SOTA LoRa APRS Tracker

Setup and User guide

Version 1.2, 08.03.2025

This document describes how to build and configure the LoRa APRS Tracker which is available from the Summits On The Air (SOTA) online shop. It is available in either kit form or as a fully built and configured tracker. The kit is available for those in the hobby who like do things for themselves, and the latter for those who just want to get on an start using this new technology - especially as part of a SOTA activation.

The SOTA LoRa APRS Tracker and accessory pack are currently available from the SOTA online shop. See the link below or scan the attached QR code.

https://sota-shop.co.uk/dp/SOTA APRS tracker/

Summits On The Air (SOTA), what is it ?

Summits on the Air (SOTA) is an award scheme for licensed radio amateurs, that encourages portable operation in hilly and mountainous areas. SOTA has been carefully designed to make participation possible for all Radio Amateurs and Short-wave Listeners – it is not just for the mountaineers amongst us! There are awards for activators (those who ascend to the summits) and chasers (those who either operate from home, a local hilltop or are even Activators on other summits). SOTA is fully operational in nearly a hundred countries across the world. Each country has its own Association which defines the recognised SOTA summits within that Association. Each summit earns the activators and chasers a score which is related to the height of the summit. Certificates are available for various scores, leading to the prestigious "Mountain Goat" and "Shack Sloth" trophies. An Honour Roll for Activators and Chasers is maintained at the SOTA online database.

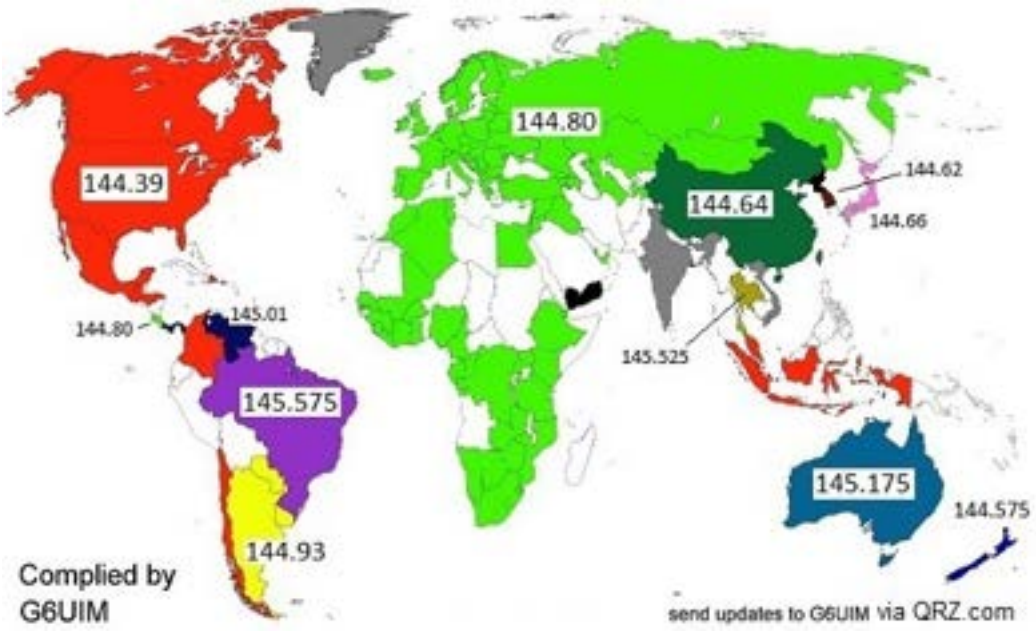
For more information on SOTA see the following link or scan the QR code

https://www.sota.org.uk

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). Below is a map compiled by G6UIM which 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. 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 and mm-wave) 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 I don't want to go into much more details about SS and CSS, because it's quite complicated. To understand how LoRa works it's 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 any interference or noise present 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.

