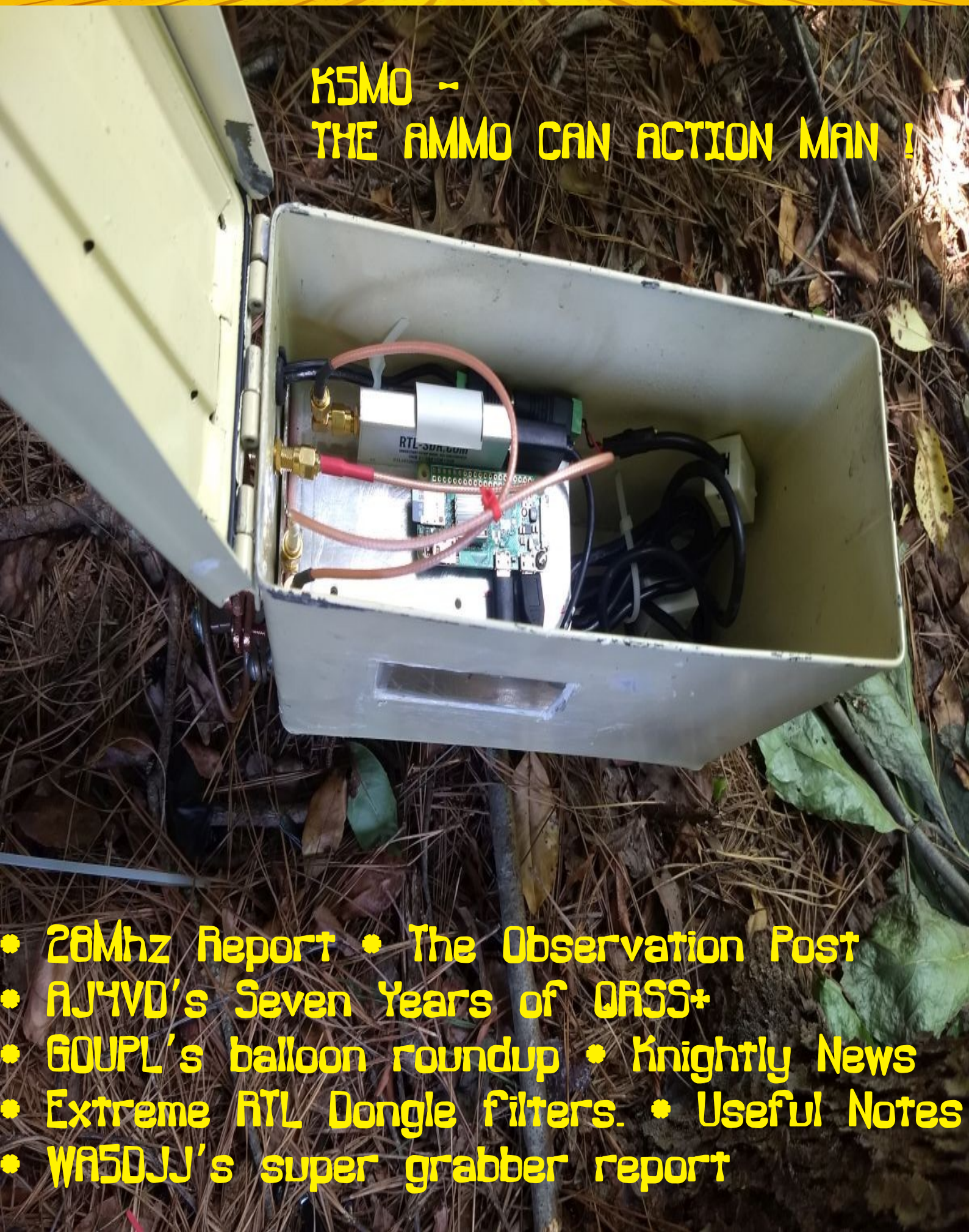
74 !

THE KNIGHTS QRSS WINTER 2020 COMPENDIUM 3rd edition

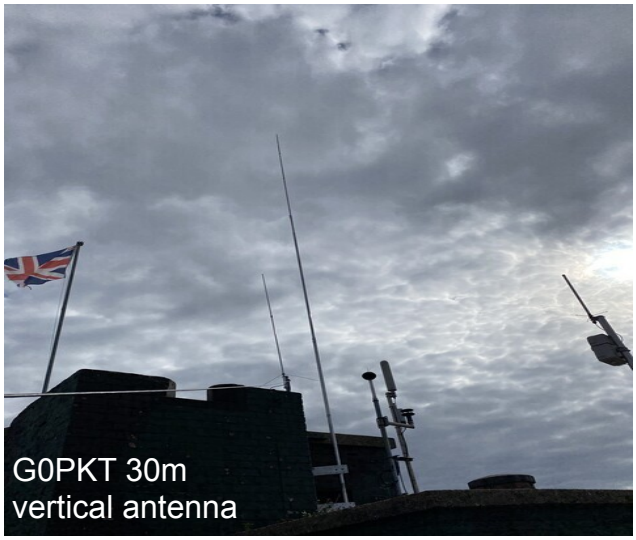


* 28Mhz Report * The Observation Post
* AJ4VD's Seven Years of QRSS+
* G0UPL's balloon roundup * Knightly News
* Extreme RTL Dongle filters. * Useful Notes
* WA5DJJ's super grabber report

Knightly News

Welcome to the third yearly compilation of the Knights QRSS compendium. We had the most amazing Sporadic E season that any of us can remember. Starting on the 18th May 2020 at about midnight UK time, there was clearly something most unusual happening. This was no ordinary propagation event, because it didn't stop for 22 hours. It had a break for a few hours and then started again for about another 22 hours. And that took about a week before this cycle of events was broken. Everyone said that they had never witnessed anything like it before. The concensus was that by about the end of August, that the Sporadic E season was starting to fade away. But at least this years season was superb. Some of us joked that maybe it had something to do with COVID-19. A nice coincidence, but alas that's probably about all it is !

10m and 30m
TX at G0PKT



G0PKT 30m
vertical antenna

The team behind the famous G0PKT QRSS beacon in Essex, England have had a full rebuild this year. The old QRP Labs Ultimate 2 transmitters had succumbed to the dreaded "tin worm" (rust) at the beach QTH and were becoming a bit unreliable. Both transmitters have been replaced with newer Ultimate 3 versions, running about 250mw output. The 30m band system now runs a vertical antenna, as does the 10m band system. Both transmitters are wall mounted in a shared cabinet.

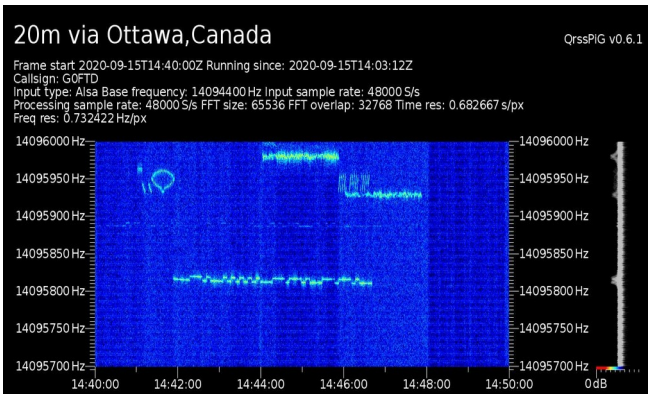
Scott AJ4VD has created some new software for the QRSS scene, called FSKVIEW. This new software can act as a normal grabber, and upload the usual style of grabs that we are all used to, but in addition it can be used alongside WSJT-X to display WSPR signal on the grab, alongside the decoded callsigns. This is a unique first.

WA5DJJ hits the news – again ! Only last year Dave achieved his ambition to construct an all band QRSS grabber using QRP Labs QCX rigs as receivers. Now he's making ANOTHER all band grabber, and replacing the old QCX rigs with QCX+ rigs.Despite no apparent circuit changes in the QCX+ rigs, Dave feels that the sensitivity appears better than the old versions. Dave is also busy doing EMC reduction to reduce noise and strange lines on the grabs. Also, he has give the world the first 24/7 50Mhz QRSS grabber. There seems to be no stopping this man. Who will be the first European 6m grabber ?

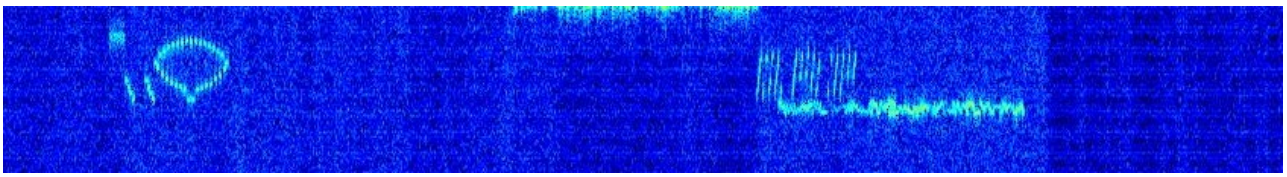
Knightly News

PA2OHH, Onno living in Spain is now building what could be described as Europe's first Super Grabber. Excellent results have been observed on 10,20,30,40,80m bands so far. Antennas consist so far as outside wires and an indoor receiving loop for 80m. Despite that QRSS continually growing, Spain has not been well represented with grabbers, and Onno is filling in the gap with excellent results.

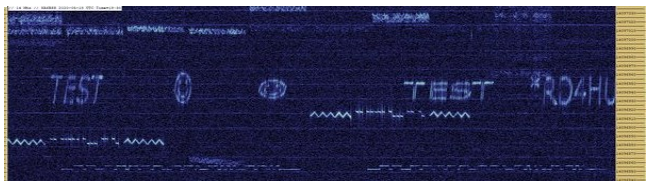

PA2OHH 80m loop



QRPp balloon launches have been proliferating during the year with excellent results. Previously these balloons tended to concentrate on exclusively using the WSPR mode, but now QRSS is becoming more common. These balloons can usually be identified by the simple balloon symbols and a launch number, as seen above and the expanded view below. Additionally this balloon also sent QRP in Hell mode too.



Some rare signals from Russia this time. New to the QRSS scene is RD4HU. Unfortunately there are few details about this station, but he appears to be active and putting out a good signal on 40m and 20m, with Hell style transmissions and pictorials.

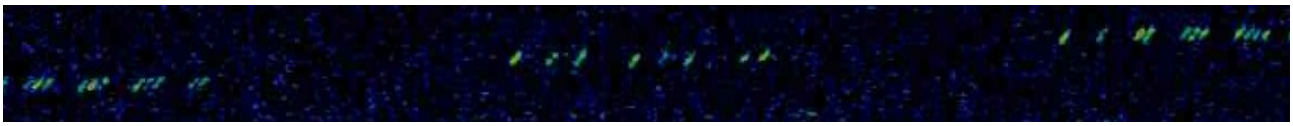


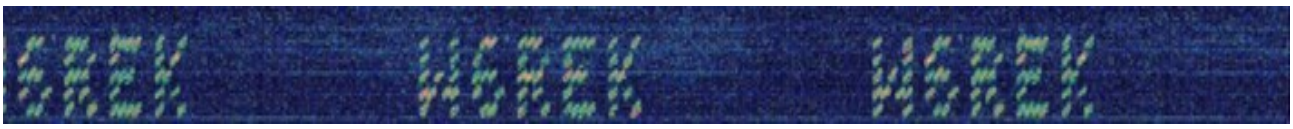
The use of remote Kiwi grabbers has still been useful amongst members, in order to fill in some holes that normal fixed grabbers cannot provide. However the use of remote Kiwi receivers has to use some caution. One has to be very careful not to monopolise a receiver. We are nothing but guests, so a few hours now and again should be the maximum. Save the sessions for when something interesting is happening.

An extension of this idea could be a QRSS club based Kiwi receiver to provide permanent links for interested grabber operators. With say four password protected channels, each "member" could provide a remote grabber from anywhere. One person could operate a 10m grabber, another a 20m, another a 40m and another maybe an 80m grabber (or indeed ANY band grabber). The Kiwi receiver could be placed at a good remote location with a suitable antenna and internet connection. The result could be four grabbers for the price of one.

