if you want recalibrate the HAPEX or if you need high resolution for a short amount of time.
- zero: in this mode the HAPEX will zero itself. Please consult the part on zeroing the HAPEX for more details. Unlike the other mode the zero does not erase the memory and does not log anything.

##### Log rate:

Up to 11,712 samples can be recorded on the device. The longer the log rate the longer the mission can last. Measurements are made every 20 seconds independently from the log rate.

The estimation of the total length of the mission is not very accurate. So it is good to allow for a 10% margin (for example set the mission length to 110 days is you want the mission to last at least 100 days).

The calibration and zero option sets the log rate to 2 seconds.

#### G. The STATUS panel

This module displays the status of the device, it lets the user know if there is an ongoing mission, its log rate, and the start and stop date. The start and stop date are always displayed in the user defined time zone (the default setting is the computer time zone).

The state of the memory is also displayed.

#### H. REAL TIME data panel

This window allows the user to see what the device is measuring in real time. The “auto-scroll” check box makes sure the latest data is always displayed.

#### I. SUMMARY panel

This panel displays basic metrics about the mission like the number of samples taken, the 64 sample maximum and minimum. It also displays the average concentration and the “active average” which is the

average concentration when the concentration is 50 units above the minimum. This section is updated in real time when there is an ongoing mission or is a summary of the completed mission stored in the device memory.

## V. ZEROING and CALIBRATING the HAPEX

Two parameters allow correction of the sensitivity of the devices: the offset and the slope parameters. They are used in the following equation:

$$PM\_calibrated = (PM\_raw + Offset) * Slope$$

The “zero” procedure allow to adjust the Offset parameter while the “calibration” procedure allows to change the Slope parameter (sensitivity).

All the HAPEX are factory calibrated against a reference device. But to maintain the best accuracy, we recommend that you **zero the HAPEX before each new sampling session** and that you **recalibrate them at least once per year**.

We designed the HAPEX so that those two operations may be performed very easily by the user with a limited set of equipment.

### A. ZERO

**We recommend to zero your device before each field session.**

A “zero” mission is a special kind of mission designed especially to zero the sensor; it adjusts the offset coefficient.

Follow the steps hereunder to zero your device:

- Set the preparation time needed (between 15 seconds and 5 minutes)
- Launch the zero mission.
- Place the device into a clean air environment.
- After the preparation time is over the device start averaging its reading during 2 minutes.
- At the end of the two minutes the device automatically sets its offset value to zero itself.

This method allows you to easily zero multiple device in a few minutes.

### B. CALIBRATION

**A yearly recalibration of the devices is recommended to make sure they have the same sensitivity.**

The “calibration” procedure allows to change the calibration parameter to ensure that each device has the same sensitivity.

You will need at least two units to perform a recalibration: a reference unit and one or more units that need to be recalibrated.

Follow the steps hereunder to calibrate your device:

- Start a “calibration” mission on each device
- Put your devices into the calibration chamber
- Wait a few minute to establish a background concentration
- Create smoke into the chamber (incense/wood chips)
- make sure the smoke is uniform by using a mixing fan
- after one or two minutes open the chamber so the particulate matter concentration level go down to their initial level
- stop the “calibration” missions
- read the “active average”, “maximum” and “minimum” value for your reference device
- connect the device you want to calibrate
- select one of the three calibration method in the interface (see details here under)
- Input the value from the reference device
- Press the “input new value” button
- The PM slope value should be updated accordingly.
- If you made a mistake you can press the “restore factory settings” button to restore factory settings.

Three methods are available to calibrate the devices: “Min/Max”, “Min/Average” or “Offset/Slope”.

The “offset/slope” method allows one to directly change Offset and Slope values. This method is for users that want to use their own adjustment method.

The “Min/Average” method is the recommended one. Simply write down the “Minimum 65 samples PM level” and the “Average active PM concentration” for the reference device and input this value in the device that you want to recalibrate. The software will automatically calculate the right slope coefficient for the device to match background and average of the reference device.

The “Min/Max” method works the same way but with the minimum and maximum instead.