SOTA LoRa APRS Tracker Case

To help Radio Amateurs to start using LoRa and APRS, SOTA have designed a rugged outdoor case for a neat little LoRa Single board computer module (SBC) called the "Heltec LoRa Wireless Tracker". This board is actually a LoRa development PCB designed by Chinese company Heltec Automation, which consists of a ESP32-S3FN8 microprocessor, Semtech SX1262 LoRa modem, 0.96" OLED display, WiFi, Bluetooth and a UC6580 dual-frequency multi-constellation GNSS SoC which supports GPS, GLONASS, BDS, Galileo, NAVIC and QZSS. For more information about the "Heltec Wireless Tracker" board please checkout the following URL, or scan the QR code embedded in the above picture with your phone.

https://heltec.org/project/wireless-tracker/

You can either buy the "Heltec Wireless Tracker" board for yourself and purchase the tracker case from the SOTA shop, or you can buy a fully assembled tracker which includes the "Heltec Wireless Tracker board" from the SOTA shop:

https://sota-shop.co.uk/dp/SOTA APRS tracker/

If you decide to source the "Heltec Wireless Tracker" board for yourself, then please remember to buy it from a reputable source, preferably from Heltec's shop on Ali-express or Amazon. You must also remember to buy the "EU433" version and not the "EU868" version (which is for Meshtastic).

The SOTA LoRa APRS Tracker case consists of a 3D printed main body and a separate front panel which neatly snap tightly together. The main body of the case houses a 3.7v 2000mAh Li Po battery, an external SMA connector (for connecting the external antenna), an On/Off switch and a small PCB which connects the On/Off switch between the battery JST XH (2.54mm) connector and the 1.25mm JST connector on the rear of the “Heltec Wireless Tracker” board. The front panel houses the “Heltec Wireless Tracker” board and allows the two buttons to be accessible when the two parts are snapped together (i.e. the case is closed). On the rear of the “Heltec Wireless Tracker” board there is a 1.25mm JST female connector and two IPEX U.FL connectors labelled GNSS and LoRa. When assembling the front panel and the main body, it is important to remember to connect up the power to the “Heltec Wireless Tracker” board using the supplied JST 1.25mm cable, and to connect up the external SMA antenna port – plugging it into the “LoRa” IPEX connector not the “GNSS” connector.

Assembling the SOTA LoRa APRS Tracker

As detailed above, the SOTA LoRa APRS tracker case comes in two sections; a main body and a front panel. The "Heltec Wireless Tracker" board snaps in the front panel; the battery, SMA to IPEX cable, Switch and power cables reside in the main body. If you purchased a complete tracker (case and Heltec board) from the SOTA shop, everything will be shipped to you pre-assembled and configured. However, if you purchased just the case from the SOTA shop, and sourced the “Heltec Wireless Tracker” board from elsewhere, you should assemble the various parts as recommended below.

On the rear of the front panel you will observe two parallel rails with grooves in them. The front panel has been designed so that the 1.6mm thick PCB of the “Heltec Wireless Tracker” board will snap tightly into the two grooves in these rails. At the top of the grooves is a end-stop which ensures the board sits correctly and lines up properly with the OLED display window, the GNSS antenna window, and with the two switches at the bottom of the "Heltec Wireless Tracker" board.

To fit the "Heltec Wireless Tracker" board it is recommended that the front panel is first placed face down on a flat surface. Next insert one side of the “Heltec Wireless Tracker” board into one of the slots in the front panel. It is recommended that the side of the board which houses the WiFi antenna (which is just a coil of copper wire) is pushed into the right-hand slot (the right-hand slot being the one where the switches are at the bottom and the GNSS antenna at the top). This is to prevent the Wi-Fi antenna from being accidentally sheared off if you are tad too vigorous in the next step. With the “Heltec Wireless Tracker” board now in the right-hand slot, make sure it is pushed up against the end-stops so that the switches are lined up correct. With everything seated correctly (especially the switches) place a thumb on one end of the “Heltec Wireless Tracker” board that is not in it’s slot

(i.e. the left-hand side) and another thumb on the other end, and then gently push. You need to apply the pressure evenly across the board and should only be slight.

