



CARE CITIZEN

Onboarding Instructions

Introduction

CARE Citizen is a project that develops an air quality monitoring system consisting of an open hardware node and a cloud platform in order to increase the number of data points by encouraging the general public to be a data contributor through citizen science.

This page contains the build instructions for the CARE Citizen node which measures Relative Humidity and Temperature (RH/T), PM2.5, PM10, and CO₂. The data gathered is sent to the CARE Citizen platform which stores the data and allows it to be visualized on a dashboard with charts and maps. This project abides by the open hardware principle as such the schematic, firmware, and 3D mounting files, etc. are freely available for the public.

Equipment and Components Needed

As seen in the table below is the equipment needed for the project:

Equipment	Description
Computer or Laptop	A Windows, Linux, or Mac computer to install Arduino IDE for uploading of firmware onto the microcontroller
Soldering iron & Solder	To solder header pins
Power drill	To drill holes onto the off-the-shelf enclosure
Screwdriver	To screw the enclosure, mounting, and PCB

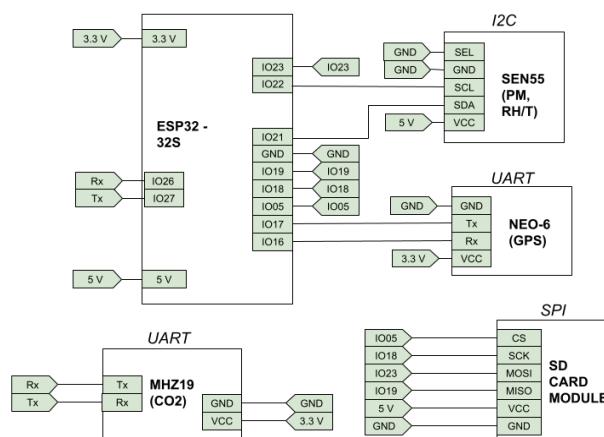
The following are the components used for the project:

Components	Description
ESP32-32S	Microcontroller with ESP32-32S chip by Espressif
SEN55	Particulate Matter, Relative Humidity, and Temperature sensor by Sensirion
MHZ19B	NDIR Carbon dioxide sensor by Winsen
Neo-6M	GPS module with Neo-6M chip from U-blox
6-pin GHR-06V Cable	Connector for SEN55 to pin headers

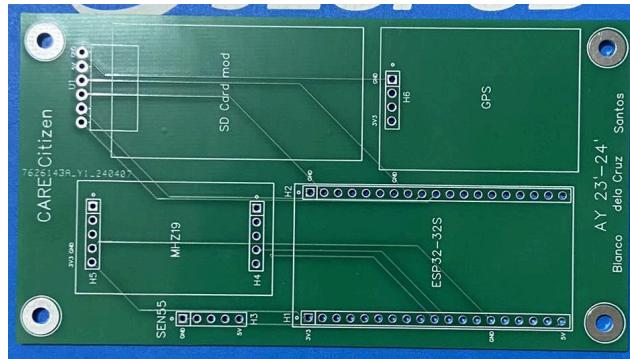
Micro-USB Cable	For firmware upload and power
5V 1A Power Adapter	For power supply
Enclosure	IP65 NEMA 4 ABS plastic enclosure with dimensions at least 160x92x74mm or greater should the provided PCB design be used. 3D mounting files are also provided.
Screws	To fasten the enclosure, mounting, and PCB
PCB	PCB Gerber files and schematic are provided to print your own PCB or modify it.

PCB Schematic

The PCB of CARE Citizen for ESP32-32S which includes the schematic and Gerber files can be downloaded [here](#). It is designed using EasyEDA and custom PCB manufacturing is from JLCPCB. The pin mapping for the modules is as follows:

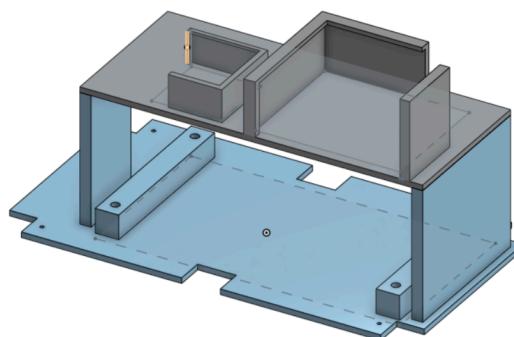


The custom PCB would look like this:



Enclosure Mounting CAD

In order to secure the components and the PCB inside the enclosure, a 3D mounting was designed to be 3D printed. Onshape was used in order to design the enclosure which can be modified by the users according to their preferences and enclosure size. The link to the document on Onshape can be viewed [here](#). Following this, STL and gcode files are also available for download [here](#). The enclosure mounting is composed of two levels in order to maximize the dimensions of the enclosure. The first level consists of the PCB wherein ESP32 microcontroller, SD card, MHZ19, and NEO6M chip is mounted. The second level is where SEN55 and the antenna of the GPS is housed.



