Ein Bild, das Kreis, Grafiken, Symbol, Stern enthält.

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Figur 1 Greenmobility@school logo

**AirScout User Manual**

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# AirScout – Measuring system for environmental parameters

The AirScout is a measuring system co-founded by the Erasmus+ program of the European Union. The development was done from October 2023 until March 2025 in cooperation with three schools:

* Gottlieb-Daimler-Schule 2 (Sindelfingen, Germany)
* HTBLuVA St. Pölten (St. Pölten, Austria)
* Lycée Technique d'Ettelbruck (Ettelbruck, Luxembourg)

The primary goal of the AirScout is to capture environmental measurements along a bike route by attaching a measuring box to a common bike.

The AirScout is a measuring system for environmental parameters. As the development was done by different schools with students having different skills, there are three final versions of the AirScout.

This version of the AirScout enables the following measurements:

* CO2
* CO
* NO2
* O3
* CH2O
* Fine dust 1 µm
* Fine dust 2,5 µm
* Fine dust 10 µm
* Temperature
* Humidity
* Air pressure
* VOC

In addition to these parameters the GPS-coordinates are measured. This allows that the measured values can be assigned to specific spot on a map.

Besides these measurements, a button is attached to mark a spot as especially dangerous for bike riders.

After taking the measurements the AirScout can be connected via WiFi to a server. When the data is uploaded, the measurements of this specific AirScout, of all AirScouts of a school or of all registered AirScouts can be displayed on a map.

# Procedure for receiving your own AirScout

The AirScout was developed as a rebuildable kit for schools and interested persons. The development and documentation were done for technically interested students to rebuild their own AirScout.

In order to build your own AirScout you can use the following chapters to gather information on requirements and the building steps.

# Requirements

## Skills

As this variant of the AirScout is a more advanced revision, the required skills are also more advanced.

* Soldering
* Working with advanced components
* Basic skills of working with microcontrollers and Linux (uploading and running programs)
* Working with a CNC machine

## Materials (Components)

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Price / pcs** | **Price total** | **Link** |
| Powerbank | 22,49€ | 22,49€ | https://www.reichelt.de/powerbank-li-po-20000-mah-4pw-pljbk1-nn-p306137.html?&trstct=pol\_3&nbc=1 |
| Cables to sensors and display | / | / |  |
| Raspberry Pi Zero 2w | 16,39€ | 16,39€ | [Raspberry Pi® Zero 2 W Raspberry Pi® Zero 2 W 512 MB 1 x 1.0 GHz kaufen (conrad.de)](https://www.conrad.de/de/p/raspberry-pi-zero-2-w-raspberry-pi-zero-2-w-512-mb-1-x-1-0-ghz-2482940.html) |
| BME688 | 7,65€ | 7,65€ | [BME 688: KI-Kombo-Sensor, Luftdruck - Luftfeuchtigkeit - Temp. - Gas bei reichelt elektronik](https://www.reichelt.de/ki-kombo-sensor-luftdruck-luftfeuchtigkeit-temp-gas-bme-688-p306044.html?&trstct=pos_0&nbc=1) |
| Multisensor ZPHS01B | 103€ | 103€ | [Multi-in-One-Sensormodul ZPHS01B](https://de.winsen-sensor.com/product/zphs01b.html) |
| GPS U-BLOX Cam-MQ8 | 38€ | 38€ | [CAM-M8Q-Breakout Multi GNSS Modul (GPS, QZSS, GLONASS, BeiDou, Galile](https://shop.watterott.com/CAM-M8Q-Breakout-Multi-GNSS-Modul-GPS-QZSS-GLONASS-BeiDou-Galileo?gad_source=1&gbraid=0AAAAADjcXpCBbRtuV990LKvmW7pg3XYy_&gclid=EAIaIQobChMIhcybzrmxigMV5BEGAB2qOgrNEAQYByABEgIExPD_BwE) |
| DEPO Epa 1.54 (E-Ink Display | 18,80€ | 18,80€ | [DEBO EPA 1.54: Entwicklerboards - Display ePaper, 1,54", schwarz - weiß bei reichelt elektronik](https://www.reichelt.de/entwicklerboards-display-epaper-1-54-schwarz-weiss-debo-epa-1-54-p224225.html?&nbc=1) |
| Short, angled micro usb Kabel | 4,99€ | 4,99€ | [PAXO 0,3m Nylon Micro USB Kabel schwarz, 90 Grad Winkelstecker, USB auf Mikro USB Ladekabel, Datenkabel, Ladekabel, USB 2.0 : Amazon.de: Computer & Zubehör](https://www.amazon.de/PAXO-schwarz-Winkelstecker-Ladekabel-Datenkabel/dp/B0B6YWZ7WF/ref=asc_df_B0B6YWZ7WF/?tag=googshopde-21&linkCode=df0&hvadid=634132199969&hvpos=&hvnetw=g&hvrand=9227996498515329725&hvpone=&hvptwo=&hvqmt=&hvdev=m&hvdvcmdl=&hvlocint=&hvlocphy=9042244&hvtargid=pla-1966968021985&mcid=4a11acbe1d7b30fc96a17b654549c0d4&th=1) |
| WIPPE 1800.1108 | 4,90€ | 24,50€ | <https://www.reichelt.de/de/de/shop/produkt/wippschalter_1x_aus_gruen_beleuchtet-108231?nbc=1&q=%2Fwippschalter-1x-aus-gruen-beleuchtet-wippe-1800-1108-p108231.html> |
| Resistor  3x10kΩ  1x1kΩ | 0,05€  0,03€ | 0,53 € | [Yageo MF0207F10KH MF0207FTE52-10K Metallschicht-Widerstand 10 kΩ axial bedrahtet 0207 0.6 W 1 % 1 St. kaufen](https://www.conrad.de/de/p/yageo-mf0207f10kh-mf0207fte52-10k-metallschicht-widerstand-10-k-axial-bedrahtet-0207-0-6-w-1-1-st-1417569.html)  [Weltron 405256 Kohleschicht-Widerstand 1 kΩ axial bedrahtet 0411 0.5 W 5 % 1 St. kaufen](https://www.conrad.de/de/p/weltron-405256-kohleschicht-widerstand-1-k-axial-bedrahtet-0411-0-5-w-5-1-st-405256.html) |
| Total Price | | 236,35€ |  |