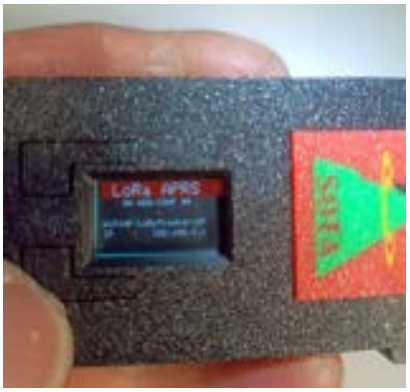
If all is well you should hear a satisfying click as the left-hand side of the board snaps into the left-hand groove. With the "Heltec Wireless Tracker" board seated firmly in the SOTA LoRa APRS tracker front panel, the next step is to check that the board is aligned correctly with the two switches on the front panel. To do this, turn the front panel over and press the two switch tabs. They should make a satisfying click if the switches on the "Heltec Wireless Tracker" board are aligned correctly with the case tabs. If the tabs on the front panel are bent or the "Heltec Wireless Tracker" board is protruding too far out of the front panel (i.e. it is not hard up against the end-stops because the switches are snagging), use two pairs of tweezers to gently lift the tabs, and then with a thumb push the "Heltec Wireless Tracker" board back into place. Don't lift the switch tabs up too much, they will snap off if you lift them more than just enough.

The final stage is to connect the JST 1.25mm female connector and LoRa IPEX connector on the rear of the "Heltec Wireless Tracker" board to the cables in the main body. You will observe that the SMA to IPEX pigtail is rather short; this is deliberate to stop it getting snagged up when the two halves of the case are snapped together. It is recommended that the SMA to IPEX pigtail is connected up first by placing the front panel (now holding the "Heltec Wireless Tracker board") on to it's side next to the main body. Lift the SMA to IPEX cable up out of the main body and snap the end connector into the IPEX connector marked "LoRa" on the "Heltec Wireless Tracker" board. Next plug in the JST 1.25mm pigtail into the JST socket on the bottom side of the "Heltec Wireless Tracker" board.

The final stage is to carefully push the main body and front panel together (without snagging any of the pigtails) so that the front panel aligns neatly with the main body of the tracker case. The best way of doing this is to push the bottom of the front panel into the bottom of the main body, while carefully ensuring that the protruding "USB Type C" connector (on the "Heltec Wireless Tracker" board) gets pushed carefully into the "USB Type C" sized hole in

the bottom of the tracker case main body. With the "USB Type C" connector firmly seated in the "USB Type C" sized hold at the bottom of the main body, next turn your attention to the top of the front panel and main body. Check that none of the pigtails or cables are likely to get caught between the side rails of the front panel and the bottom of the case; and then with your thumb and forefinger push the front panel into the main body. Use a pair of tweezers to move any cables out of the way if there is a chance they will snag.

If all is well, then both parts should snap together very tightly. If the case body and the front panel are a little tight coming together, cup your hands together with the bottom of the tracker sitting in your cupped hands, and then use both thumbs to pull down on the top of the front panel while at the same time pushing. That usually does the trick if things are a big tight.



If the front panel and main body do not snap together tightly, then it is probably because one of the pigtails or power cables has got snagged between the battery and the "Heltec Wireless Tracker" board. Open up the case a few mm (a thin steel ruler is a good tool for doing this) and using a pair of tweezers or long nose pliers, try moving the cables around until they no longer snag.

The final thing to do is now screw in the antenna (either the one supplied with the "Heltec Wireless Tracker" board, or the flexible EU433 antenna available in the accessory pack), switch on your SOTA LoRa APRS tracker and then make sure it boots up. If the OLED display doesn't show anything, it's probably because one of the power connectors is loose.

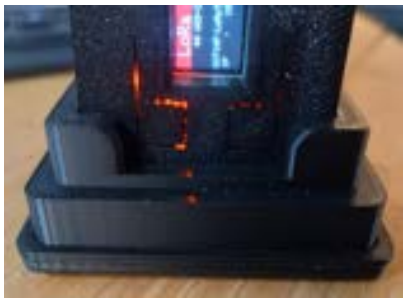
Assembling the SOTA LoRa APRS Tracker Accessory pack

The SOTA LoRa APRS Tracker accessory pack is an optional extra that can be purchased at the time of checkout from the SOTA shop. The accessory pack includes a wrist band, belt clip, flexible 3dBi gain EU433 antenna, a "USB Type C" charging/docking station and a "USB Type C" cable.

Some parts of the accessory pack come as self-assembly. The two parts which need assembling are the rear belt clip (which needs screwing on to the main body of the case) and the USB charging/docking station. To attach the rear belt clip to the main body use the two M2.5 screws supplied in the accessory pack. There are two M2.5 threaded holes on the rear of the main base body.