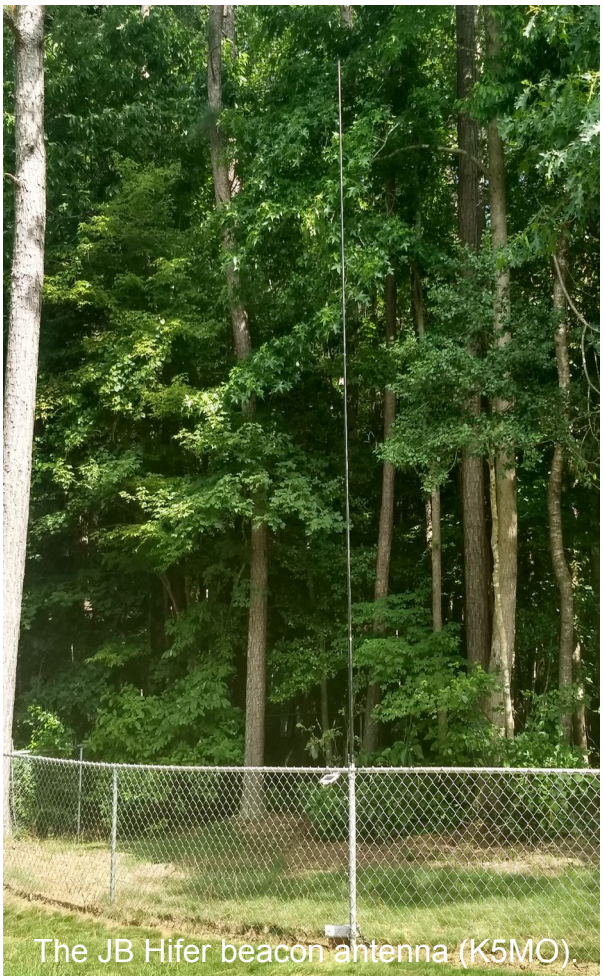
Knightly News

Henry W6REK has been conducting experiments again this year. The latest is what I call a sort of Phase Alternate Line (PAL) format if you're an old analogue TV engineer. Henry decided to send a series of discreet "marks" at slightly different intervals and frequency. To the untrained eye, they may even look like some QRM. However when all the required images are stacked using an image stacker, and the discreet marks are overlayed, the full call sign appears ! Bill W4HBK was stunned when he accidentally found them. Well done Bill and Henry. First grab shows and example of discreet markings, and the second shows the eventual results when all the required grabs are stacked.





The 22m Hifer band has attracted some attention this year amongst the Knights. In the US and Canada, the 13.5Mhz ISM band allows the use of what is called "intentional radiators". This loophole means that operators can get away with radiating about 2mw of power to an antenna, licence free. This loophole is exploited by those who wish to run tiny QRSS or WSPR beacons. Typical distances of 1000 miles are normal, but I once successfully observed some transmissions via a European based Kiwi receiver. Quite a few operators are existing radio amateurs too, and are members of the Knights QRSS.



The JB Hifer beacon antenna (K5MO)

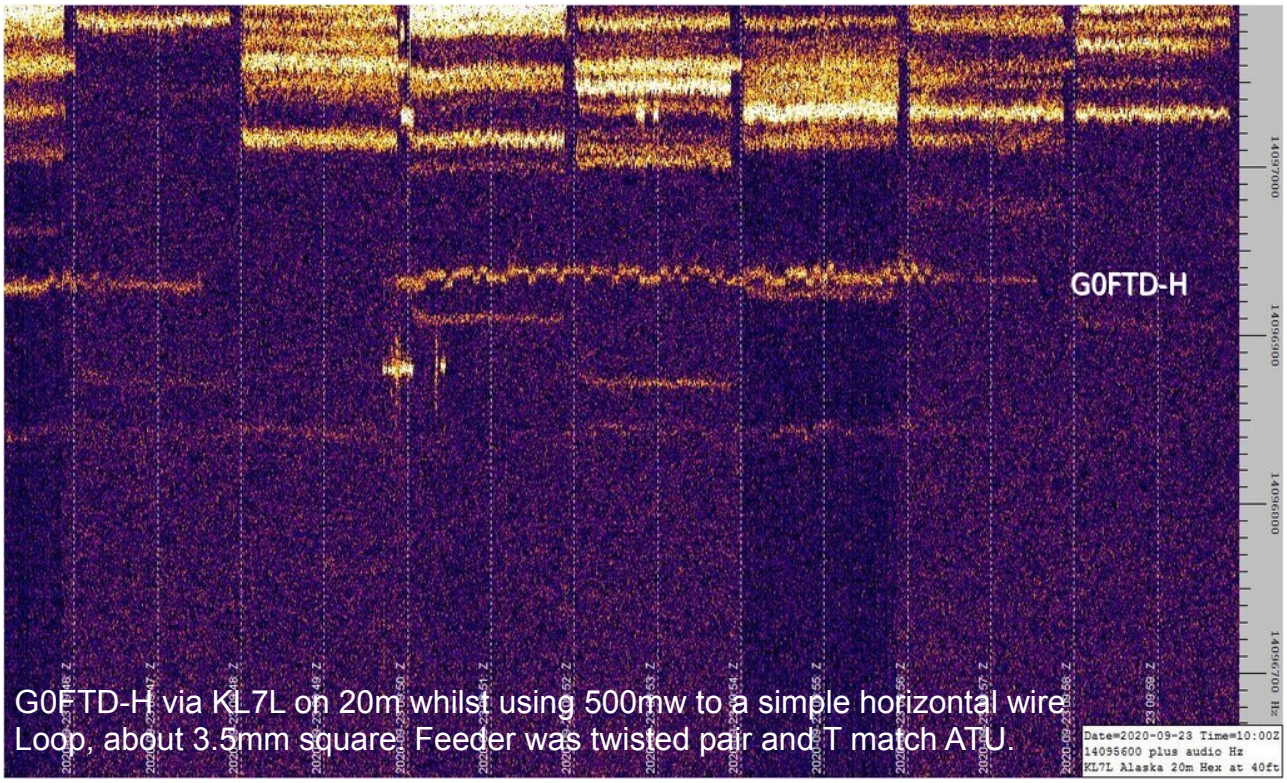
The typical ISM Hifer band watering hole tends to be around 13.555.240Mhz – 13.555.650Mhz. Typical modes used are QRSS, WSPR and normal CW at manually sent speeds. There are not too many grabbers available for the 22m Hifer band, although WA5DJJ run a full time system. Other reporters are usually temporary in operation, or do not publicly upload their grabs to website. Instead they prefer to only post reception reports and single grabs to the Long Wave Club of America (LWCA) bulletin board. The club has an excellently run website here - https://www.lwca.net/ and does have members typically from the US, Canada and the UK.

John K5MO is a keen Hifer operator, and currently runs his beacon "JB" using a simple oscillator, a small battery, solar panels and a vertical antenna (see left). Estimated radiated power is about 2mw. I have certainly seen John's beacon via an Ottawa based remote receiver during the summer of 2020. John has also been experimenting with his Raspberry Pi based 10m grabber this year with some excellent results.

Which brings us around to this years front cover photo. Here we can see the K5MO's remote 10m grabber. John's ammo can special can be seen packed with an RTL V3 receiver dongle, and a Raspberry Pi Zero running HB9FXX's QRSSPIG grabber software. You can also see various power line filters in the box too. QRSSPIG handles both the RTL dongle directly and also produces and uploads the 10 minute grabs. There's a rectangular slot cut in the side of the ammo can to allow better transmission of the 2.4Ghz WiFi signal back to the house. The antenna is a dipole at about 30 ft above ground level. 10M sensitivity with the RTL dongle is excellent and produced good stable reception of Sporadic E signals this year so far.

K5MO 10m grabber

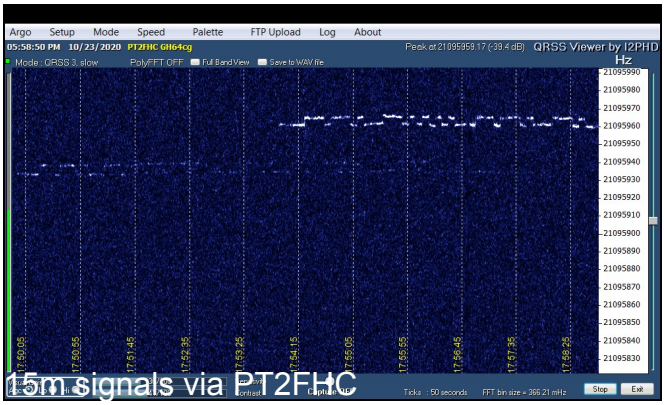
G0FTD has been having fun with a spare U3S and a joke antenna system. The antenna is nothing more than a loop of wire wrapped around the bedroom, hidden by the wallpaper. So far the main tests have been on 10m and 20m, and have been compared to the main antennas, which are in the attic space. Andy noted that it only took a few sunspots (up from zero) to make a difference, and was amazed to see the path from G<>KL7 land open with only the bedroom antenna. Super Dave WA5DJJ said that Andy should patent the antenna. The wire antenna has now been rebranded as the "QRSS Invader" ! Other signals heard near the time where M0BMN and TF3HZ. The same indoor horizontal loop has also been making waves on 15m. G6GN has been using various Kiwi receivers for for various tests in October.



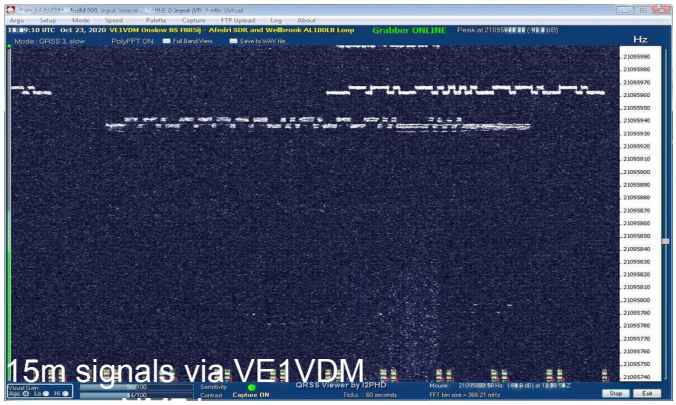
G0FTD-H via KL7L on 20m whilst using 500mw to a simple horizontal wire Loop, about 3.5mm square. Feeder was twisted pair and T match ATU.

Knightly News

Mike G6GN sent in a grab made via the PT2FHC receiver based in Brazil, during a set of 15m band tests that were originally instigated by VE1VDM. Mike managed to pull out his own signal as well as G0FTD on who was using his indoor wire loop antenna and 500mw. Sunspot number at the time was 11. It just goes to show how a few sunspots make all the difference. Stephen NM7J is back home after his spell in Thailand as HS0ZHB.

