

Build Tutorial for SNR based GNSS Reflectometry (GNSS-R) Project

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Parts

The parts list can be found here: [Parts List Excel File](#)

1. Preparing Arduino

You will need:

1. Arduino MKR NB 1500
2. Micro SD Card

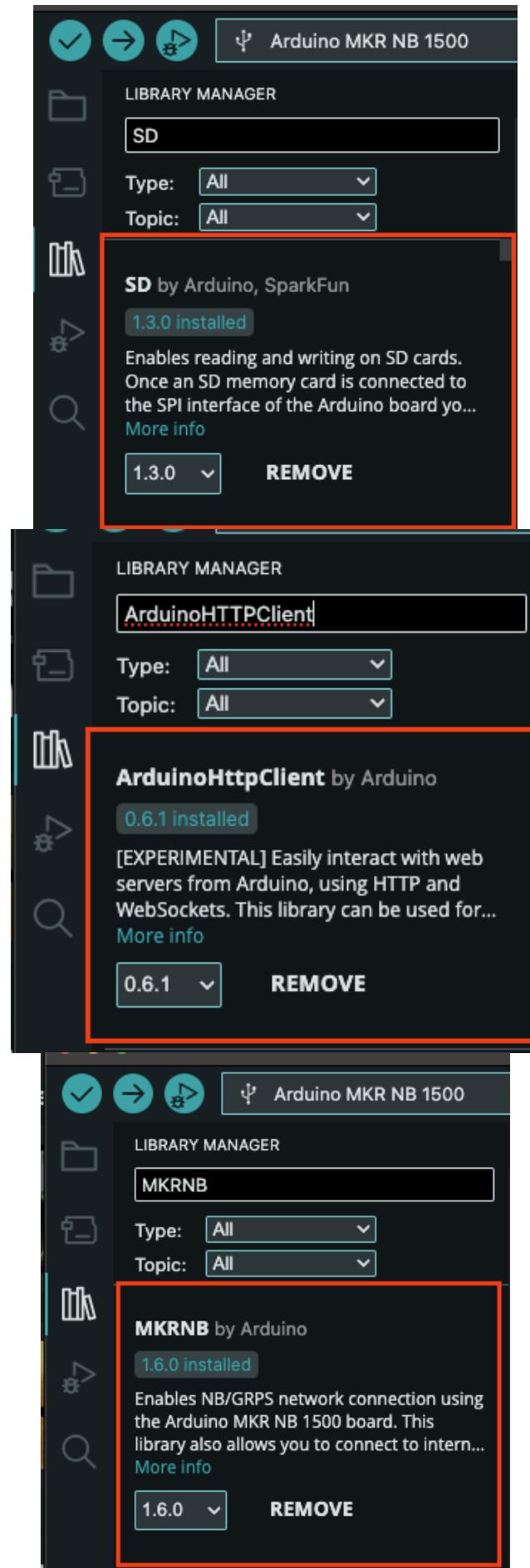
1.1 Arduino IDE Setup

Download the latest version of the Arduino IDE from here: <https://www.arduino.cc/en/software>

The first thing to do is install the board group from the Board Manager. To do this click the second icon in the sidebar and search for "Arduino SAMD". The board group you want to install is called "Arduino SAMD Boards (32-bits ARM Cortex-M0+)", install the latest version of this.



You can then install the library that we will need for this project. We will need the MKRNB library which handles communication between the cellular network and our device. To do this click the library icon below the boards manager and search for MKRNB and install it. You will also need to install the SD library, which handles communication with the SD card, and the ArduinoHttpClient, which handles the HTTP requests to Dropbox. To do this search for "SD" and "ArduinoHttpClient" and install



1.2 Format the SD Card

Before you can use the SD card with the Arduino you will need to format it. The link below has instructions on how to do this for both Windows and MacOS. Ensure that the SD card is formatted as FAT32 so that the Arduino can read it. <https://support.garmin.com/en-NZ/?faq=QqSbC0YZTz57kLm7uRQxZ7>

1.3 Get the firmware

Now that we have the board group and library installed we can upload the firmware to the Arduino. To do this create a new sketch and copy the code found [in the main.cpp file here](#) into the sketch. You will also need to copy or download the files `dropbox.cpp`, `dropbox.h` and `main.h` into their own files as well. To do this by copying click the three dots near the top right of the arduino IDE and then "New File" call the file the same as the file you are copying. You can then paste the code into the new file. You will need to do this for all three files.

