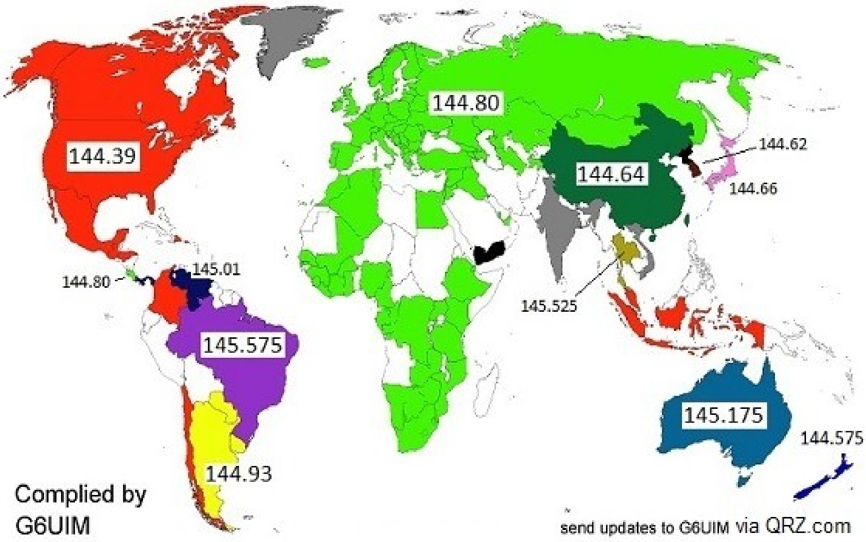
M0JKS LoRa APRS Vehicle Tracker

Setup and User guide

Version 1.1, 01.06.2025

Automatic Packet Reporting System (APRS), what is it ?

The Automatic Packet Reporting System (APRS) is an amateur radio based mechanism for real-time communications, which allows small packets of data to be sent and received over RF. More recently, APRS now permits data packets to be routed from RF, through the Internet and then back to RF through devices called iGates (internet Gateways). It was invented in the 1990's by Bob Bruninga, call-sign WB4AP (now sadly SK). It is based on a tweaked version of the ITU-T X25 protocol called AX25, which amongst other things, adds an amateur radio call-sign and a 4 bit SSID to the existing X25 protocol. The addition of a amateur radio call sign allows the X25 protocol to be used to send small packets of data to and from APRS equipment belonging to licensed Radio Amateurs; and the SSID allows the APRS system to differentiate between different APRS equipment belonging to a single Radio Amateur. Until very recently, APRS was predominately used around the world on 2m using Audio Frequency-Shift Keying (AFSK). The map below (compiled by G6UIM) shows what frequencies are allocated around the world for AFSK based APRS on 2m; and where.



LoRa APRS, how is that different to AFSK APRS?

Audio Frequency Shift-Keying (AFSK) based APRS uses two frequencies in the audio spectrum, 1200Hz and 2400Hz, to represent binary data at a speed of 1200 bits per second (or as only one bit is sent at a time, 1200 baud). For example, the letter "A" in ASCII (a standard for representing alpha numeric characters in computers from the 1960s, but still used today) is 65 in decimal (base 10), 41 (written as 0x41 or 8'h41) in hexadecimal (base 16), and 01000001 in binary (base 2). To send the letter "A" using AFSK, a device call a MoDeM (Modulator/Demodulator) takes the binary version of a alpha numeric character (for example 01000001 for "A"), processing it one bit at a time and sending an audio tone of 1200Hz if it encounters a logic "1" and an audio tone of 2400Hz if it encounters a logic "0". The audio tone is then FM modulated to the carrier frequency of 144.8MHz

(EU), 144.39MHz (US) and then transmitted. Depending on how long each tone is transmitted for, dictates the bit rate. A baud/bit rate of 1200 bit/s means each tone is transmitted for a period of just under 1mS (883uS to be precise). This is deliberate to ensure that the receiver can distinguish between a tone at 1200Hz (a logic “1”) and a tone 2400Hz (a logic “0”), especially if the Signal to Noise Ratio (SNR) of the received signal is poor.