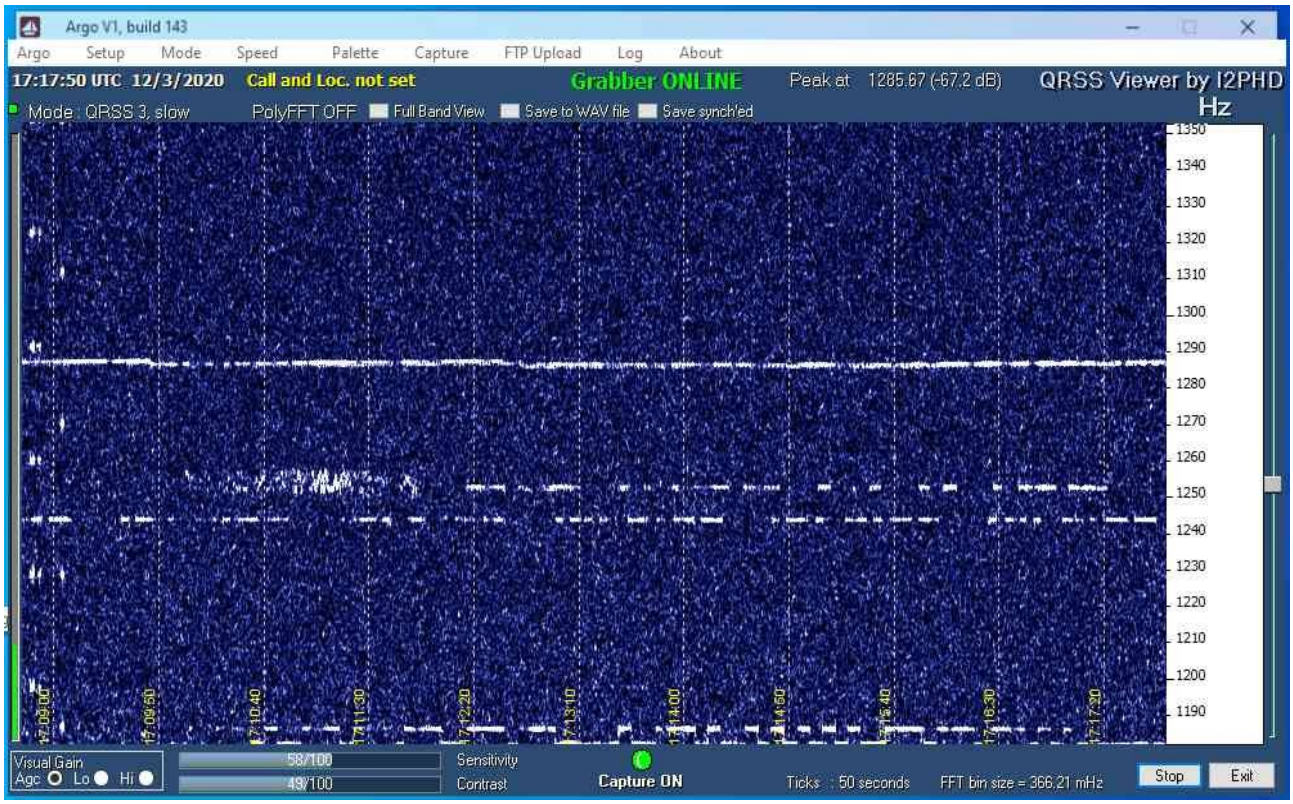


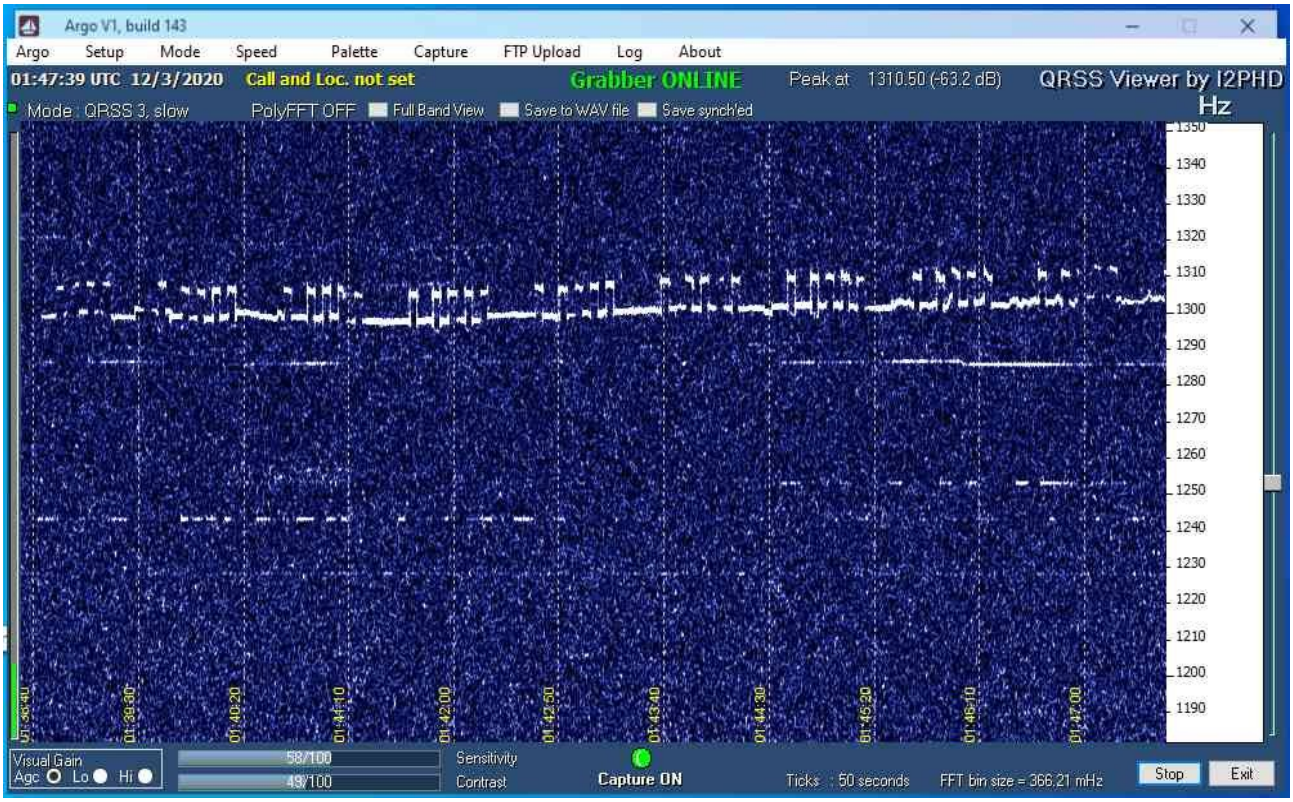
He is using a QRP Labs rigs with a maximum of 1w output. Stephen has been suffering a few antenna mast failures, but his determination has kept him on the airwaves. Below you can see his mast before and after, and a cactus of unknown impedance. It sure looks nice and sunny in New Mexico.



Knightly News

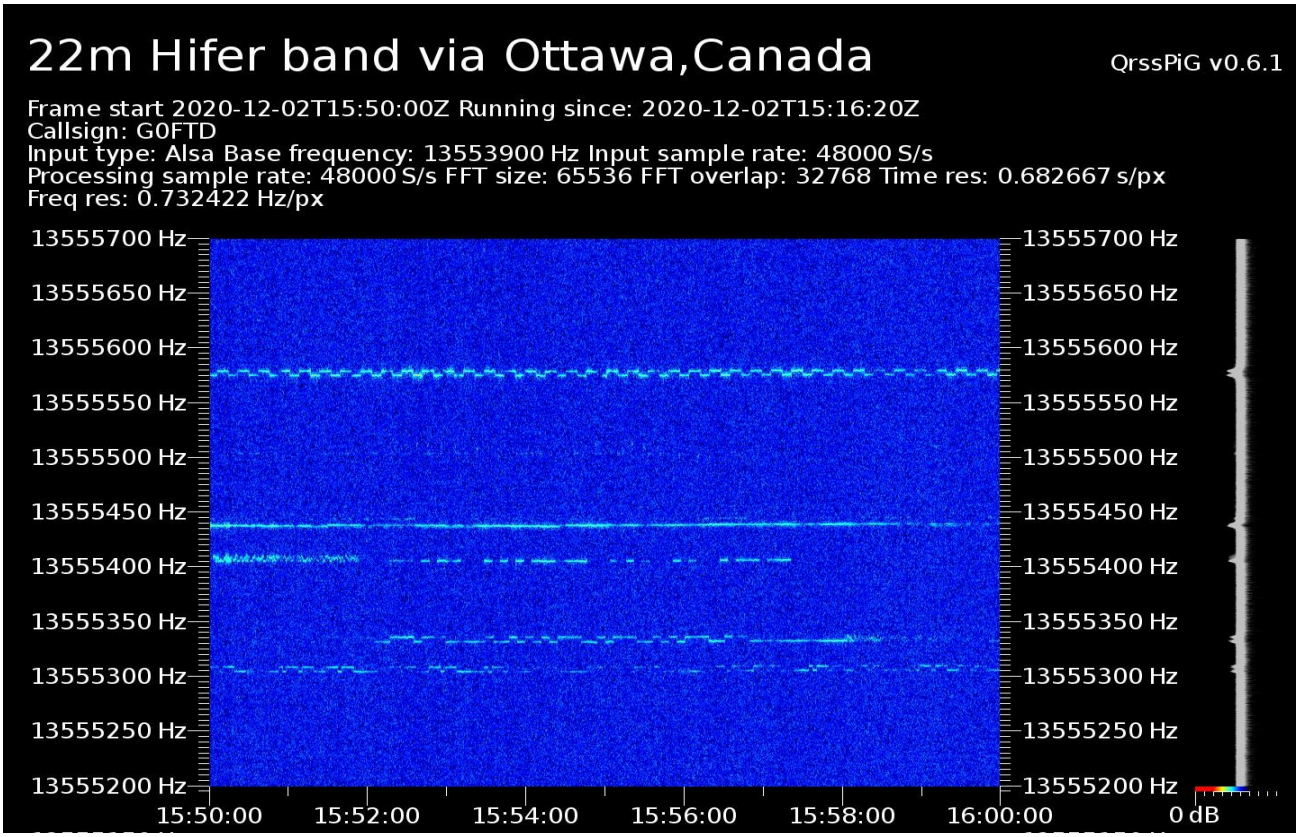
As noted earlier, the Hifer 22m and has been attracting some more attention this year. The use of QRSS on the band, along with CW and WSPR appears to be increasing. Here's a selection of what has been seen in recent months. The following grabs come from the K5MO Hifer grabber in North Carolina. The line across the first grab is actually a very slow Morse signal, and not a stray carrier. K3SIW can then be seen, followed by RY (W1TAG) and I think VA3ROM with telemetry data. The lower grab shows a wobbly signal from EH being tested from Conneticut.