When copying the `arduino_secrets.h.example` file remove the `.example` so you should have a file called `arduino_secrets.h`. In this file you will need to type in your sim providers APN, if you are using spark you can leave this as `m2m`. For the dropbox key follow the below guide.

1.4 Dropbox Key

To get a dropbox API key you will need a Dropbox account, and to create an app. To create an app go [here](#) and click the "Create App" button and sign in to your account if prompted. Then select "Scoped Access" and "App folder", then give your app a name, you can call this anything you want. Once you have created the app you will be taken to the app, click on "Permissions" in the bar below the app name and add the `file.content.write` and `file.content.read` permissions. Click "Submit" to save the changes. Then go back to the settings page and click "Generate" under the "OAuth 2" section. This will generate an API key that your Arduino can use to save the NMEA logs to your Dropbox account. Copy this key and paste it into the `arduino_secrets.h` file in the `SECRET_DROPBOX_KEY` definition.

1.5 Uploading the Firmware

Now plug the Arduino into your computer and select the board group that we installed earlier. Then select the board from the board selector beside the upload button. It should be indicated as "Arduino MKR NB 1500". If it is not go to Tools -> Board -> Arduino SAMD Boards (32-bits ARM Cortex-M0+) and select the Arduino MKR NB 1500. You can then click the Upload button, Right Arrow Icon, to upload the firmware to the Arduino.

1.6 C++ Definitions

At the top of the file below the `#include` directives there are a few definitions that you can change if you have some different configs

- `#define GPS_BAUD 38400` default baud rate for the u-Blox NEO-M9N GPS module, only change if using a different module
- `#define SERIAL_BAUD 9600` baud rate for the serial monitor, only change if you want to change the speed of the serial monitor.
- `#define IDLE_THRESHOLD 10` threshold for no output from GPS module to be considered "idle". In milliseconds.

- `#define SDCard 4` SD card chip select pin, only change if not using the MKR SD Shield.
- `#define WAIT_FOR_VALID_GPS` comment out if you want to start recording data immediately, even if the GPS module is not ready.
- `#define MAX_BASENAME_LEN (8+1)` maximum length of the basename of the log files
- `#define MAX_FILENAME_LEN (MAX_BASENAME_LEN+1+3)` maximum length of the log file name including extension
- `#define DEBUG` comment out if you want to disable debug messages, recommend to comment out when confirmed working.
- `#define GPS_BUFFER_SIZE_TYPICAL 512` typical size of the GPS nmea, used for buffer pre-allocation

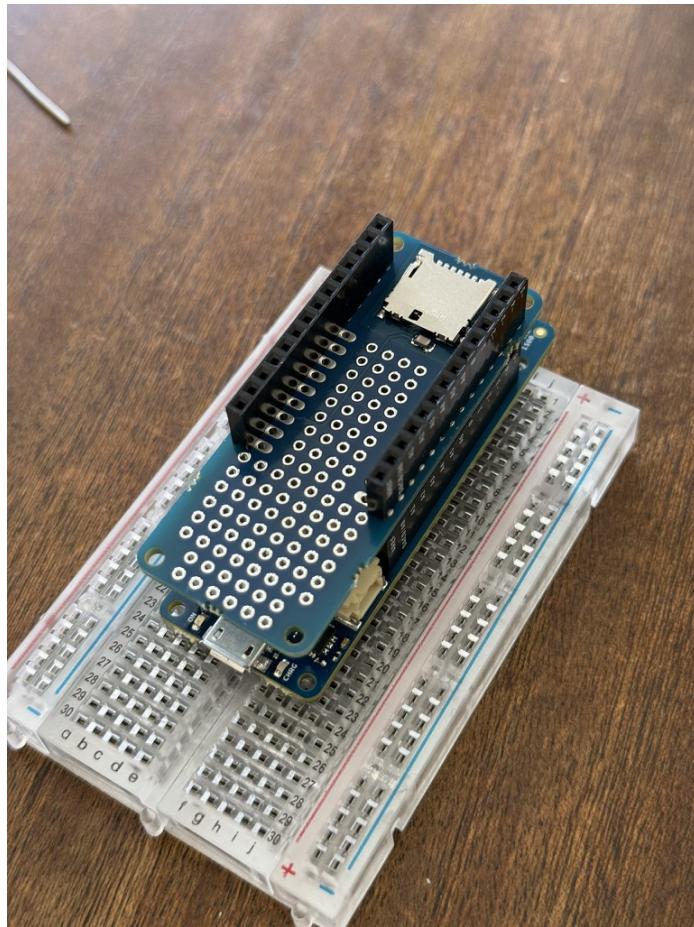
2. Connecting the Electronics

2.1 Connecting the Arduino and SD Shield

You will need:

1. Arduino MKR NB 1500
2. Micro SD Card
3. Arduino MKR SD Shield
4. Header Pins
5. Breadboard

Start by plugging the SD Shield into the Arduino. To do this simply line the pins up on the SD shield to the pins on the NB 1500 and push them together. The pins should line up with the headers on the Arduino as shown below. As a general guide the SD card slot should face away from the micro USB port on the Arduino.

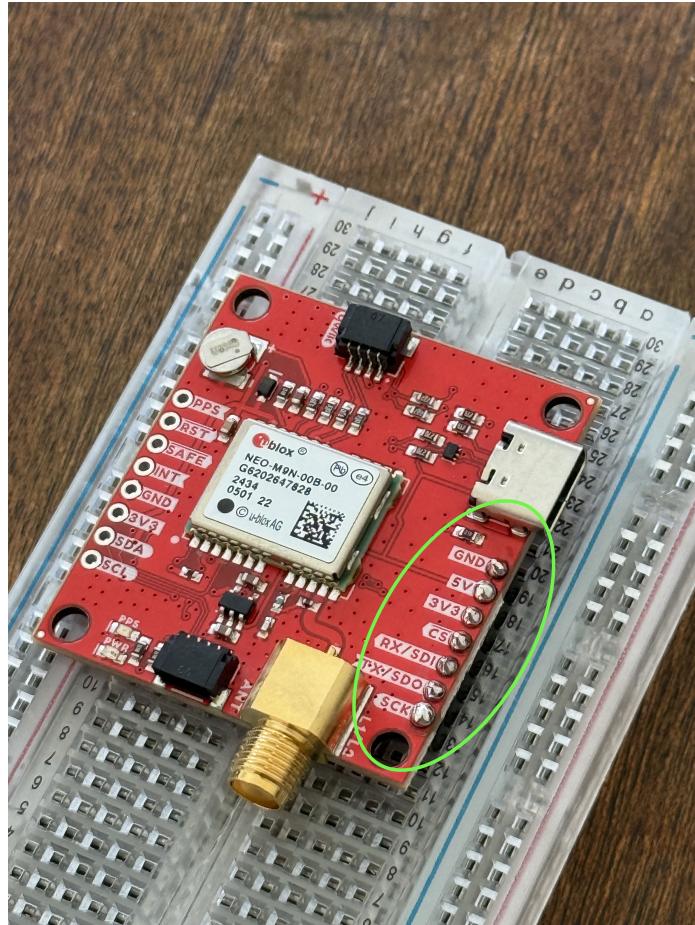


2.2 Connecting the Arduino and GPS Module

You will need:

1. Arduino MKR NB 1500
2. Sparkfun NEO-M9N GPS Module
3. Breadboard
4. Jumper Wires
5. GNSS Antenna

To connect the GPS Module to the Arduino you will first need to solder the header pins to the GPS Module. To do this cut the header pins to the correct length and solder them to the GPS module. The pins should be soldered to the empty row that is on the USB port side of the PCB. Then put the header pins into the breadboard so that the longer side of the pins goes into the breadboard, then place the SD Shield on top of the header pins. You can then solder the header pins to the SD Shield.



Once it has been soldered you can plug the GPS Module and Arduino into the breadboard. To do this place the Arduino on one end of the breadboard and the GPS module on the other end. Ensuring that none of the pins from the GPS Module are connected to the same tracks that the Arduino is on. You can then connect the two devices using jumper wires.





The first image shows an example of bad placement of the board and GPS module.