Until quite recently, APRS really only used AFSK; and usually on 2m or 70cm. However, a new low power, long range proprietary technology called LoRa (**Lo**ng **Ra**nge) was introduced in the last few years by the French (now US) company Semtech. As the name suggests it is designed for Long Range communications but using Low Power. To achieve this, LoRa uses a digital modulation technique called Spread Spectrum (SS), and a particular variant of SS called Chirp Spread Spectrum (CSS). If this all sounds to good to be true, it’s because it is. There is no free lunch with digital communications, and SS is no different. To achieve long range, low power communications, SS modulation techniques deliberately spreads a low bandwidth baseband signal over a much larger modulated bandwidth. This sounds nuts, right? As Radio Amateurs we are taught that bandwidth is a precious resources and that we must be careful to use it wisely and with consideration for other users. However, Spread Spectrum, which was designed for military communications, and was actually invented by a Holywood actress called Hedy Lamarr back in the 1940’s, has a very different approach to spectrum usage and efficiency. Up at high frequencies (e.g. beyond UHF) there is lots of bandwidth available (especially to the military), and so when operating at these high frequencies, the prevention of interference, either deliberate (i.e. jamming) or due to external factors is far more important than the conservation of bandwidth.

At this point we don’t need to go into much more details about SS and CSS, because it’s quite complicated and involves some tricky maths. To understand how LoRa works, it is sufficient to know that when a transmitting station deliberately spreads a baseband signal over a much larger modulated bandwidth, when a receiving station then does the reverse (called despreading) the wanted signal is de-spread back to baseband, but the opposite happens to any interference/noise that is picked up in the communications channel. The act of despreading the wanted signal has the effect of spreading unwanted signals (i.e. interference or noise) over a much larger bandwidth, reducing it and so increasing the Signal to Noise Ration (SNR) of the recovered signal. Thus with CSS (and with other SS techniques also) we get something called processing gain, which is basically the ratio of the baseband signal to the spread signal. In LoRa this is called the Spreading Factor or SF. The higher the SF, the higher the processing gain, but lower the overall data rate. For something with a low data rate such as APRS, but which needs to be Long Range and Low Power, LoRa is thus a great fit.

LoRa APRS Vehicle Tracker Setup

Your LoRa APRS Vehicle Tracker is shipped pre-programmed and in a mode where you can connect to it using WiFi on your phone. You can then use your favourite browser to access the web configuration page. It should display information on the OLED display similar to the photograph shown on the right. The photograph shows the Heltec Wireless Tracker board (that resides insides inside you LoRa APRS Vehicle Tracker), but you do not need to remove it from the IP67 waterproof case to configure it. You will only need to do that if you need to change the default LoRA APRS frequency from 433.775MHz (EU) to 439.9125MHz (UK) or 434.855MHz (see below).

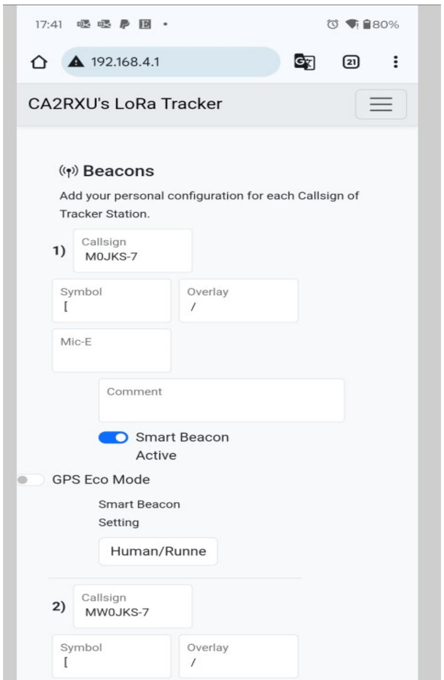
To begin configuring you LoRA APRS tracker, use your phone to connect to the WiFi Access Point:

LoRaTracker-AP

When prompted, enter the following WiFi passcode: “**1234567890**”

When the Wi-Fi is connected, open up a web browser on your phone and enter the following URL:

http://192.168.4.1



My Motorola (Android) phone tends to get confused at this point as it is way too clever for it’s own good. It works out that it cannot access the internet via the Wi-Fi AP “**LoRaTracker-AP**” on the tracker, so automatically switches to a Wi-Fi AP it knows is connected to the internet (i.e. my home Wi-Fi router). If you encounter this issue, you may need to tell you phone to forget about your home Wi-Fi connection (so it cannot automatically connect), or configure the tracker out of the range of your home Wi-Fi.