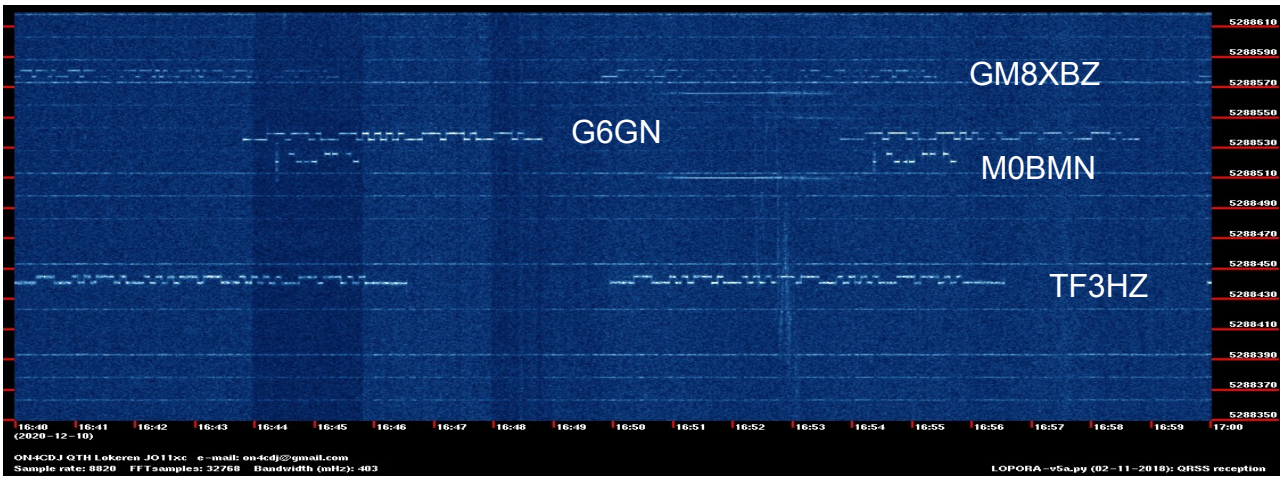


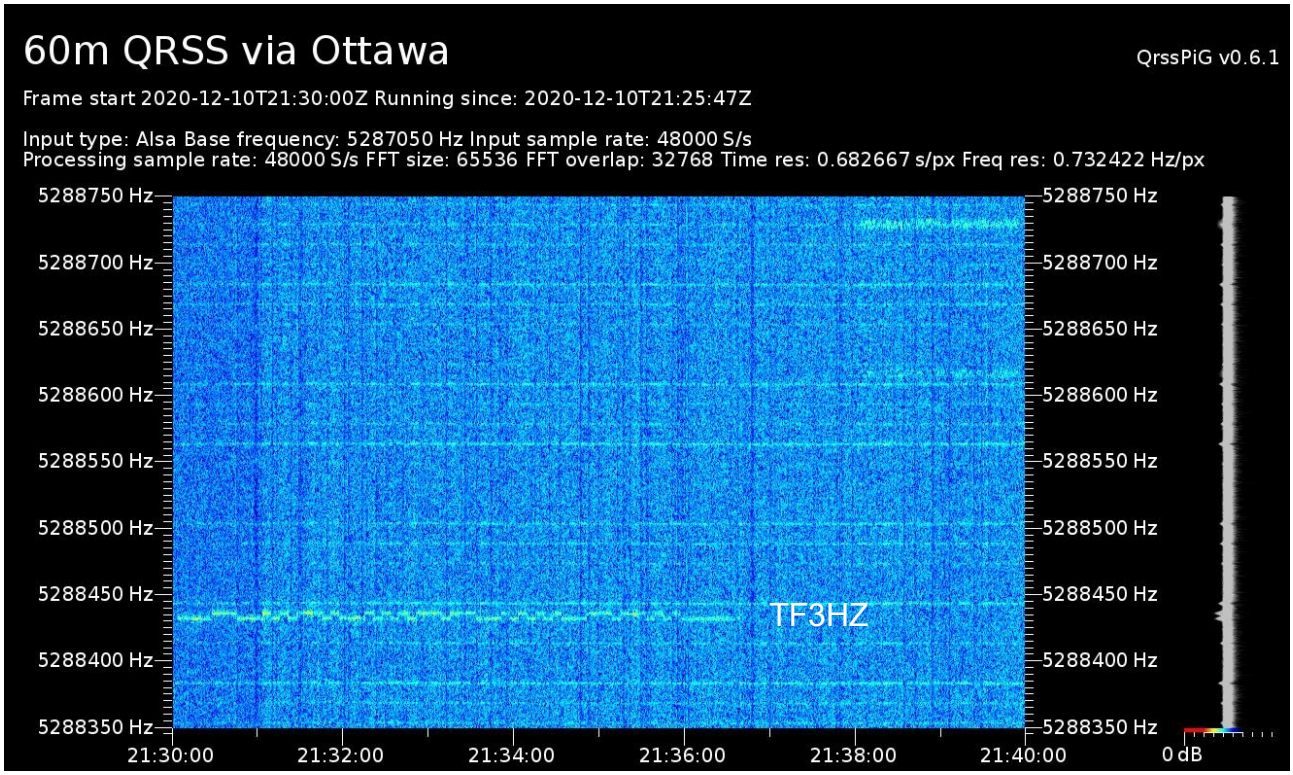
Knightly News

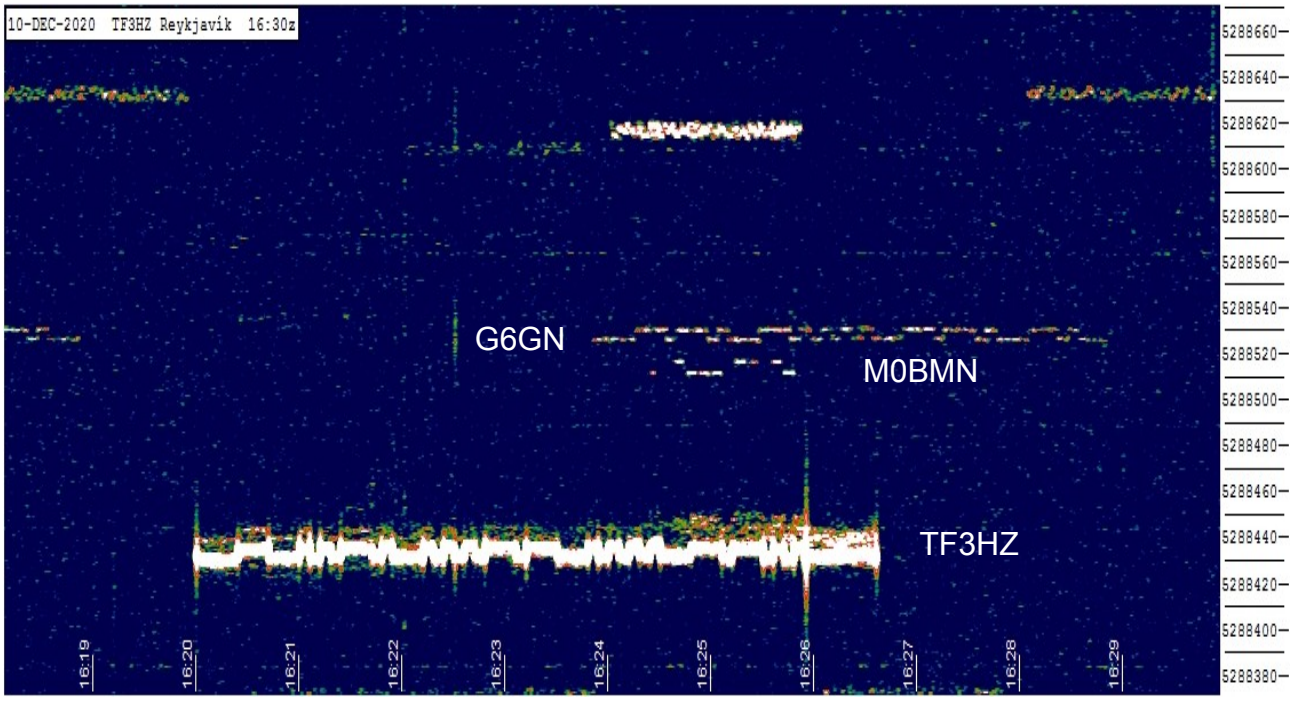
Andy G0FTD has been connecting to some Kiwi receivers for occasional Hifer band reception tests, usually via Ottawa or a UK based receiver. Excellent reception is usually noted from many east coast USA Hifer's that make it into Ottawa at good strength (upper grab). Meanwhile Mike G6GN also decided to have a little dabble on the 22m Hifer band. Mke saw EH making it through to Ireland in November 2020. Useful links. K5MO Hifer grabber - https://www.qsl.net/k5mo/hifer.jpg and 22m operator info can be found here - https://www.lwca.net/sitepage/part15/index.htm



The 60m band has finally seen some action since David GM8XBC sent out a plea for some in December. As always, the Knights rallied to the cause and we saw grabbers become active from TF3HZ, ON4CDJ, N8NJ and G0FTD utilising Kiwi receivers from Norway, England and Ottawa in Canada. Those transmitting were GM8XBC, M0BMN,TF3HZ and G6GN. TF3HZ made it over to Ottawa, but no G/EU signals were seen. ON4CDJ was highly consistent with seeing many signals. See grab immediately below.

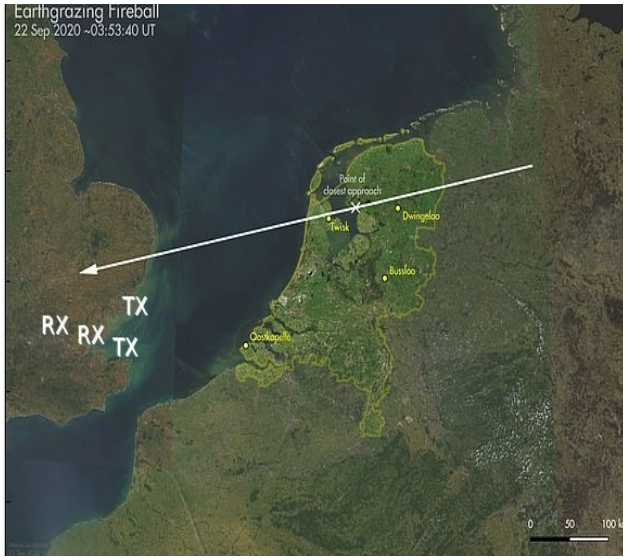




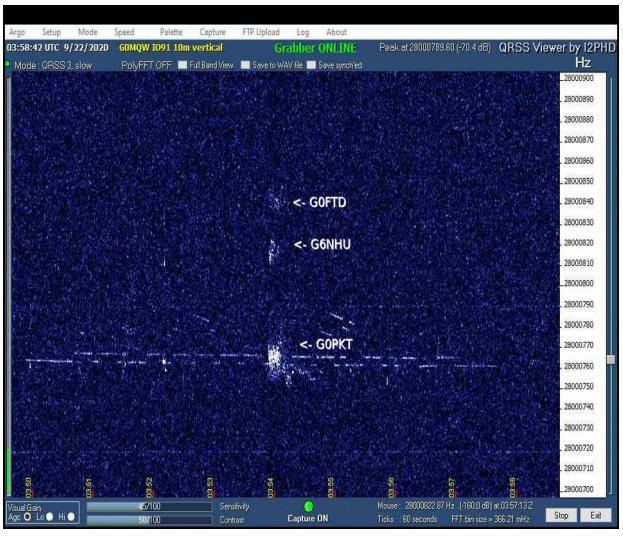


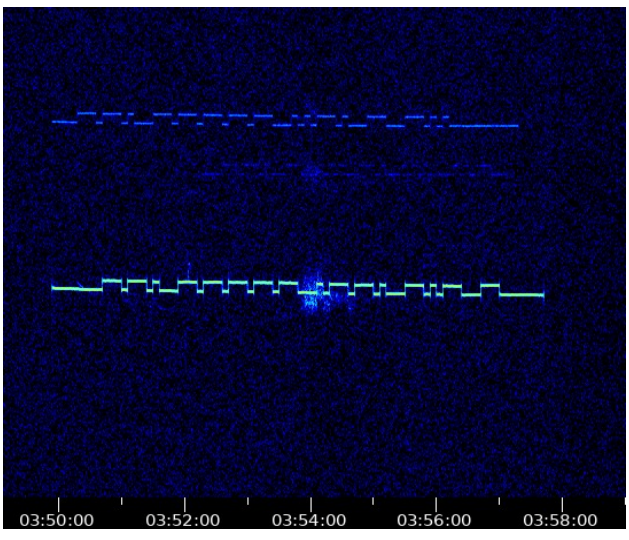
The grabs immediately above from the grabber of TF3HZ shows G6GN, M0BMN (using DFCW) and a very strong TF3HZ transmitter too. [Do I detect some multipath on TF3HZ's TX ?] One feature (if you can call it that), is the horizontal line QRM that is seen in darkness hours. This is caused by over the horizon radar. The source is believed to be in the Caspian Sea area. As we end this years highlights, can I say that it's been nice to finally be able to report not only on the usual bands, but to get some 22m and 60m action in the report too. Hopefully one day we can report on some 160m or 630m band activity. We need YOUR reports.!

The 28Mhz Report



We start with some exciting new regarding a spectacular meteor scatter observation on 10m. [Credit to G0MQW for spotting this one]. The British newspaper, The Daily Mail (click the link) reported that a meteor on the 22nd September 2020 had a rather unusual journey. Instead of entering the Earth's atmosphere and burning up, it instead entered the atmosphere, coming as low as 56 miles above Earth, and then left the atmosphere to carry on it's journey. The time reported was at 03:53:40, and the effect upon QRSS signals on 10m was observed perfectly by G4IOG and G0MQW grabbers (see below). The map above shows the reported trajectory of the meteor, along with an approximate visualisation of where the two grabbers are located, and the transmitter sites that were transmitting at the time. The map is marked with RX, to show the locations of G4IOG and G0MQW, as well as the approximate locations of the transmitting stations.