Modifying Enclosures

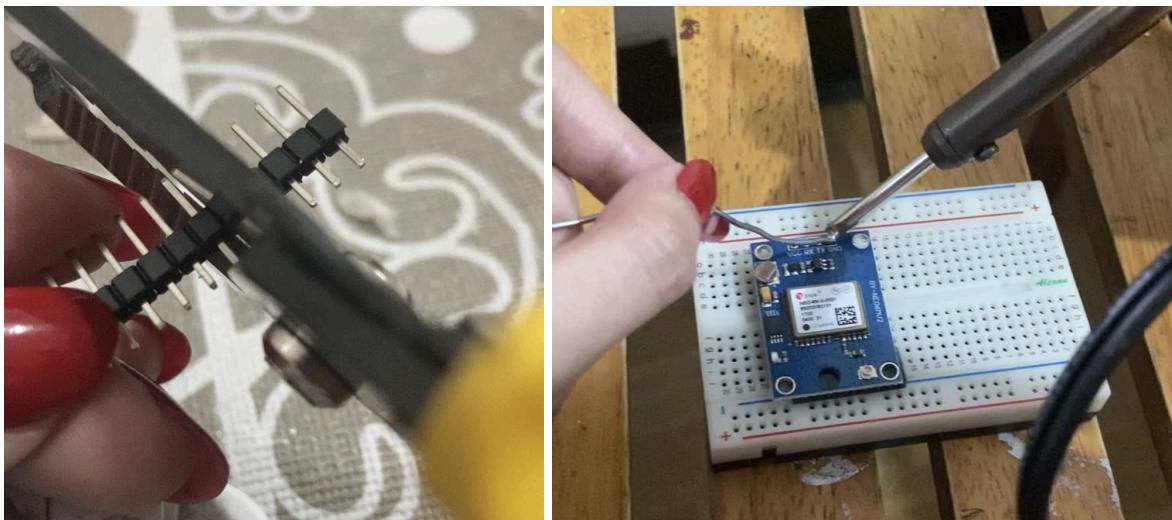
When buying off the shelf enclosures, it is important to ensure that there are holes for air flow. This is to provide accurate results for the sensors particularly, SEN55 which uses laser dispersion, and MHZ19. A way to modify enclosures is to drill holes using a power drill which can be seen below. A beehive pattern was used to maximize the spacing of the holes and on one side of the enclosure. This side should be placed downwards so as to be protected from weather elements such as wind, rain, and dust. Alternatively, overhangs can be printed and glued to the side of the enclosure.



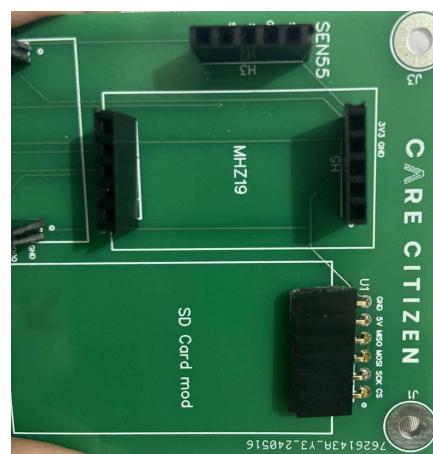
Soldering Components

On soldering components, determining which pin headers to use, male or female is a must. An example on soldering the GPS module is shown below.

Male pin headers are cut to the desired number of pins which in this case is four. The pin header and GPS are placed on a breadboard to be secured while soldering. Alternatively, taping it can also be done.



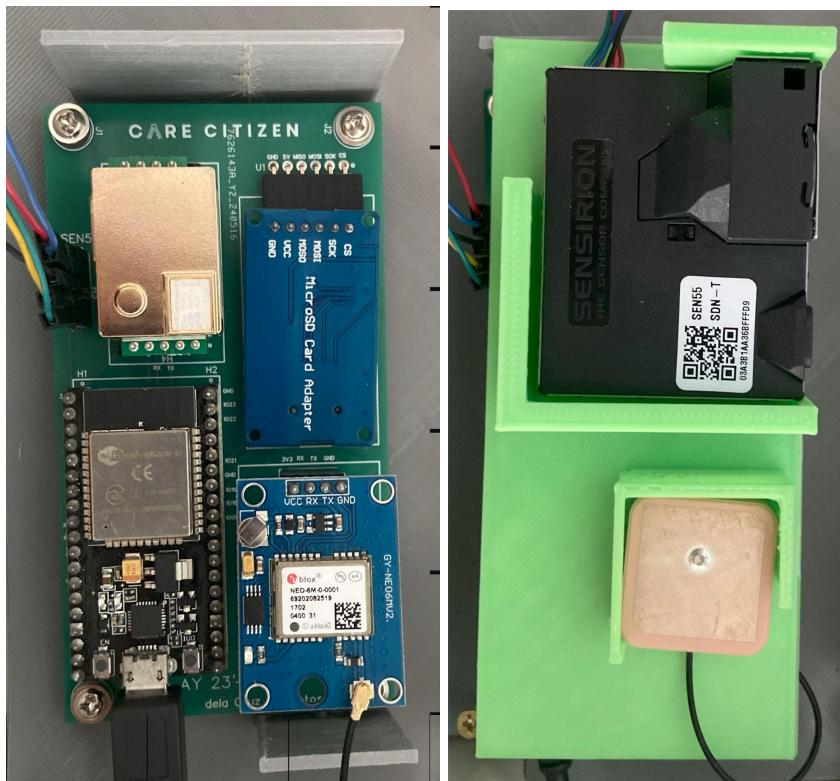
Meanwhile, soldering female header pins are required for the PCB. The process is the same with cutting female header pins to the desired number of pins, inserting and securing them in the hole, and soldering it in place. A sample of how it should look is shown below.