## Materials Box

|  |
| --- |
| Acrylic glass |
| Wood (thickness: 3mm) |
| Outdoor Glue |
| Foam rubber300mm x 300mm x 5mm |
| Klickfix Handlebar adapter Link |
| Hex-screws DIN 439 |
| Countersunk-screw (ISO 10642) |

## Devices

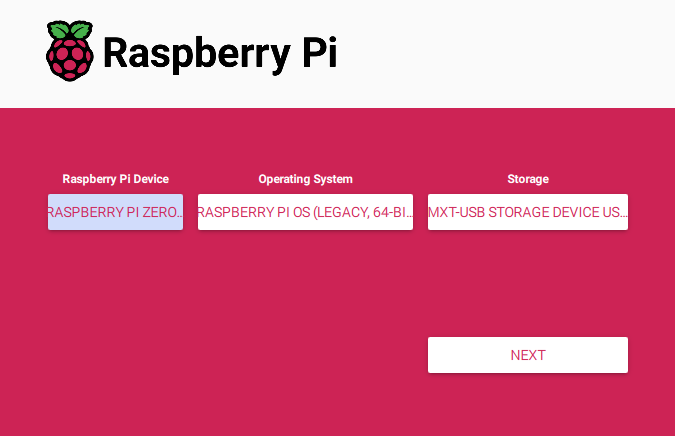
|  |
| --- |
| Soldering Iron |
| PC or Laptop |
| Laser Cutter |
| (D:2mm) Drill |
| Screwdrivers, Pliers |
| Equipment for SMD-soldering |

# Software installation

## Step 1: Install the operating system to the SD Card

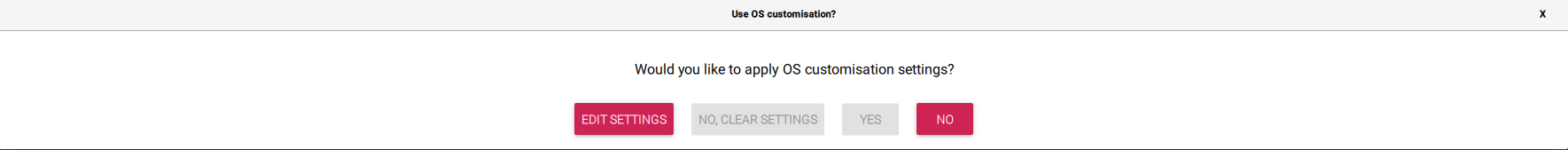
Download the Raspberry Pi Imager from <https://www.raspberrypi.com/software/> and start the program.

Insert the micro SD card into the Computer. Select the corresponding model of the Raspberry Pi, in this case the Raspberry Pi Zero 2 W. Choose the operating system Raspberry Pi OS (Legacy, 64-Bit) Lite, you can find it under Raspberry Pi OS (other). Then choose your SD card and click on continue.



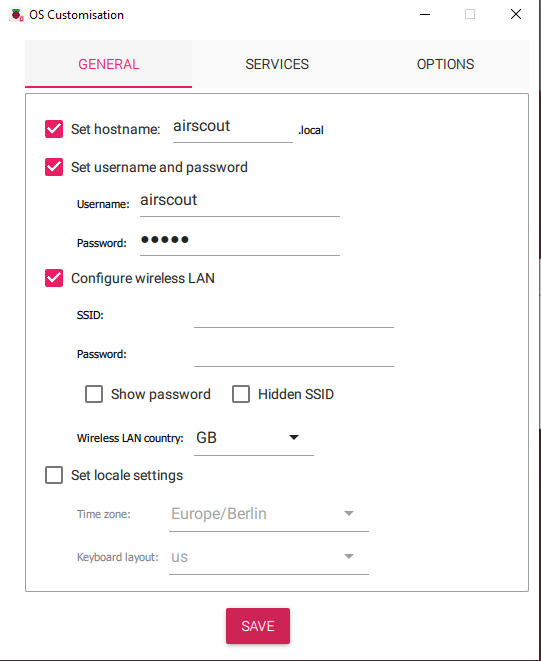
Figur 2 Raspberry Pi imager

**Click on change settings.**



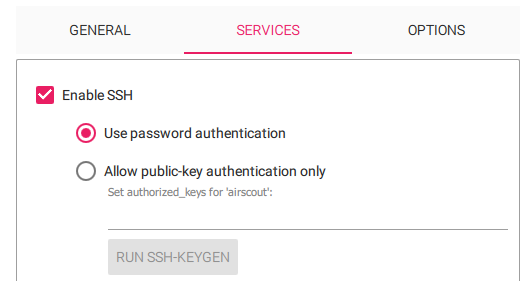
Figur 3 Raspberry Pi conformation window

Choose hostname, username, password and the Wi-Fi you are connected to. Note or remember the login data as you will need it later.