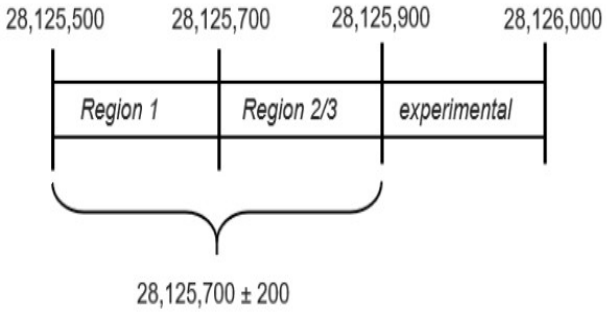




In October 2020, 10m finally aligned itself to being just below the WSPR band. Up until this date, 99% of 10m operation tended to be a British / European activity, and such it had remained on the traditional bottom 1Khz band segment, with little reason to change. But with increased interest in North America, a new solar cycle 25 cracking open, and more construction of 10m grabbers, it seemed that the time was right for a change. It was put to a general vote on the Knights group and was un-opposed. Unusually there was some informal band planning involved within the QRSS segment. This was because 10m signals were often fragments of signals, made from meteor scatter reflections, tropospheric refractions, aircraft scatter, very short E later reflections, lasting on a minute or two, or auroral. In fact F layer propagation was probably the least reported mode.

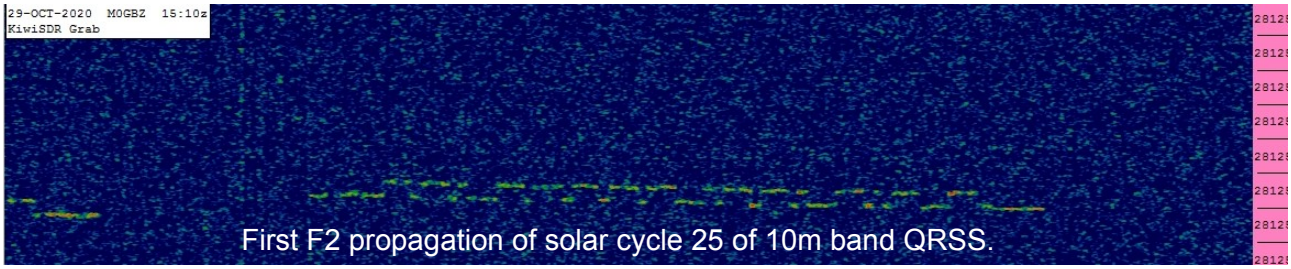
So it was decided to take measures to protect these weak fragments by dividing up the QRSS segment into regional segments. The result was a wideband QRSS segment that became 500Hz wide, including a guard zone for protection against errant WSPR signals.

It seemed a waste to let the buffer band not be used, so G0FTD suggested that it become a sort of expansion band or bandits bands. The latter is useful for testing, especially of you have a drifting transmitter. A “channel” spacing of 15Hz seems practical, because transmitter drift of receiver accuracy is not the best for some equipment at 10m. RIGHT new band plan graphic provided by AJ4VD.



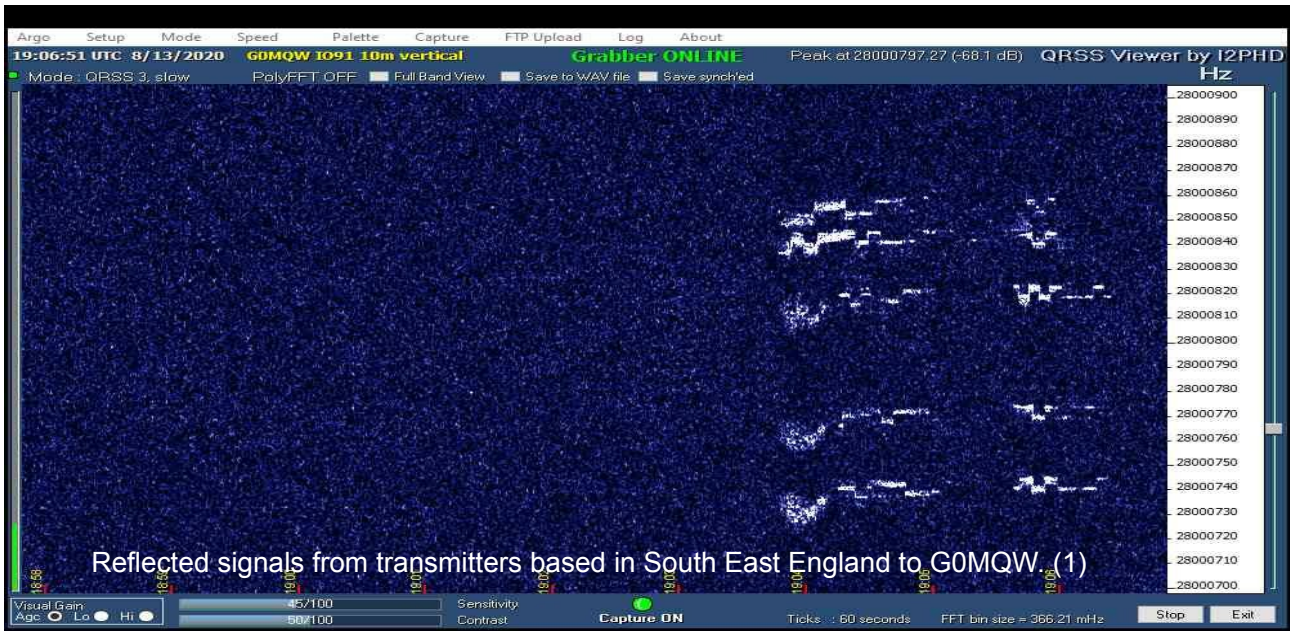
The lack of activity, at present and as predicted in ITU Region 3, means that it is probably practical to share the Region 2 sub-band for the time being. As always, it’s all voluntary. QRSS Knights are of course both autonomous as a group and as individuals !

First 28Mhz F2 propagation of Solar Cycle 25 reported. M0GBZ can claim the prize of capturing the first trans Atlantic F2 propagation of Solar Cycle 25. By using a Kiwi SDR based in New York, Euan managed to receive G0PKT (Martello Radio Group) with a good signal. The capture is shown below. Congratulations to both of you.



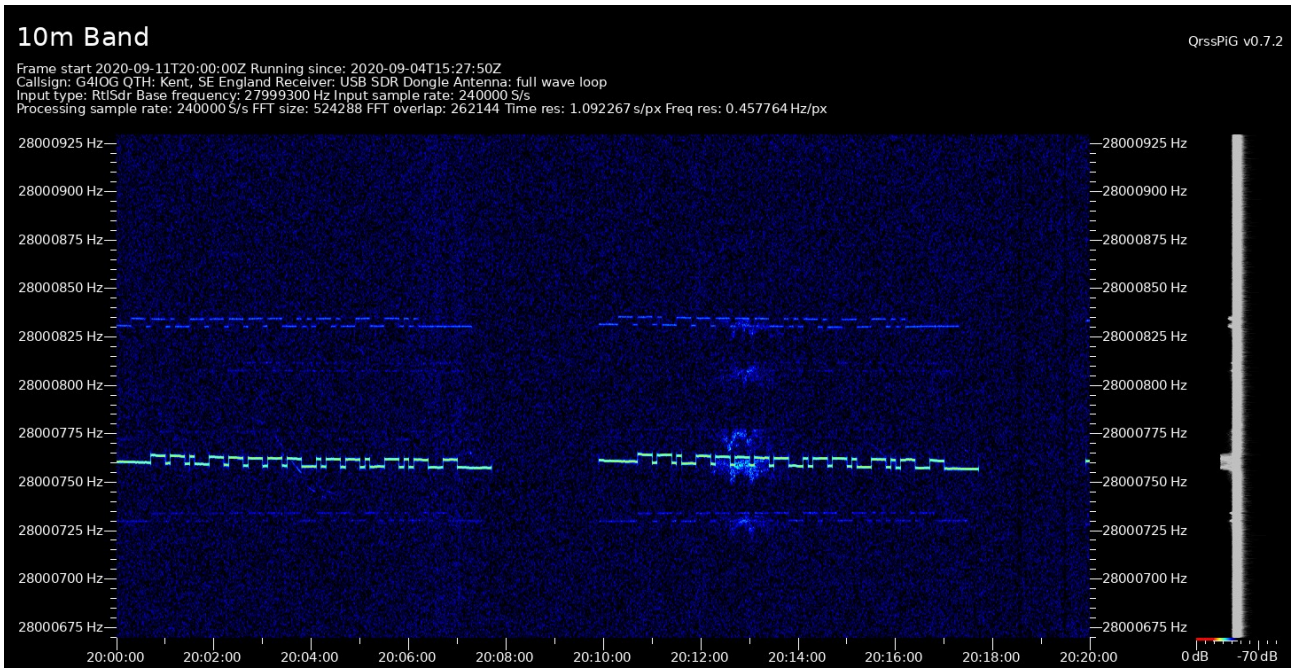
First F2 propagation of solar cycle 25 of 10m band QRSS.

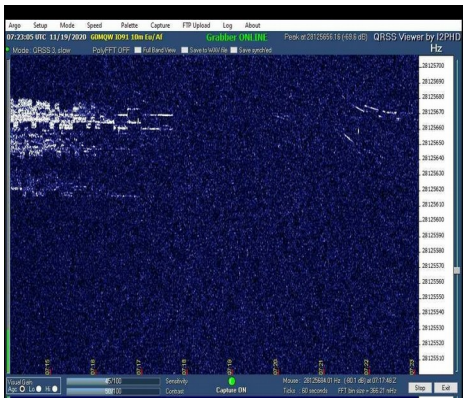
And now over to the main meteor scatter reports and the Perseids back in August 2020. As usual one of the Kings of 10m grabbing (there are several 10m grabber kings in the UK). G0MQW observed the “usual suspects” about 75 miles away being reflected back towards him.



Reflected signals from transmitters based in South East England to G0MQW. (1)

Bob G4IOG also managed to capture some meteor scattered signals from the same stations. Here's a nice clean grab that shows the same transmitters all about 50 - 75 miles distance from Bob.