**NB:** The calibration module is enabled only when a completed calibration mission has been logged on the device.

## VI. The reset Button

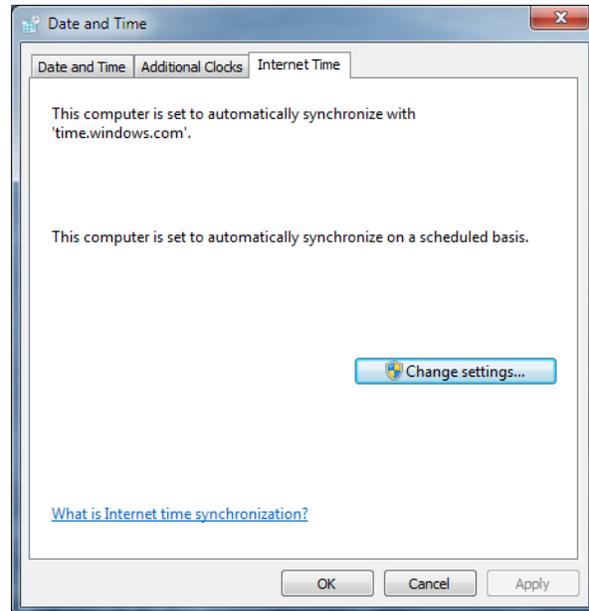
If for any reason the device become irresponsive you can try to press the reset button with a paper clip. A reset does not erase the memory inside the device. It just restart the micro controller. If that does not fix the problem the battery is probably too low for the device to operate correctly. The software has an auto-reset function to insure that the device will never freeze during a mission. If the logger starts to hang it will automatically reset itself after 8 seconds.

### *A note about time stamps*

The HAPEx Nano automatically synchronizes itself with your computer clock when you start or stop a mission. So if the time on your computer is not accurate it will create some issues.

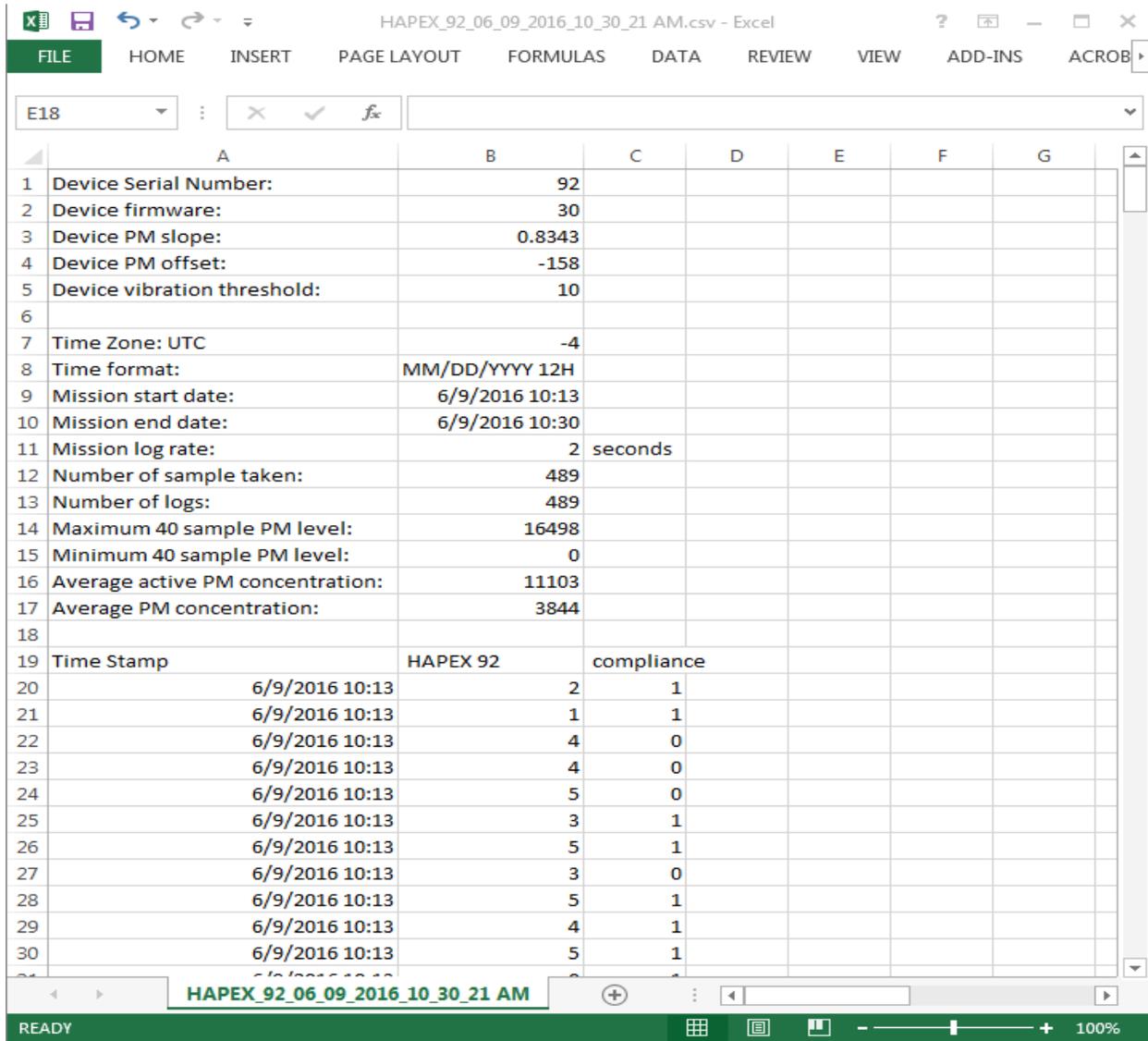
The time zone are taken into account and so it will not be a problem if the computer that start and the one that stop the device are not set on the same time zone.