Figur 4 imager settings

Also make sure SSH is active like so:



Figur 5 imager settings SSH

Click on save to use your settings.

After this click on **yes**, to write the OS to the SD card. **hzgt**

Figur 6 write data to SD

Once the SD card is ready, you can take it out, and put it into the Raspberry Pi.

Boot up the Raspberry Pi by connecting it to power (USB), and wait a few minutes, because it takes some time at first bootup.

## Step 2: Install software on the Raspberry Pi via Remote Shell

When your Raspberry Pi is booted up, you can connect to it via remote shell (ssh).

For this open a console on your computer (e.g. PowerShell).

Type *ssh <username>@<hostname>.local* and hit enter. (Make sure you use the same username and hostname you chose in the first step and replace *<username>* and *<hostname>.*)

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Automatisch generierte Beschreibung**

Figur 7 connect via SSH

Answer the question with yes and hit enter.

**Ein Bild, das Text, Screenshot, Schrift enthält.

Automatisch generierte Beschreibung**

Figur 8 SSH password

Type in the password you chose in Step 1 and hit enter. (You will not see the password while typing.)

**Ein Bild, das Text, Screenshot, Schrift enthält.

Automatisch generierte Beschreibung**

Figur 9 connection successful

If you see this, the connection was successful and you can start installing software and controlling the Raspberry Pi.

First type *sudo apt update* and hit enter.

When the update has finished, install git using the following command: *sudo apt install git -y*

After this you can download the AirScout code with this command: *git clone* [*https://* *github.com/jipi3001/AirScout*](https://github.com/DO9KO/AirScout.git)*-main*

The code is now in the ~/AirScout Directory, you can move there with this command: *cd AirScout-main*

Install everything needed to run (Python Library’s, Database) with this command:

*sudo bash install.sh*

Before running the code, you have to activate the serial port with this command *sudo raspi-config*

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Automatisch generierte Beschreibung***

Figur 10 interface options

Move to Interface Options with the arrow key and hit enter.

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Automatisch generierte Beschreibung***

Figur 11 serial port

Then move to Serial Port and hit enter.

**Ein Bild, das Text, Screenshot, Display, Schrift enthält.

Automatisch generierte Beschreibung**

Figur 12 disable shell over serial

Answer with **No**.

**Ein Bild, das Text, Screenshot, Display, Software enthält.

Automatisch generierte Beschreibung**

Figur 13 enable serial port

Then with yes, OK and Finish. If you are asked to reboot say **yes**.

The Raspberry Pi should reboot automatically, so you have to connect again with

*ssh <username>@<hostname>.local*

## How to execute script on boot:

Open the cmd and connect to Pi using ssh airscout@airscout.

**Execute following commands:**

* sudo systemctl enable rc-local
* sudo chmod +x /etc/rc.local
* sudo nano /etc/rc.local
* add the line "(sleep 10; /usr/bin/python3 /home/pi/myscript.py) &" before the exit 0

**It should look as following:**

#!/bin/bash

(sleep 10; /usr/bin/python3 /home/pi/myscript.py) &

exit 0

Make sure #!/bin/bash is at the top.

Ensure & is at the end to run it in the background.

Don’t remove exit 0.

Save and exit (CTRL + X, Y, ENTER).

If you want to stop the process manually:

* ps aux | grep main.py

(output should look similar to this:

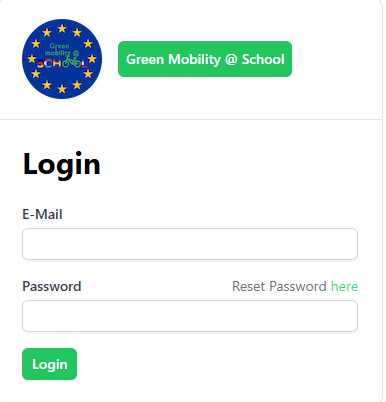
root 704 2.1 4.6 329776 19880 ? Sl 09:53 0:01 /usr/bin/python3 /home/airscout/AirScout-main/main.py

the first number (in this case 704) is your process ID

to end the process execute:

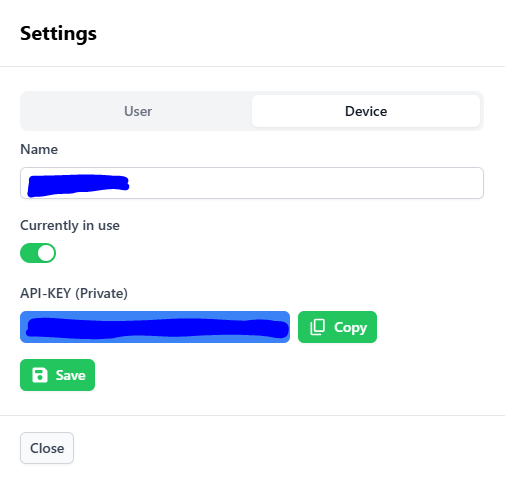
* sudo kill 704

## Connecting to database



Figur 14 website login

For the following steps you have to acquire your own account detail from your contact at the Austrian school HTL St. Pölten. After receiving those you can go to the website (gm4s.eu/login) to log in with the provided email and password to be able to upload your measured data.