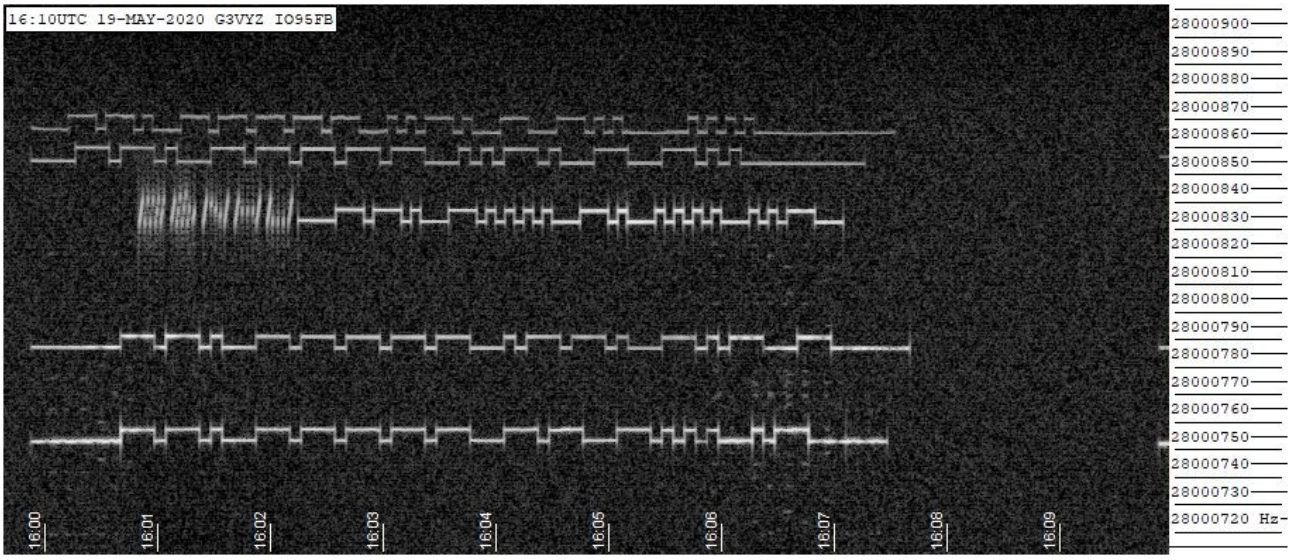


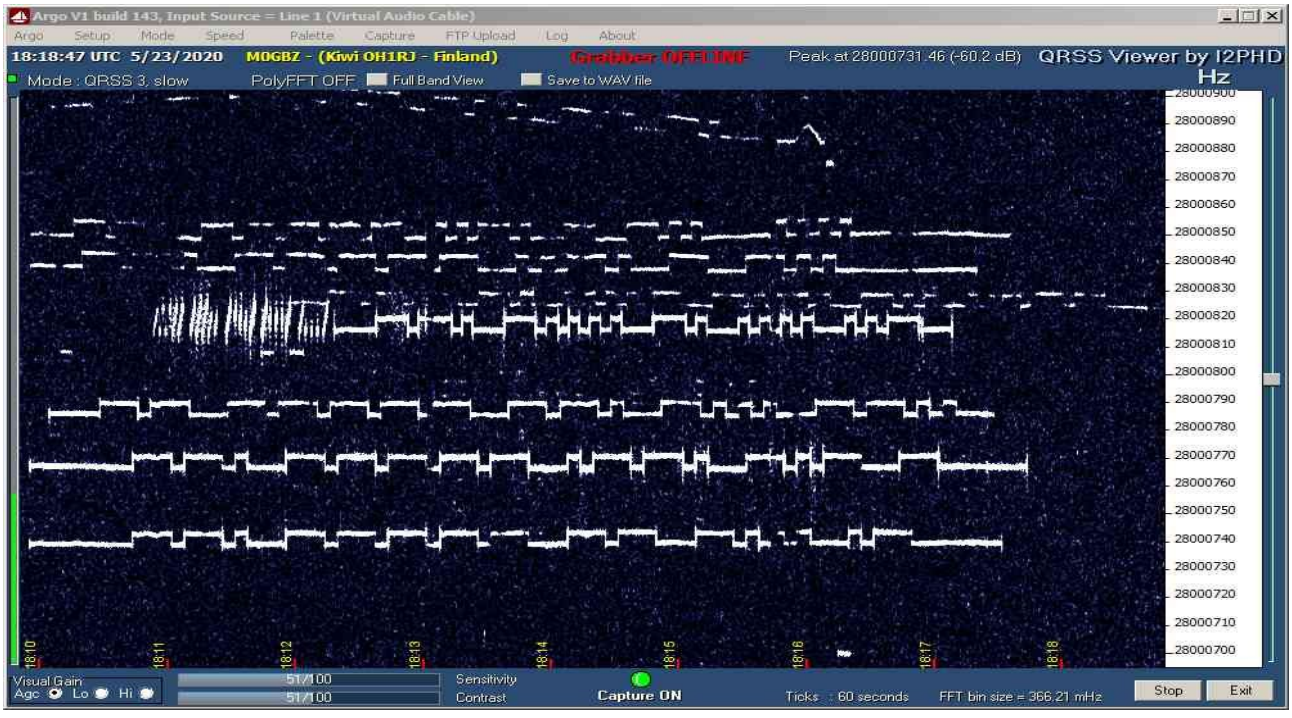


Images from G0MQW during the Leonids meteor shower of November. Excellent signals from stations located about 75 miles away on 10m. OK1FCX even spotted 10 minute reflections of G0MBA on 30m using the G4IOG grabber !

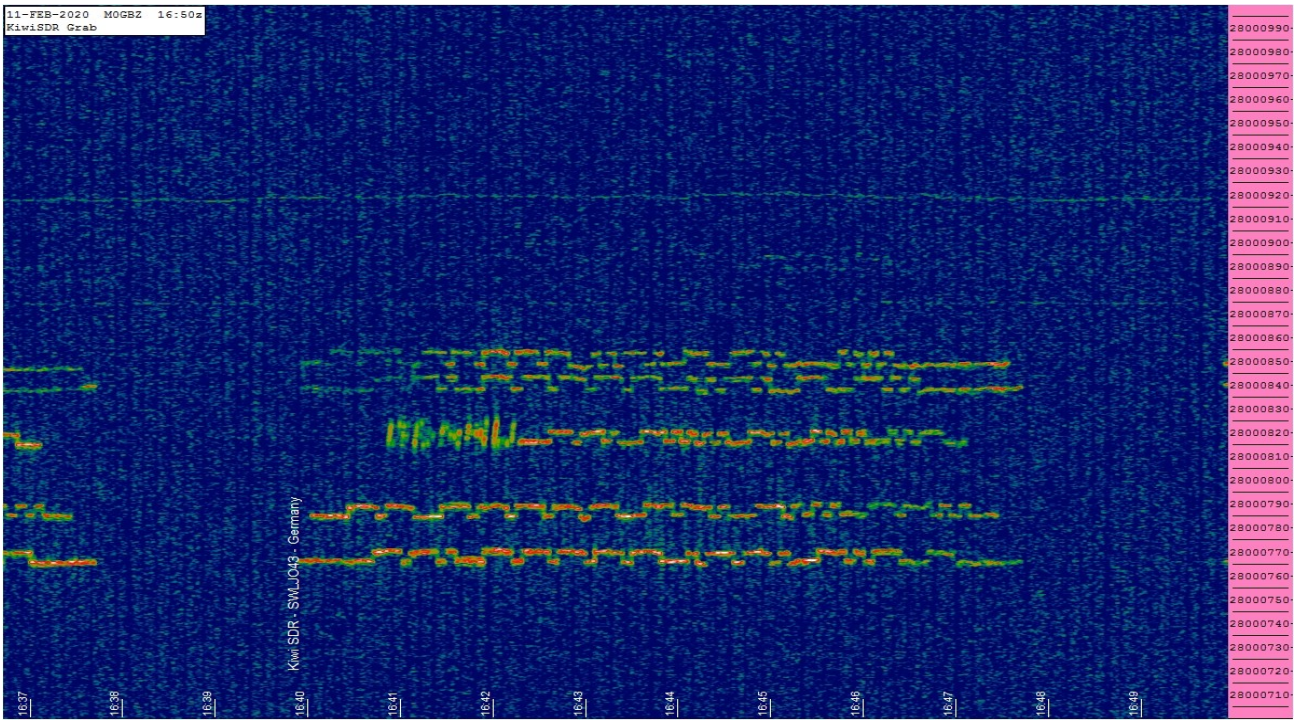
And now for something different. G0FTD decided to run a two transmitter experiment throughout the year. One transmitter used a quarter wave vertical. The other used a horizontal square loop. The object of the exercise was to see if there was any advantages in using a particular polarisation, either as the opening began, throughout the opening or towards the end. At this stage it might be wise to consider that during the test period there were no F2 layer openings available. The only mode of propagation was Sporadic E, which tends to favour a high angle of radiation. Results may well be different for F2 layer DX openings but we will have a wait a few years to get a chance to test this. To help identify which transmitter was which, the call sign had the letter "H" added to the end, to signify the indoor horizontal loop antenna. In fact the antenna was installed in the spare bedroom !

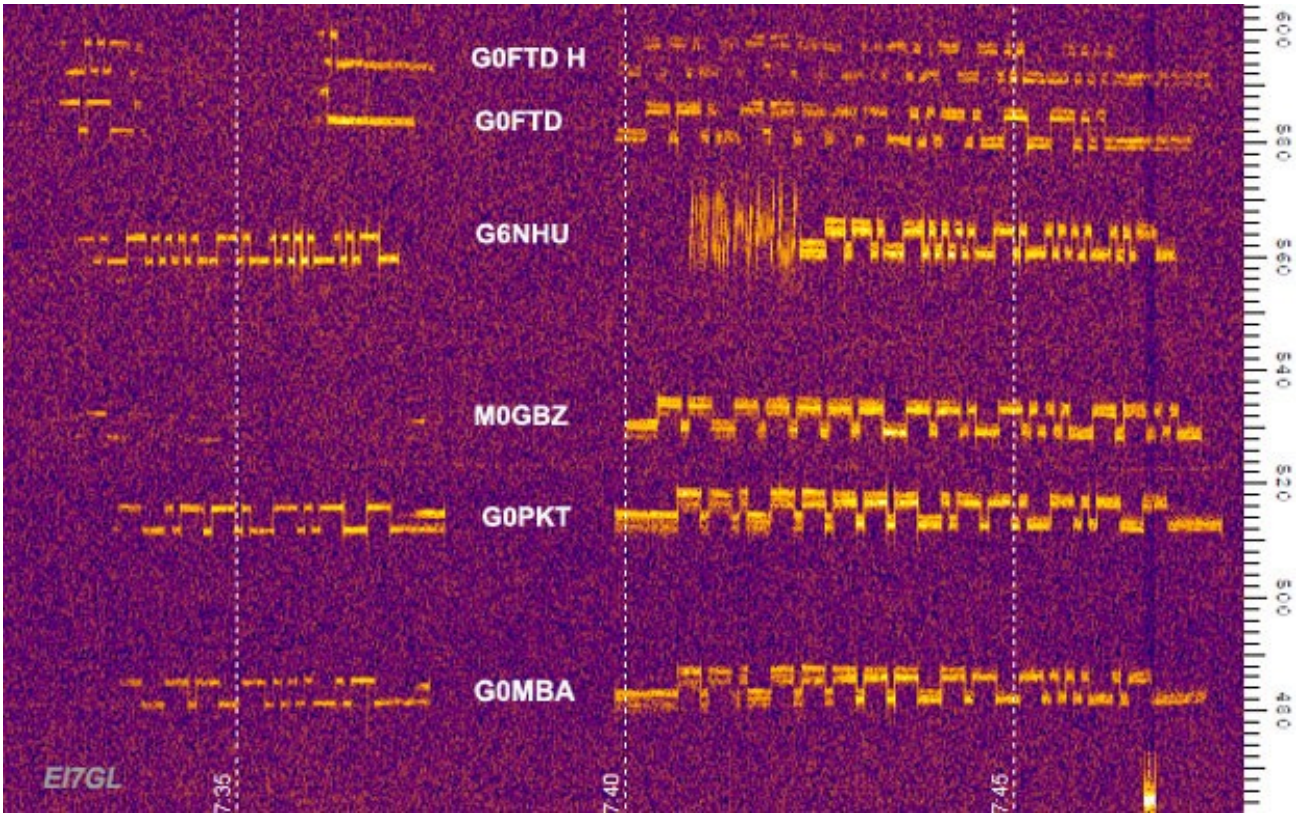
The results appear to prove that the ionosphere is not polarisation sensitive But this has been known for years. But it's nice to prove it and see the results yourself rather than just reading text books about it. Whilst many grabs were obtained, I have limited the number of grabs in this article enough to prove the concept.



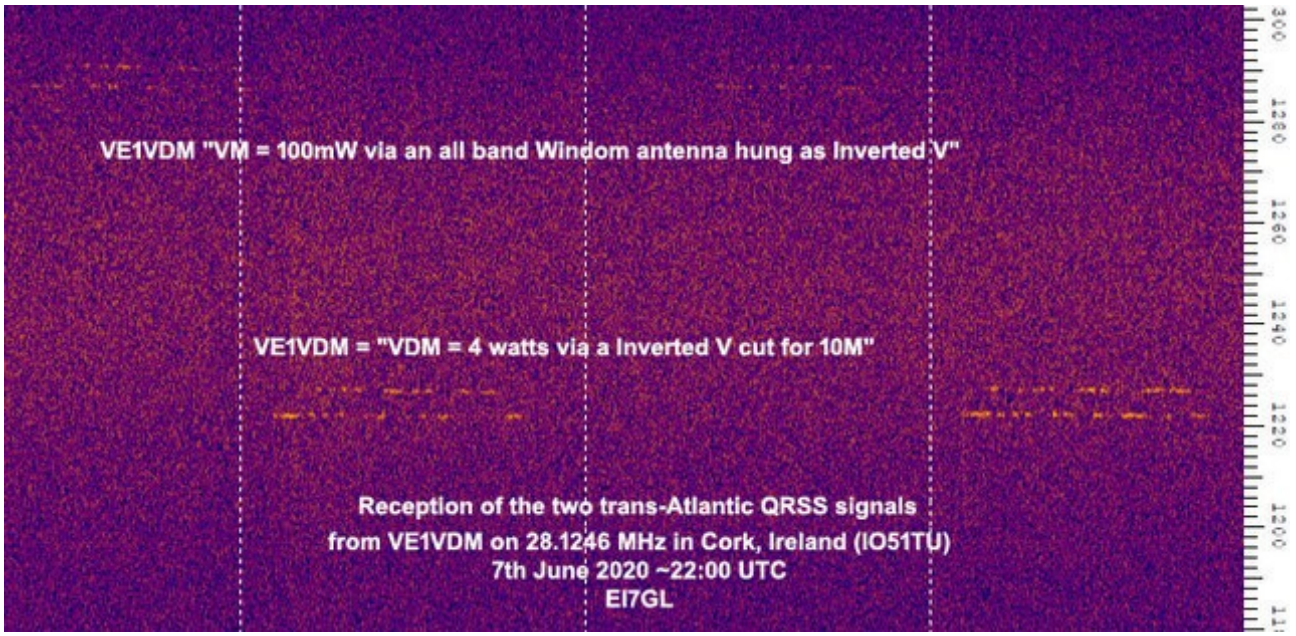


As you can see, both signals “track” each other. Both the peaks and dips are the same regardless of polarisation. The inspiration for this test came many years ago when I read an article in Practical Wireless November 1989, that measured incoming polarisation with two receivers and an oscilloscope. That magazine is over 25 years old and I think it should be out of copyright according to the Berne Convention. It maybe available via known archive sites. If in doubt consult a lawyer etc etc.