If all goes correctly, you should be presented with a web page on IP address 192.168.4.1. You will then be able to change the call-sign, SSID and any other options you see fit. As the software is, by default, designed to track a Human walking at around 3 to 4 miles per hour (5 to 7 km per hour) the default APRS symbol used is that of a Human. In APRS, symbols are created by the combination of two ASCII character. The first is called the “Symbol” and the second the “Overlay”.

Below is a table showing all the possible APRS “Symbol”/”Overlay” options that one can select.

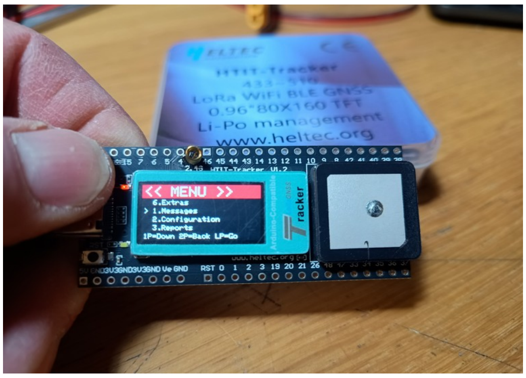
https://blog.thelifeofkenneth.com/2017/01/aprs-symbol-look-up-table.html

The default is a human walking, which translates to the APRS symbols “[“ and “/”. If you want to change this to a motor car, replace the “[“ character in the “Symbol” box (see above) with and “>”. This will ensure your LoRa APRS Vehicle Tracker is represented on the APRS map (aprs.fi) as the following Symbol:

Once you are happy with the configuration options you have changed, click on the three parallel parts at the top right-hand corner (next to “CA2RXU’s LoRa Tracker”) and you should be presented with a big green “Save” button. Click on the green “Save” button, the LoRa APRS Vehicle tracker will immediately reboot, and should now display the updated call-signs; or whatever else you changed.

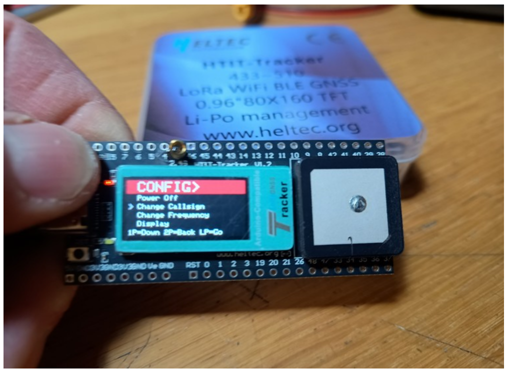
LoRa APRS Vehicle Tracker changing Frequency using the buttons

Please do not be tempted to change the frequencies in the “LoRa” section on the web interface page to what you want. These frequencies are enumerated in the software, and fiddling with them will mess up the menu mechanism for switching between frequencies. In the software there are currently three LoRa frequencies that APRS operates on around the world; they are 433.775MHz (EU/RoW), 434.855MHz (Poland) and 439.9125MHz (UK).