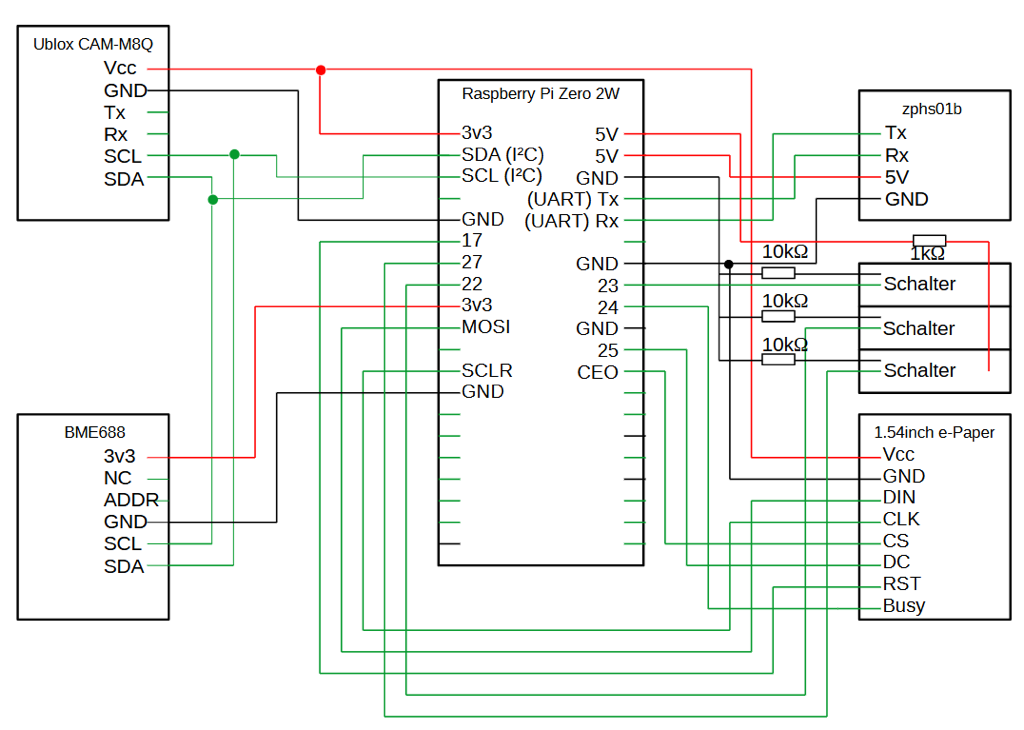


Figur 15 API key location

After gaining access to the website, you need to get your API key, which is located in the settings under "Device". This API key must be inserted into the code where the comments say so.