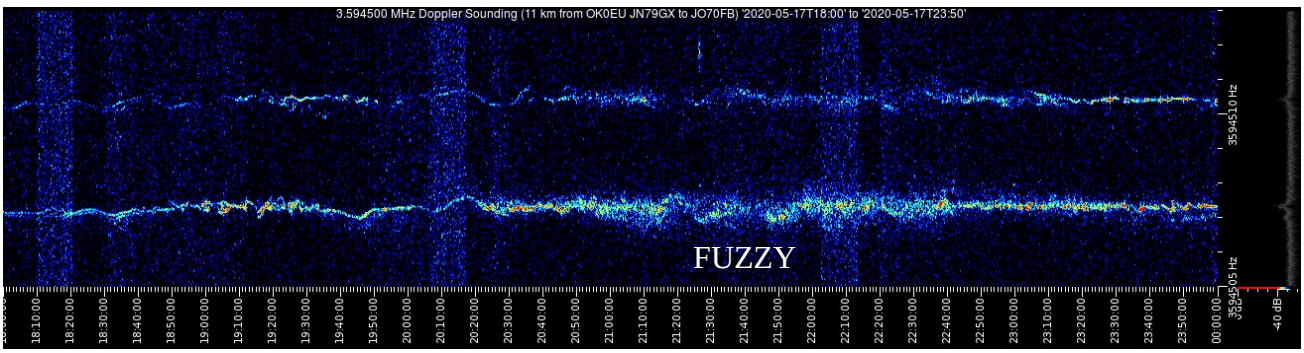
John EI7GL has been observant of 10m and managed to grab what is probably the first trans-Atlantic reception on 10m for a very long time. That came in the form of what was probably double or triple hop Sporadic E reception of VE1VDM (shown below). VE1VDM also ran two transmitters with different power levels to get an idea of what differences there may be.



In the days of old, it would be pretty difficult to detect multi hop Sporadic E signals. Our SSB or CW modes would be good enough for single hops, and occasionally double hops. However with the advent of modern modes like WSPR or QRSS, we are able to dig down deeper into the noise and detect those additional hops !

In fact, in the past using WSPR mode, G0FTD and G0PKT Have been able to detect summertime multi-multi hop Sporadic E into the midwest USA !!

One useful tip, if you want to have some form of warning that the E layer might be disturbed and about to produce something on 10m, either shortly or in the next 12 hours then you will often see the 80m band NVIS signals go fuzzy. In Europe, it's useful to monitor the OK1FCX 80m NVIS grabber. This has proved quite useful in the past.

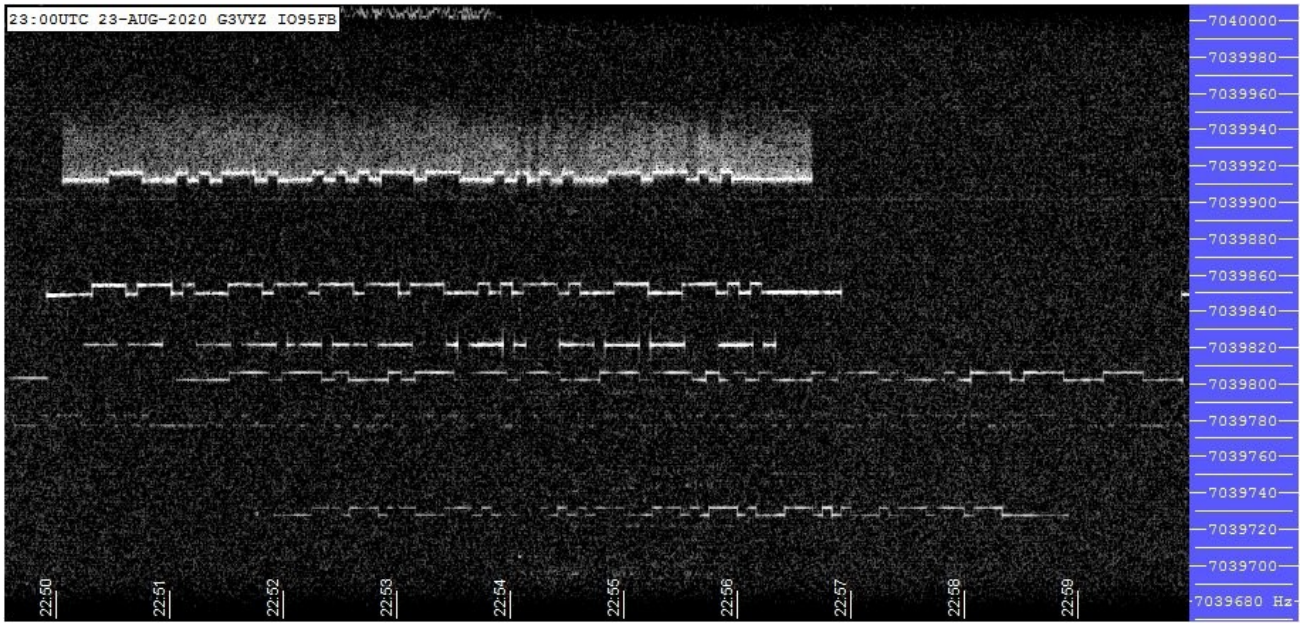


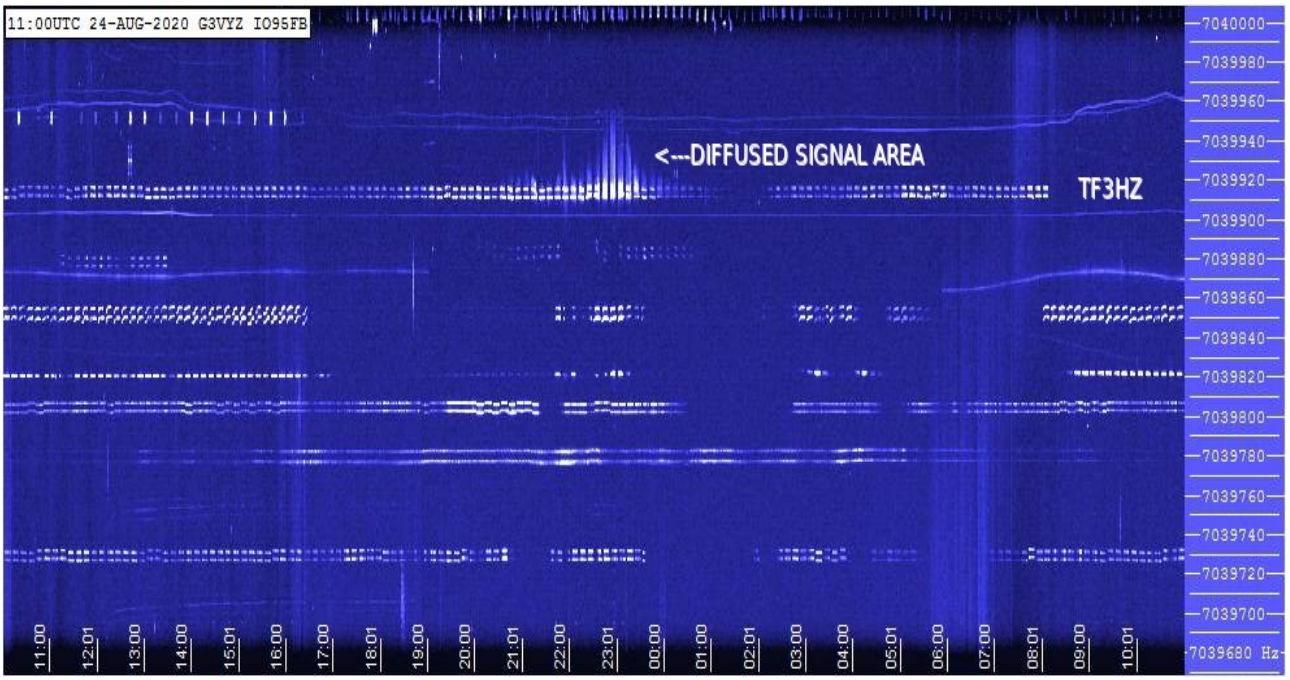
And finally, just to note that the Geminids meteor shower this year produced excellent results too on 10m. This year the pings on the grabbers took on a different look to them. You can never take things for granted it seems in the world of radio propagation. There were no auroral events to report this year, but this is typical for the solar cycle low. The chance will increase as solar activity increases.

The Observation Post

Looking inside the Ionosphere.

The Ionosphere is a fascinating beast. Constantly changing and never the same, just like a cloudscape. Our radio signals are no exception, and now and again we are blessed with a unique insight into what's happening "up there" when we use QRSS. With luck, if you are at the right observation point at the right time, you can see them.