To make sure you don't run into time stamps problem set your computer to automatically adjust its time through the internet (that is usually the default setting).



## VII. Interpreting the data

The file produced by the device is fairly straightforward. It looks like this:



The screenshot shows an Excel spreadsheet with the following data:

	A	B	C	D	E	F	G
1	Device Serial Number:	92					
2	Device firmware:	30					
3	Device PM slope:	0.8343					
4	Device PM offset:	-158					
5	Device vibration threshold:	10					
6							
7	Time Zone: UTC	-4					
8	Time format:	MM/DD/YYYY 12H					
9	Mission start date:	6/9/2016 10:13					
10	Mission end date:	6/9/2016 10:30					
11	Mission log rate:	2 seconds					
12	Number of sample taken:	489					
13	Number of logs:	489					
14	Maximum 40 sample PM level:	16498					
15	Minimum 40 sample PM level:	0					
16	Average active PM concentration:	11103					
17	Average PM concentration:	3844					
18							
19	Time Stamp	HAPEX 92	compliance				
20	6/9/2016 10:13	2	1				
21	6/9/2016 10:13	1	1				
22	6/9/2016 10:13	4	0				
23	6/9/2016 10:13	4	0				
24	6/9/2016 10:13	5	0				
25	6/9/2016 10:13	3	1				
26	6/9/2016 10:13	5	1				
27	6/9/2016 10:13	3	0				
28	6/9/2016 10:13	5	1				
29	6/9/2016 10:13	4	1				
30	6/9/2016 10:13	5	1				

For each time stamps two values are displayed: the concentration of PM2.5 and the “compliance”.

### Compliance

If compliance = 0 that means that the device was not worn. If compliance = 1 then the device was worn during the corresponding time period. When the average of multiple samples is logged then compliance is set to 1 only when 50% or more of samples measured showed some active movement.

### PM

The value of PM are unitless. To get a value of PM in mg/m<sup>3</sup> you need to multiply the raw signal by the Particulate Coefficient. This coefficient depends on the type of aerosol sampled. To measure the particulate coefficient you need to use a gravimetric system co-located with the HAPEX Nano.

The following equation may be used to measure PC:

$$PC = \frac{[avg\ PM\ concentration\ from\ gravimetric\ (\frac{mg}{m^3})]}{[avg\ PM\ concentration\ measured\ by\ HAPEx\ (unitless)]} \text{ in } (mg/m^3)/(raw\ HAPEx\ unit)$$

It is best if you can establish this coefficient for each household that is part of the study. For example the gravimetric system may be used during 24 hours along with the HAPEx while the HAPEx alone will sample for longer time period.

Alternatively, this coefficient may be determined on only a sub-sample of the household and then extrapolated for the other households. We recommend that at least 20% of the households have both the gravimetric and HAPEx measurement. In this case it is important to stratify the household per type of fuel used and to establish the particulate coefficient individually for each strata since the aerosol properties will change between different fuels.

Real time reading in mg/m<sup>3</sup> may then be calculated like that:

$$HAPEx\ PM\ reading\ (mg/m^3) = HAPEx\ raw\ readings\ (unitless) * PC$$