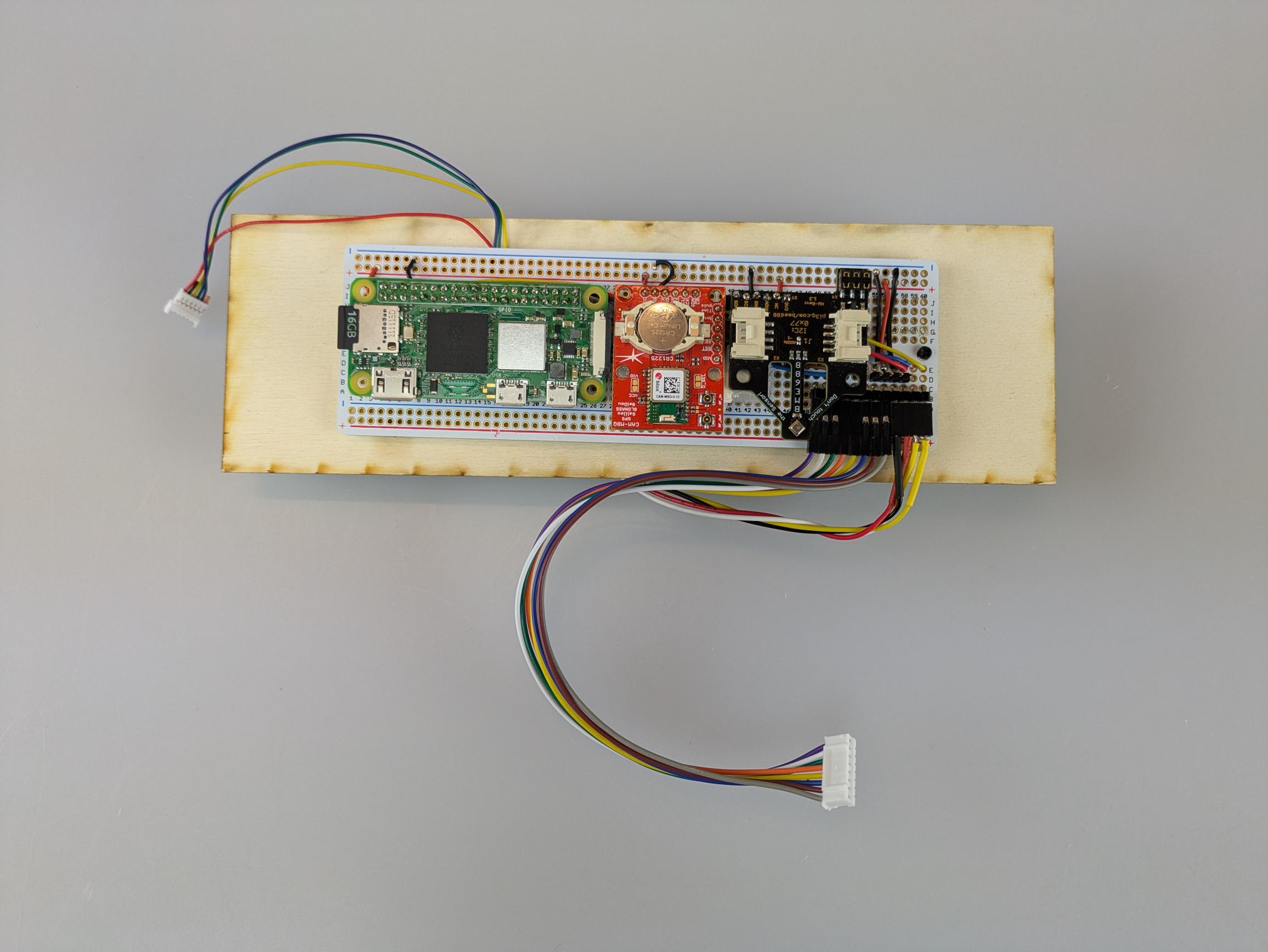
# Circuit

Connect the electrical components as shown in schematic below.

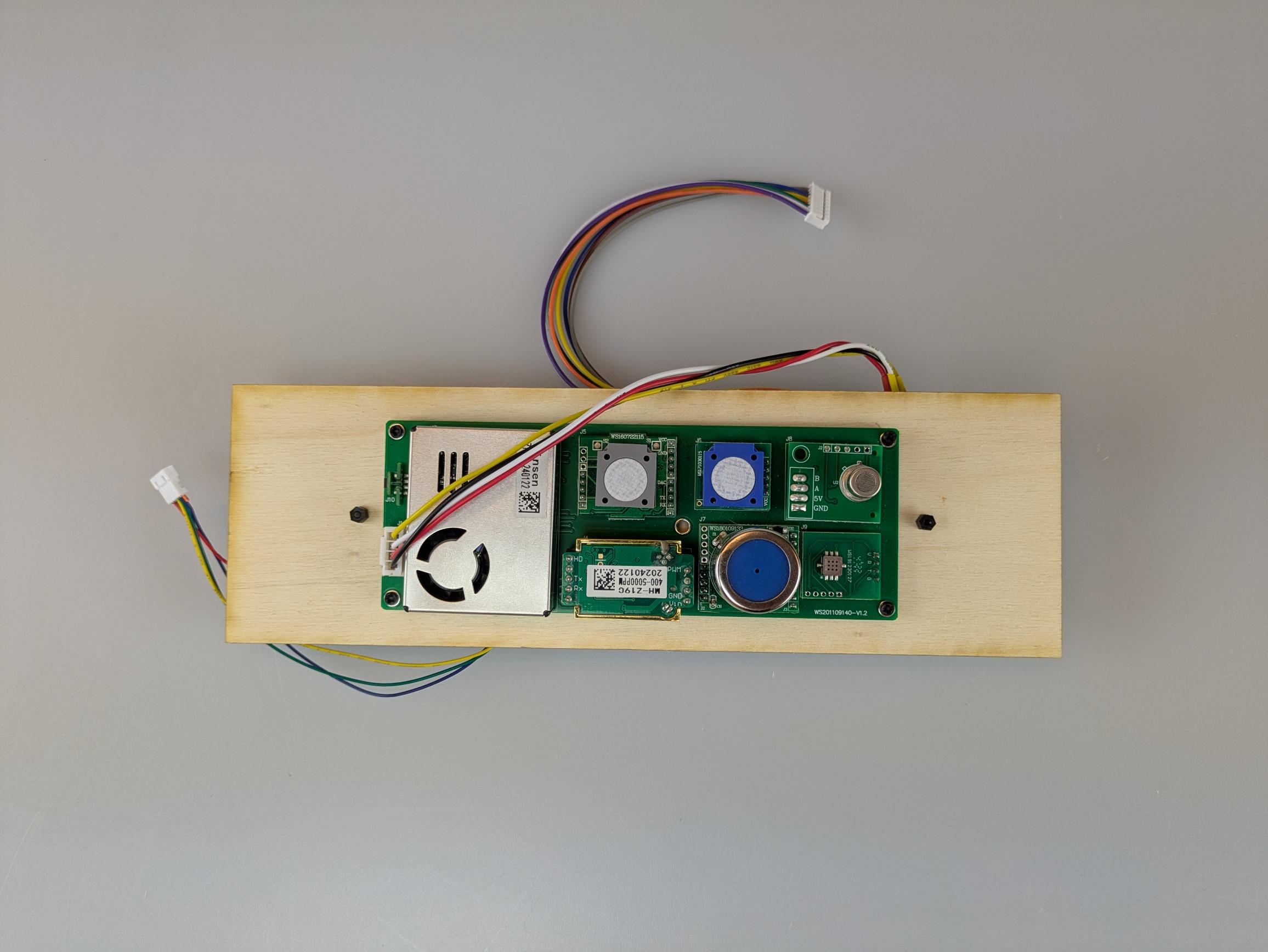


Figur 16 AirScout electrical schematic

It is possible to connect the components directly to the Raspberry Pi using wires. For a more permanent solution it is possible to solder the components on a perfboard, like shown in the pictures below.