The USB charging/docking station consists of three main parts that need to be assembled. They are the body of main charging/docking station, a "USB Type C" 90° adaptor, a bottom plate, four screws and four self-adhesive feet. To assemble the USB

charging/docking station, turn the main charging/docking station body upside down, and holding it in the palm of your hand insert the "USB Type C" 90° adapter through the hole. Next place the docking station on a flat surface (still upside down) and then place the bottom plate over the bottom of the charging/docking station body. Then using the four self tapping screws supplied, secure the bottom plate in place. Finally, cover the four self-tapping screw heads with the self-adhesive feet supplied.



To being charging your SOTA LoRa APRS tracker, plug one end of the USB cable - the “USB type A” end) into a PC or a USB wall charger, and then push the "USB Type C" end into the "USB Type C" 90° adapter that is now located inside the charging docking station. Next place your SOTA LoRa APRS Tracker into the USB charging/docking station. On the rear you will see there is a small recess which the end of the belt clip will latch against.

This is to prevent the SOTA LoRa APRS tracker from becoming unseated when charging. To remove the SOTA LoRa APRS tracker from the USB charging/docking station, simply push the top of the belt clip (so the bottom of the belt clip comes out of the recess) and then lift out.

A point to note here is that the switch on the SOTA LoRa APRS tracker is, just a switch. It sits between the 2000mAh 3.7V Li Po battery and the "Heltec Wireless Tracker" board (JST 1.25mm) battery connector – simply so that the battery can be isolated when not in use. When the SOTA LoRa APRS tracker is seated in the USB charging/docking station, and is on-charge, it is important to remember that the switch needs to be turned ON so that the Li Po charger IC on the "Heltec Wireless Tracker" board (i.e. TP4054) is physically connect to the battery. Even though the "Heltec Wireless Tracker" board will boot up when it is being powered via USB (when seated in the USB docking/charging station), if the switch is not turned ON, the battery will not charge. You will know when the TP4054 is charging the battery as the bright orange LED on the "Heltec Wireless Tracker" board will shine through the gabs in the left-hand button on the front case. When charging is complete the orange LED will go off. It will also not be illuminated if you do not have the switch turned ON.

Finally, you will no doubt observer that the percentage battery charge level (reported on the OLED display) is somewhat misleading during USB charging. When charging from USB, the A/D on the ESP32 which measures the battery voltage level, is actually measuring the charge voltage of the TP4054 during the constant current and constant voltage phases of charging. If you would like to power down the ESP32 and OLED display on a SOTA LoRa APRS Tracker during charging, simply press the left hand button three times – so it displays the “CONFIG” menu.

Next ensure that the right arrow symbol “>” is next to the “Turn Tracker Off” option. If it is not, short press the left-hand button once to move it. Keep doing this until the “>” symbol is next to “Turn Tracker Off”. Next long press (around 2 seconds) the left-hand button so that “starting DEEP SLEEP” is displayed on the OLED. Shortly after this the ESP32 on the "Heltec Wireless Tracker" board will go into a deep sleep mode. It will also turn of the OLED (and presumably the SX1262

LoRa modem) but the Li Po charger IC (TP4054) will continue to charge the 2000mAh 3.7v Li Po battery. Again it will only charge if the switch is turned ON.

Specifying your call sign at the SOTA shop checkout

The software installed on the SOTA LoRa APRS tracker allows up to three different call-signs/SSID combinations to be configured. When purchasing the SOTA LoRa APRS tracker if the "configuration" option was selected during checkout, the tracker will be configured with the call sign you requested – it will be repeated three times. The default SSID will be 7 unless you request something different in the "comment" field on the store tracker configuration option page. You can also use the "comment" field to also request other call-signs and SSIDs, which for U.K. operators should be use if you wish to have a regional call sign identifier include (i.e. E,W,M,I,D,J,U). For example, you could specify M0JKS-7, MW0JKS-8 or MM0JKS-9 if you wanted. Remember you can only have three. You can then use the buttons on the front of the tracker to switch call-signs, which in the UK is useful when switching between operating in England, Scotland, Wales, Northern Ireland, Jersey, Guernsey and the IoM. See "**Changing SOTA LoRa APRS Configuration using the buttons"** below on how to do this.