Assembling the Node

Now we are ready to assemble! The first step is to secure the 3D mounting onto the enclosure using screws. The PCB will also need mounting screws.

Next is placing the components onto the PCB board and securing SEN55 and the antenna of the GPS onto the 2nd level of the mounting. Please make sure that the micro-USB cable is also connected to the microcontroller. It should look like this on the inside.



Once this is done, you can now screw the lid of your enclosure and mount it on a wall with a height of an average person as this is the breathing zone. An example of mounting it is using hooks and securing it further with mounting tape.



Firmware

The firmware of the node will be publicly available for download on the CARE Citizen webpage and a [GitHub repository](#). These are open for modifications by the users depending on their use case. Prerequisite library installation instructions are provided as well as how to flash the code.

Prerequisite Installations for Arduino Version

1. Install Arduino IDE on their [website](#).
2. Upon installation of the IDE, in Boards Manager, install **esp32 by Espressif Systems**.

3. In Library Manager, install the following libraries:

- a. Sensirion I2C SEN5X by Sensirion
- b. PubSubClient by Nick O'Leary
- c. MH-Z19 by Jonathan Dempsey
- d. TinyGPSPlus by Mikal Hart
- e. WiFiManager by tzapu
- f. Arduinojson by Benoit Blanchon
- g. ESPSoftwareSerial by Dirk Kaar, Peter Lerup

Flashing the Code for Arduino Version

1. Download the code in the CARE Citizen webpage or [GitHub repository](#).
 - h. Note that users must edit the Access Key to the hash key generated upon their registration to the platform on the User Info page.
2. Connect your board through a micro-USB that is data-capable.
3. Make sure you select the board **Node32S** and select the correct serial port.
 - a. The correct port should automatically be detected but it can also be viewed on your computer's device manager as a USB to UART Bridge. If not, a driver for this should be installed.
4. Upload the code from Arduino onto the ESP32 microcontroller. Make sure to press the boot mode button in order to successfully flash the code.



Prerequisite Installations for ESP-IDF Version

1. Install Espressif IDE including ESP-IDF and all dependencies.
2. Build the **main.c** code onto the launch target, esp32c3.
3. Libraries included in the code were from:
 - a. Example ESP-IDF WiFi Provisioning Manager
 - b. Example ESP-IDF NMEA GPS Parser
 - c. Example ESP-IDF SD SPI
 - d. Example ESP-IDF MQTT-TLS
 - e. Sensirion SEN5x driver
(<https://github.com/Sensirion/embedded-i2c-sen5x>)
 - f. MHZ19 driver
(<https://github.com/UncleRus/esp-idf-lib/tree/master/components/mhz19b>)
4. Configure Access_Key to your access key in User Information

Flashing the Code for ESP-IDF Version

1. Download the code in the CARE Citizen webpage or [GitHub repository](#).
 - a. Note that users must edit the Access Key to the hash key generated upon their registration to the platform on the User Info page.
2. Connect your board through a micro-USB that is data-capable.
3. Make sure you select the board **esp32c3** as a new launch target and select the correct serial port.
 - a. The correct port should automatically be detected but it can also be viewed on your computer's device manager as a USB to UART Bridge. If not, a driver for this should be installed.
4. Build and upload the code onto the ESP32-C3.



CARE Citizen Dashboard

The CARE Citizen Platform allows users to register their device for data visualization. It has a dashboard that allows users to see the location of the node, and the parameter readings.

Connecting to the Internet

The node must be connected to the Internet in order to send the payload through MQTT and be visualized on the dashboard. A WiFi manager was used in order to seamlessly connect the node to WiFi. The following are the steps:

1. Go to your WiFi settings and find CARECitizen access point.
2. Upon connecting to this AP, you will be redirected to 192.168.4.1. Here click Configure WiFi
3. A list of available networks will be displayed. Select your WiFi's SSID and enter the password.
4. The node will then be connected to WiFi.

Creating an Account

For data visualization, the user must register on the webpage. Here are the steps for registration.

1. Toggle the Register button. Here enter your name, email address, and password.
2. Once you get a successful message, you can now log in.
3. Upon logging in, you can see your info in the User Info page. Kindly note the access key as you will use this for editing the firmware.
4. Toggling the Data Visualization page would allow you to see the graphs of the parameters being measured.