Figur 17 circuit board backside with components

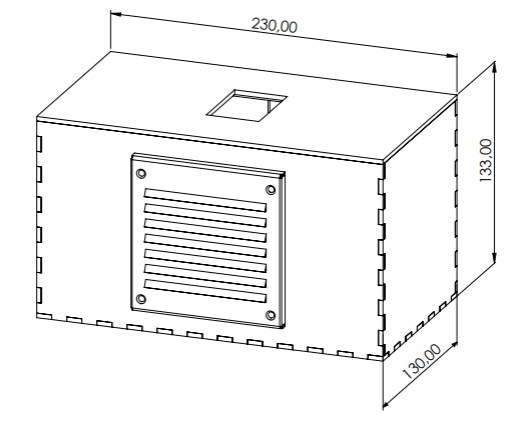


Figur 18 circuit board frontside with components

# Case

## Box

First, a wooden box measuring 23 x 13 x 13.6 cm with a wood thickness of 0.3 cm was cut using a laser cutter and then assembled.



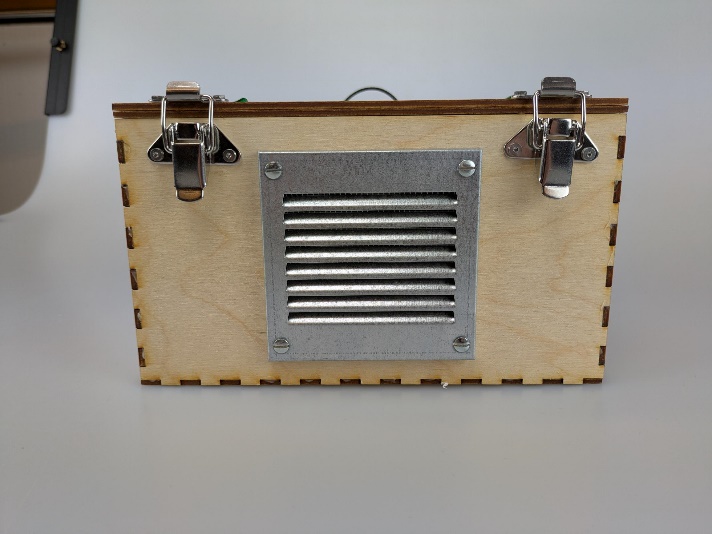
Figur 19 box 3D

To ensure stability, small interlocking joints (as deep as the wood’s thickness) were cut along the edges of the box, allowing the sides to be securely connected. However, the edge where the lid sits was left smooth.



Figur 20 interlocked joints

On one of the longer sides (the one facing forward), a large hole was cut to allow air to flow into the box. Then a metal grid was screwed over the opening to prevent rainwater from entering the box.



Figur 21 box front side

Next, two rails were cut and glued inside the box on both sides. These rails ensure that the sensor mounting plate can slide in and out oft he box smoothly.