Tweaking the SOTA LoRa APRS Configuration using the web interface

If you wish to change the frequency, call-sign or SSID that are programmed into your SOTA LoRa APRS tracker, then the easiest option is to force the tracker into web configuration mode. You can then easily connect to it from your phone web browser over WiFi. To do this press the left-hand button on the tracker three times in succession, so that the display switches to "CONFIG" mode. Next short press the left-hand button so that the ">" character moves down next to "Config WiFi AP", then long press the left-hand button (about 2 seconds) and you should see the display say "STARTING WIFI AP".

At this point the SOTA LoRa APRS tracker should reboot and come back up in WiFi/Web configuration mode. Your SOTA LoRa APRS tracker is now in a mode where you can connect to it using WiFi on your phone, and then using your favourite browser access the web config page. To do this connect to the following WiFi AP:

LoRaTracker-AP

It has no encryption enabled, so simply select this and then navigate to your favourite web browser on your smartphone by entering the following URL:

http://192.168.4.1

My (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 WiFi AP "LoRaTracker-AP", so automatically switches to a WiFi AP it knows is connected to the internet (i.e. my GPON 802.11N router).

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-signs you want to use and any other options you see fit. 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 SOTA LoRa APRS tracker will immediately reboot, and should now display the updated call-signs; or whatever else you changed. As I note below, do not be tempted to change the frequencies in the “LoRa” section. These frequencies are enumerated in Richardo’s software and fiddling with them will mess up the menu mechanism for switching between frequencies.

Changing SOTA LoRa APRS Frequency using the buttons

When purchasing a SOTA LoRa APRS tracker from the SOTA shop, if the “configuration” option was selected during checkout, it will be configured with the call-sign and SSID you requested. The default will be CALLSIGN-7 where “CALLSIGN” is the call-sign you entered. You also have the option to specify a different SSID other than 7 (in the range 0-15).

The software version installed on a full SOTA tracker is now version *2025.02.13,* but this may change with future versions. This version of the software allows up to three different call sign and SSID options, and three different VCO frequencies. There are currently three LoRa frequencies that APRS operates on around the world, they are 433.775MHz (EU), 434.855MHz (Poland) and 439.9125MHz (UK). If you look at the configuration file in “data/tracker_config.json” you will see these

I do not recommend fiddling with these unless you fancy diving into the code. The order is important, as the code enumerates the positions so the first in the list is the EU frequency, the second is the frequency in Poland and the third is the frequency in the UK.

If you wish to change the current frequency of operation, for example you are a UK operator and wish to use you SOTA LoRa APRS tracker in the EU, simply use the two buttons on the "Heltec Wireless Tracker" board to change frequency. Press the left hand-button twice and you should be presented with the “MENU”. 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. 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) :


As mentioned above, there are currently only three enumerated frequencies in the code (February 2025). However this may change.

Switching call-signs using the front panel buttons

If your SOTA LoRa APRS tracker is configured with multiple call sign/SSID combinations (either you did it yourself, or asked for it to be configured that way when your purchased it from the SOTA shop), then at some stage it may be necessary to actually switch between them. For example, you might be doing an SOTA activation along the border of two countries and at some stage will need to switch between different call-signs. This is particularly true in the U.K. when activating on the borders of England and Wales, or Scotland and England. The simplest way to switch call-signs is to long press (2 seconds or more) the left-hand button until the next call sign in the list is displayed. Long press to select, and after a few seconds your SOTA LoRa APRS tracker will be using the new call-sign. Repeat once more to access the next call sign in your list.

Getting help and support

Thank you for purchasing a SOTA LoRa APRS tracker from the SOTA shop. By purchasing certificates, trophies and other merchandise from the SOTA shop you are helping to support the running of the Summits On The Air program. The software installed on a SOTA LoRa APRS tracker was written by Richard Gunzmann (CA2RXU), the latest version of which is available from his excellent GitHub repository

https://github.com/richonguzman/LoRa_APRS_Tracker

If you have issues with, or questions regarding your SOTA LoRa APRS tracker, your first port of call should the various forums on the SOTA reflector

https://reflector.sota.org.uk/t/sota-branded-aprs-tracker/37261/

If you get no joy there, then e-mail *sota.lora.tracker@gmail.com*

73 Dave (MØJKS)