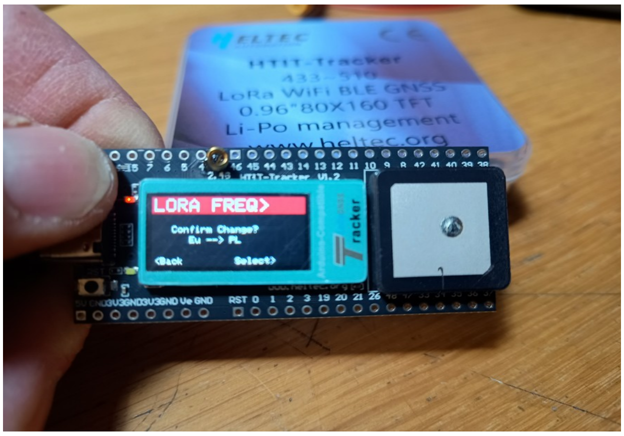


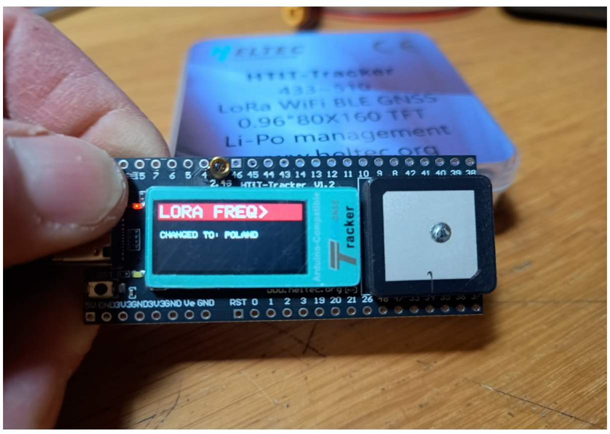
If you wish to change the current frequency of operation, for example you are a license UK amateur radio operator and wish to use your LoRa APRS tracker in Europe, you will need to use the buttons on the front of the Heltec Wireless Tracker board (which sits inside your Vehicle tracker) to do this. The LoRa APRS Vehicle tracker is designed to be mounted on top of a vehicle so has been designed to be 100% watertight. This is why the two buttons are not exposed. Thus to change frequency you will have to remove the Heltec Wireless Tracker board from inside the Vehicle Tracker first. To do this simply undo the four self tapping screws on the bottom of the tracker, remove the bottom plate, slacken the USB cable gland and hten using a small screwdrive, gently tease out the Heltec Wireless Tracker board. You can now use a USB-C to USB-A cable to externally power the board.

With the Heltec Wireless Tracker board out of the case and powered over USB-C, use the two buttons on the front of the board to change frequency. Press the left hand-button twice and you should be presented with the “MENU” as shown in the photograph above.. Next give the left-hand button a short press so that the “>” character moves down so it is next to “2. Configuration”.Now press the left-hand button for a long time (about two seconds) to switch to the menu to the “CONFIG” page as shown in the picture to the right. Now give the left-hand button a short press so that the “>” moves down so it is next to “Change Frequency” and then press the left-hand button for a long time (again about 2 seconds) so that the menu switches to new page called “LoRa FREQ>” page.

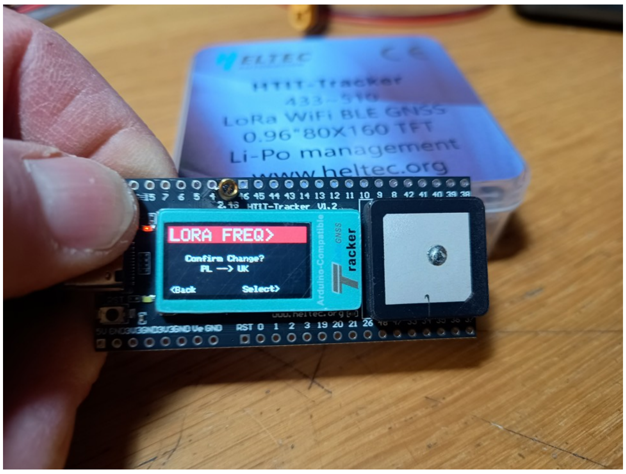


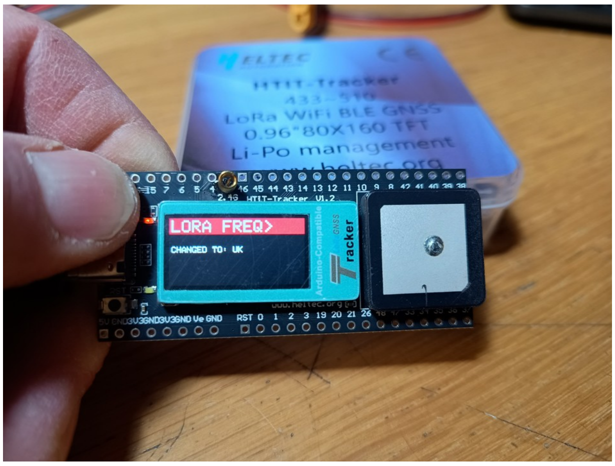
As mentioned above the frequencies are encoded in the code so that the first entry in the configuration file is the EU frequency (433.775MHz), the second is the frequency in Poland (434.855MHz) and the third is the frequency in the UK (439.9125MHz). The change frequency menu option allows you to switch between frequencies in the following order EU → PL → UK → EU, basically in a loop.





For example, if the current frequency set is that of the EU (433.775MHz), then to switch to the UK frequency is it necessary to switch to frequency in Poland first:





You will then need to repeat the same operation to switch from the frequency in Poland to the frequency in the UK (i.e. PL → UK).

When you are happy with changes , press the left-hand button twice in succession to finish.

73 Dave (MØJKS)