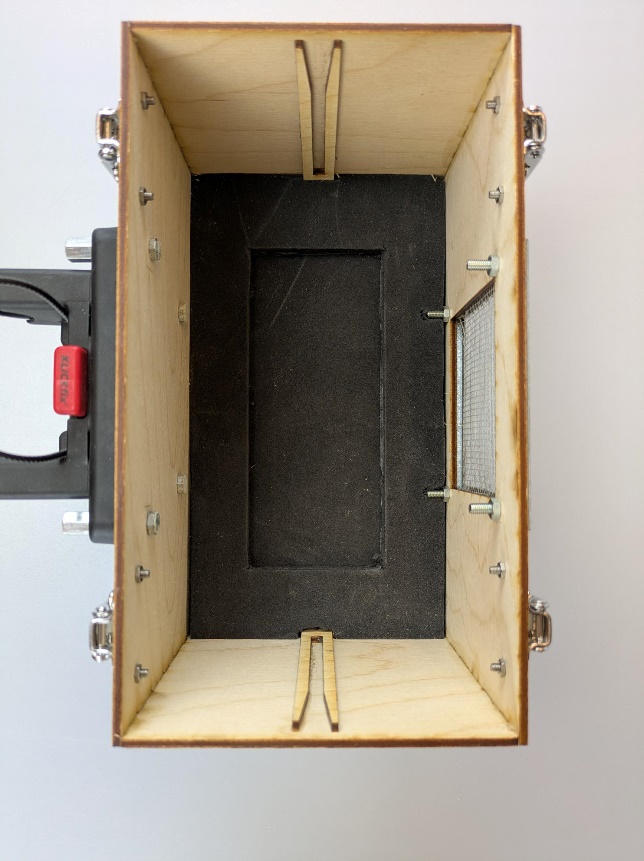


Figur 22 box rails

• Inside the box, we glued two layers of foam rubber

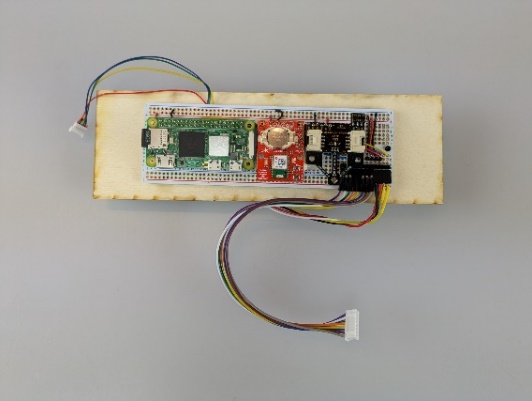
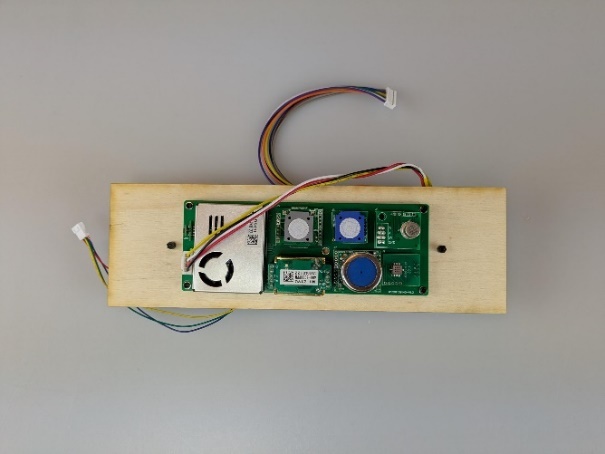
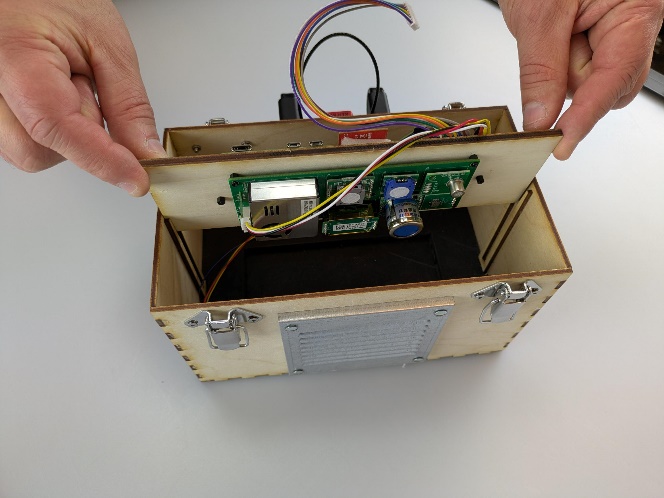
• The bottom layer was used to fully pad the base of the box.

• The second layer was used to secure the power bank by cutting a hole with the exact size of the power bank, ensuring it stays in place.



Figur 23 rubber pads inside

All the electronics were mounted onto this sensor plate, the sensors on one side facing the metal grid and the Raspberry Pi on the other side.



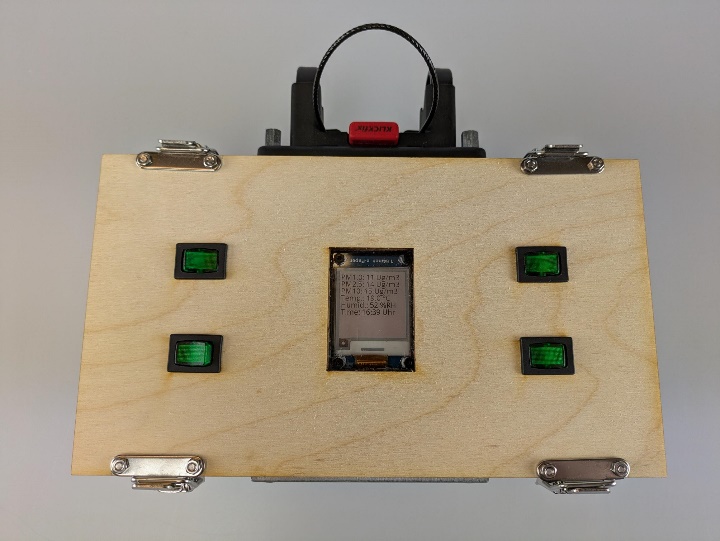
Figur 24 sensor plate front and back

## Lid Construction

The lid consists of three wooden layers:

• The two top layer rest on the edges of the box and are glued together to ensure stability and make room for the Countersunk-screw.

• They have a 3.5 x 5 cm hole in the center, positioned upright along the longer side. This is essential to make the LCD display readable from a bicycle.



Figur 25 lid top view

• 8 holes are drilled into the 2 big plates with Countersunk-screws to later attach hinges. Additionally another 8 holes have to be drilled into the case to attach the other part of the hinges.

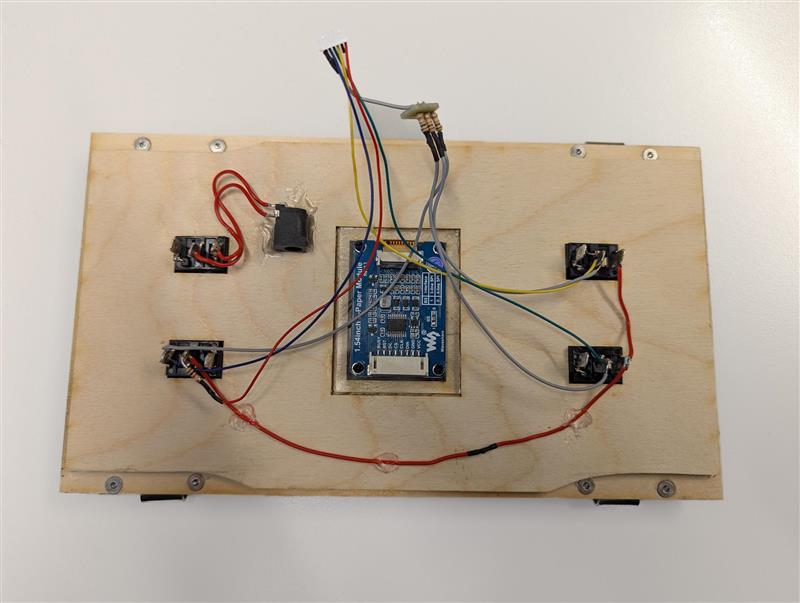


Figur 26 hinges

• The third wooden plate is 0.3 centimeters smaller on all sides and fits inside the box, ensuring that the lid stays in place when the three layers are glued together.