The connections are as follows:

- GPS Module VCC -> Arduino 3.3V
- GPS Module GND -> Arduino GND
- GPS Module RX -> Arduino TX
- GPS Module TX -> Arduino RX

You can then connect the GNSS Antenna to the GPS Module. To do this plug the GNSS Antenna into the SMA connector on the GPS Module. This is the big gold connector on the side of the board, to connect it simply screw the antenna onto the connector.

2.3 Cellular Connection

Add in info about how to get sim card

To start break the first layer of the sim card off so that you are left with the second-biggest size, the Micro Size. Then plug the sim card into the sim card slot on the back of the Arduino. The sim card slot is on the back of the board at the opposite end to the micro USB port. The sim card should be inserted with the gold contacts facing up.

Then plug the Laird antenna into the U.FL connector on the Arduino. This is the small circle connector on the front of the board, above the Sim card slot. This connector can be a bit tricky to plug in, so be careful when plugging it in. It can also come out easily so we would recommend using a small amount of hot glue or tape to hold it in place once you have confirmed that everything is working. [Add photo of completed board](#)

2.4 Preparing the Power System

Euan to write or give information for me to write this up

3. Mounting the system

Craig to write or give information for me to write this up

4. Testing the system

4.1 Activity LEDs

There is a red LED on the Arduino that will blink every time data is written to the SD card. Ensure that this is flashing to make sure that data is saved. There is also a LED on the GPS module that will blink once a second when it has a fix. This means that it has a connection to the satellites and is ready to record data. The red LED on the arduino will only start to blink once the GPS module has a fix.

Add photo highlighting these LEDs

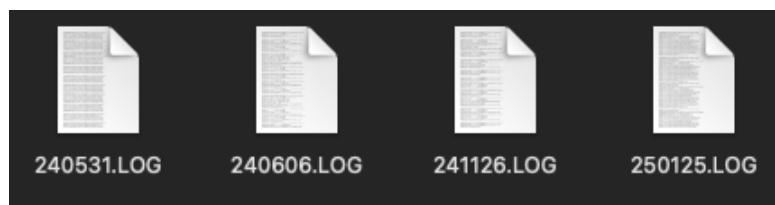
4.2 Serial Monitor

You can also check that the NMEA sentences look correct through the serial monitor. To do this follow the steps for plugging the arduino into the computer from [1.3 Uploading the Firmware](#). Then open the serial monitor by clicking the magnifying glass icon in the top right of the Arduino IDE. The baud rate should be set to 9600.

Add photo of serial monitor showing NMEA sentences

4.3 Data Files

The files that are saved to the SD Card will have an .log extension. The file names will look like the below photo:



Where the first two digits are the year, the second two digits are the month, and the last two digits are the day. This date is in UTC.

The data in the file should look like the below example

```
$GNGGA,000018.000,4443.0117,S,16910.7100,E,2,17,0.65,345.2,M,6.1,M,,*5E
$GPGSV,3,1,12,03,62,297,48,26,59,075,49,31,58,126,48,04,52,236,43*7D
$GPGSV,3,2,12,16,40,018,44,28,25,119,42,50,23,307,40,09,14,243,40*7A
$GPGSV,3,3,12,06,09,222,46,29,06,131,38,195,06,330,27,194,,,25*45
$GLGSV,2,1,08,80,79,002,43,70,71,203,35,79,40,142,43,69,37,054,46*69
$GLGSV,2,2,08,73,23,330,43,71,20,221,39,87,08,197,24,86,05,244,33*67
$GNRMC,000018.000,A,4443.0117,S,16910.7100,E,0.03,0.00,310524,,,D*6A

$GNGGA,000028.000,4443.0117,S,16910.7099,E,2,17,0.65,345.3,M,6.1,M,,*5D
$GPGSV,3,1,12,03,62,297,48,26,59,075,49,31,58,126,48,04,52,236,43*7D
$GPGSV,3,2,12,16,40,018,44,28,25,119,42,50,23,307,40,09,14,243,38*75
$GPGSV,3,3,12,06,09,222,45,29,06,131,38,195,06,330,24,194,,,25*45
```

\$GLGSV,2,1,08,80,80,003,43,70,71,203,34,79,39,142,43,69,37,054,46*61
\$GLGSV,2,2,08,73,24,330,42,71,20,221,33,87,08,197,24,86,05,244,32*6A
\$GNRMC,000028.000,A,4443.0117,S,16910.7099,E,0.01,0.00,310524,,,D*6A