• Additionally, the hole for the LCD display is slightly larger so that a plexiglass sheet can be glued into it to protect the display.

•side note: On the picture you can see two connectors (the black for power and the white one for data) which allow you to remove the lid completely. This is not necessary however makes usage a bit more simple



Figur 27 LCD display inside

• To attach the Klickfix Handlebar adapter Link 4 holes have to be drilled



Figur 28 holes handelbar

# Switches

## ON/OFF switch

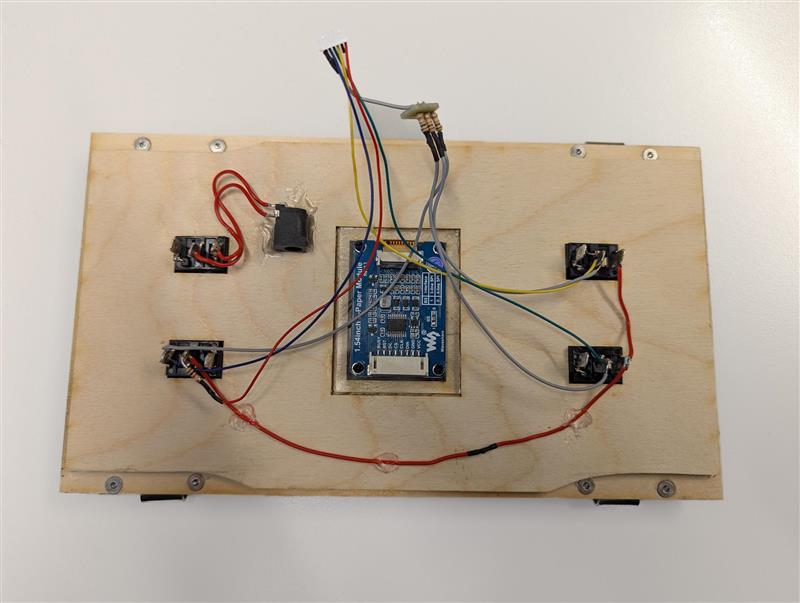
To make a physical on/off switch we made an alteration to the USB cable between the power bank and the Raspberry Pi. Here is how to do it:

1. Cut the USB cable in half
2. Remove the insulation on the small red and black wires inside the USB cable (the other wires can be ignored because they are used for data transfer which is not needed in this case)
3. Make sure to put on heat shrink before the following steps to insulate everything properly!
4. Solder a switch in between the red wire end with an extension
5. Reconnect the black cable with a wire extension

After completing all the previous steps the power should be cut off once flipping the switch.

## Control switches

To control the different settings on the AirScout there are three different switches connected to the Raspberry Pi. Wire them according to the wiring diagram above, it should look similar to this picture.



Figur 29 lid inside view

## Connection to lid

Every GPIO Pin needs to be connected with one female exit cable. The Switches put in the lid need to be connected with a male entry cable. Whilst connecting the Switches you need to only connect two Switch pins because one is for a lamp inside the Switch which wont be used. After connecting all the GPIO pins to the female exit cable and all the Switch pins to the male entry cable (Like in the wiring diagram and the picture above)

# Use

To control the AirScout connect via ssh (ssh <username>@<hostname>.local).

When entering your previously set password you won’t see what you are typing.

## Connecting to WiFi

You can connect to wifi using the *sudo raspi-config command. (sudo raspi-config nonint do\_wifi\_ssid\_passphrase myssid mypassphrase)* Make sure to replace myssid with your wifi name and mypasphrase withyour wifi password.

## ON/OFF switch

The ON/OFF switch turns the Airscout physically on and off.

## GPS

Switches between the script with and without GPS so measurements can be done indoors.

The GPS module usually nedds around 15min to establish a connection.

When being in an environment without good GPS reception, we recommend using the

no-GPS switch. When doing so, you have to enter the desired coordinates in the main script line 33-34.

## Switching information on the display

The switch switches between the two faces of the display to show different information.

## Sending/Saving data

The switch starts and ends the measurements. When turned on a measurement is being done every 30 seconds and saved into a file and will be later uploaded to the gm4s website when connected to WiFi.

## Charging the device

To charge the device, simply remove the power bank from the box and connect it to a power supply unit for charging, using a USB C or micro USB plug.

# Troubleshooting

## No WiFi connection (connection over ssh not possible)

Make sure that the Wi-Fi network configured is available. Make sure the controlling computer is connected to the same Wi-Fi network.

## No measurements?

Make sure the Raspberry Pi is connected to power. (Indicated by green LED.) Make sure all electrical components are connected correctly. Make sure to be outside for some time, because the GPS Signal is too weak indoors. Make sure the program is running.

## More help

For Raspberry Pi: <https://www.raspberrypi.com/documentation/>

Source Code: <https://github.com/jipi3001/AirScout-main>

If you encounter unusual problems or bugs, feel free to contact the development team.

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