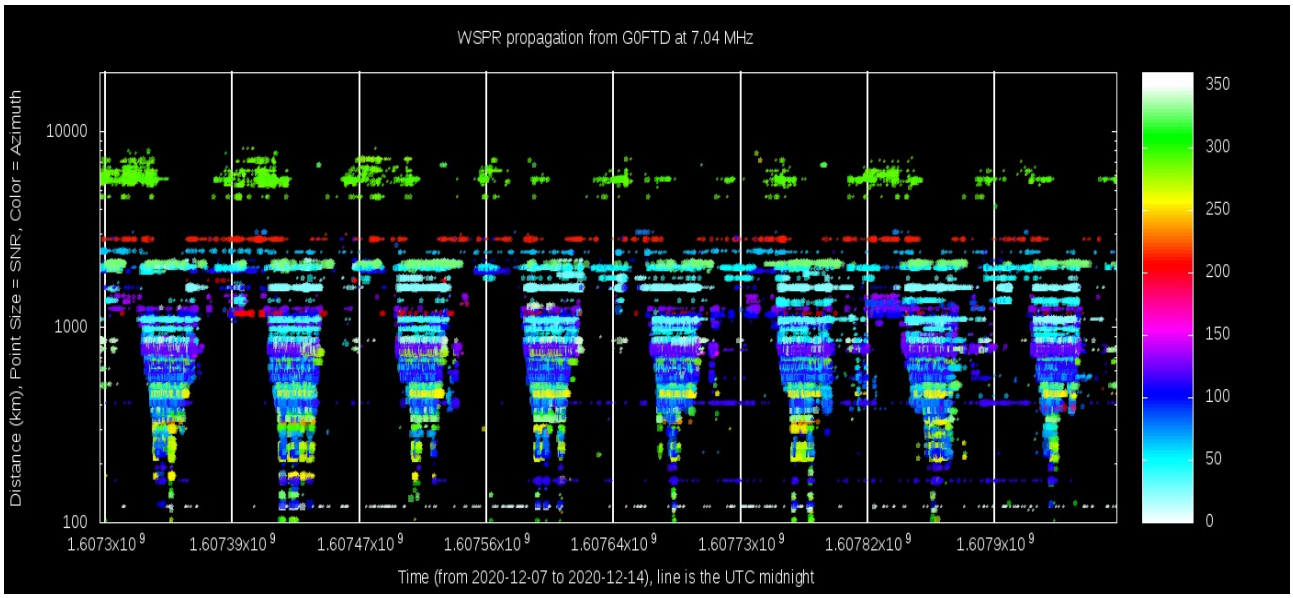


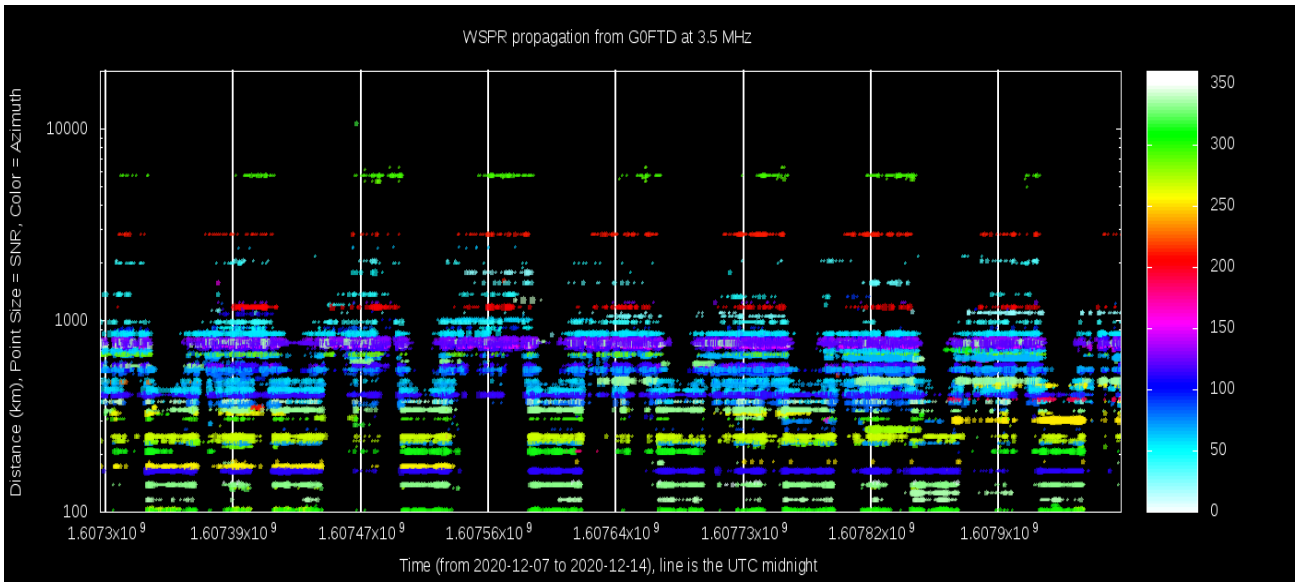
Grey line propagation was having an effect on TF3HZ's signal was interesting. Both F layers were merging, and as TF3HZ's signals were passing through this point they became diffused quite nicely, as much as 30Hz. Youtube link here.

The Observation Post

Meanwhile at Radovan's OK1FCX's observation post, a certain G0FTD has been observed on a long term basis. For several years now, Radovan has been automatically scraping WSPR spots involving the three permanent 24/7/365 transmitters from Andy G0FTD.

The results are then published each day on Radovan's website. Each chart shows the **distance on the vertical axis**, and the t**ime / day on the horizontal axis**. Below are two charts taken from early December 2020, for the 80m and 40m bands. You can clearly see how night ad daytime effects the long and short skip conditions on both bands. Short skip is better around midday, and long skip around midnight.





For the latest info, including a 10m band chart please visit:

https://www.qsl.net/ok1fcx/

A Super Grabber's Work never seems to end

By Dave WA5DJJ

I built the SUPER GRABBER as a engineering prototype to study the process of collecting and viewing QRSS signals from all over the world using inexpensive, easy to build hardware, and simple antennas. While the hardware part was straight forward and interesting, other problems of performance evaluation were more illusive.

I now have 13 individual QRSS grabbers on various antennas faithfully listening to their 200Hz bands on frequencies from 2200M to 6M. Now the question is "how do I know that they are all working?" What methods or practices can I do to ensure that I can receive a QRSS signal on any of the grabbers? Following are the methods I am using to try to evaluate all of my QRSS Grabber's performance.

Firstly I have a great group of QRSS Mafia Members around me that are helping me by keeping a signal on each of my grabbers as "keep alive" signals. They keep a low powered or regular powered signal on the air on one or more of the Grabbers so that when you look at it on the internet, you see a signal. That really helps for the close in signals but what about the far away ones?

The number of "far away" signals are on a catch as catch can basis and there are a few QRSS transmitters that I see daily on my grabber and from that can try to evaluate performance. I usually use a Propagation prediction program and with the Solar Flux Index, A index, and K index, So I can get a feel for what the long range propagation is like.

I wish there was more "far away" QRSS signals, but that varies drastically from day to day. I am always hoping that all the U3S Operating WSPR transmitters (there must be thousands by now) would slightly modify their WSPR transmission programs to include one or two QRSS transmissions in each 10 minute period to greatly enhance the quantity and diversity of QRSS signals on the air. But my attracting interest in QRSS is a bit painful.

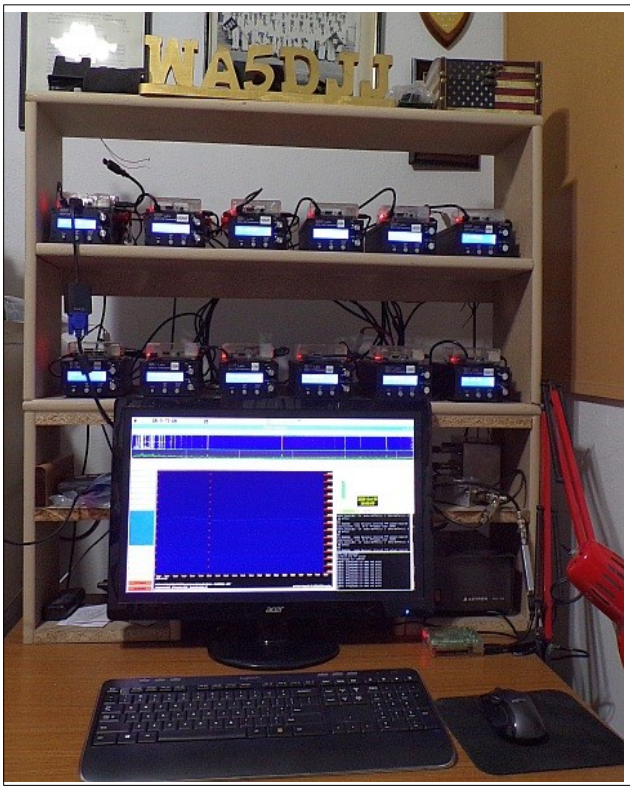
Another method which has given me some really good data has been to modify my Grabber's Raspberry Pi program load which used LOPORA for QRSS to include also running WSJTX in the WSPR mode. What this does is allow me to use QRSS in the normal Spectrum Analyser mode and view QRSS signals normally, but also receive and report WSPR signal detection for each grabber receiver.

It is also an excellent method of determining what the radio wave propagation is doing. Adding WSJTX to my Grabbers also had some other very useful side effects. It gives me a 3KHz wide view spectrum analyser view of the receiver band pass when looking for interference problems and finding signals that seem to have slipped out of my QRSS Screenshot frequency range. It also has given me a audio input level meter to aid in adjusting the receiver audio output to the sound card from my receivers.

This one addition has helped me setup and keep track of the input audio adjustments that keeps the QRSS grabbers aligned. (LOPORA also has an input audio level indicator and balancing the audio input to both WSPR and LOPORA has helped me keep the adjustment process of receiver audio output / LOPORA input / WSPR input all in harmony).

Another method I am just starting is to take a WSPR signal count of the number of WSPR signals on each band that are received by my grabber receivers. I have just started this. I take a count of the number of signals copied over the 24 hour period hoping to find a trend as the weeks and month go on. It is a easy thing to do and it gives me a feel for how the Grabber Receivers are operating. (I know this is arbitrary number because of the variable of the number of WSPR stations transmitting varies from minute to minute/day to day but it may be useful to spot trends of signals in the bands) I will do this for a while to see if it is useful. So, these are my methods to try to keep track of my SUPER GRABBER'S performance.

You may have your own methods that maybe vastly different from mine. That is OK! I have only been doing this for about 4 years now and I am still learning what works, what is a waste of time, and what doesn't work. All of these things are being done with the hope that improved performance of an inexpensive QRSS grabber system is possible.



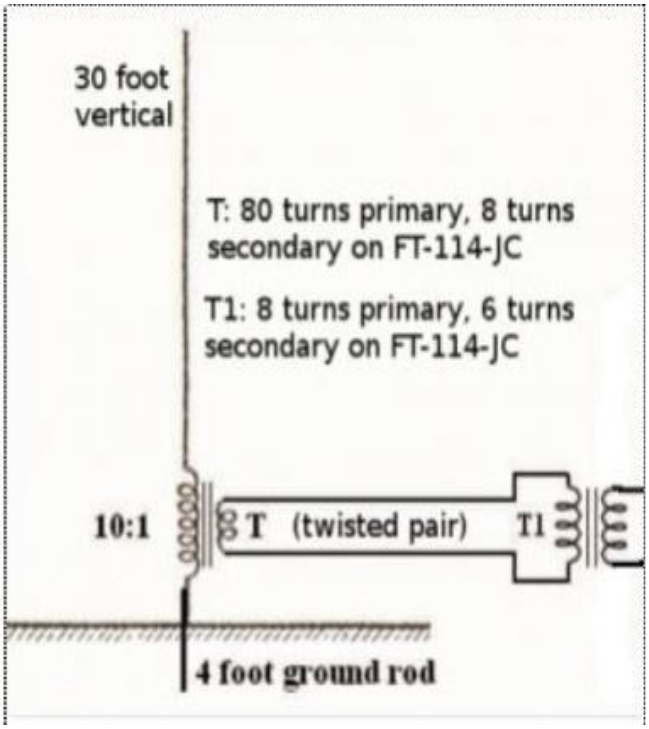
LEFT. Dave's world famous "Super Grabber" that has been rebuilt <u>again</u> using the 2020 versions of the QRP Labs QCX trancievers. **BOTTOM.** Dave back in 1960.

The Super Grabber work continues on too 2200M and 630M. Since I started the QRSS SUPER GRABBER, I have been trying to get something setup to monitor the 136KHz and 474KHz bands here in New Mexico. My dream was to have a QRSS Screenshot as well as a WSPR monitor on both bands. Since 2018, I really started concentrating on these two bands as the rest of the SUPER GRABBER was up and running pretty well on the HF bands. I live is a rather compact urban area of Las Cruces, New Mexico and have very little space for large antennas or just any antennas really. So, the antenna for the LF and MF frequencies was going to be one of the problems. The other problem to make this more difficult is the locally generated noise in the local area.

To the north of me about 1,000 feet away is a 300+ apartment building. To the southwest of me is another one about 3,000 feet away and there are many small 3 or 4 apartment buildings all around me. I live in a town house which is a row of houses on both sides of the street and the combined RF noise from all of the computers and other electronics is sometimes unreal. On many of the first few attempt to listen on the LF and MF frequencies was very discouraging. I was always blaming the local noise for masking my receivers so I couldn't detect anything. But I kept trying. On day I was reading a blog from N1BUG about a LF/MF antenna prototype that sounded like I could put in my yard.

http://blog.n1bug.com/2017/11/21/low-noise-vertical-for-lf-and-mf-receiving/

This would be about the 10th or 20th try to receive something on LF/MF with a small antenna, but what do I have to lose. Maybe, Just maybe one of these will work. The diagram I started with was this one and tried to build me something close to test with:



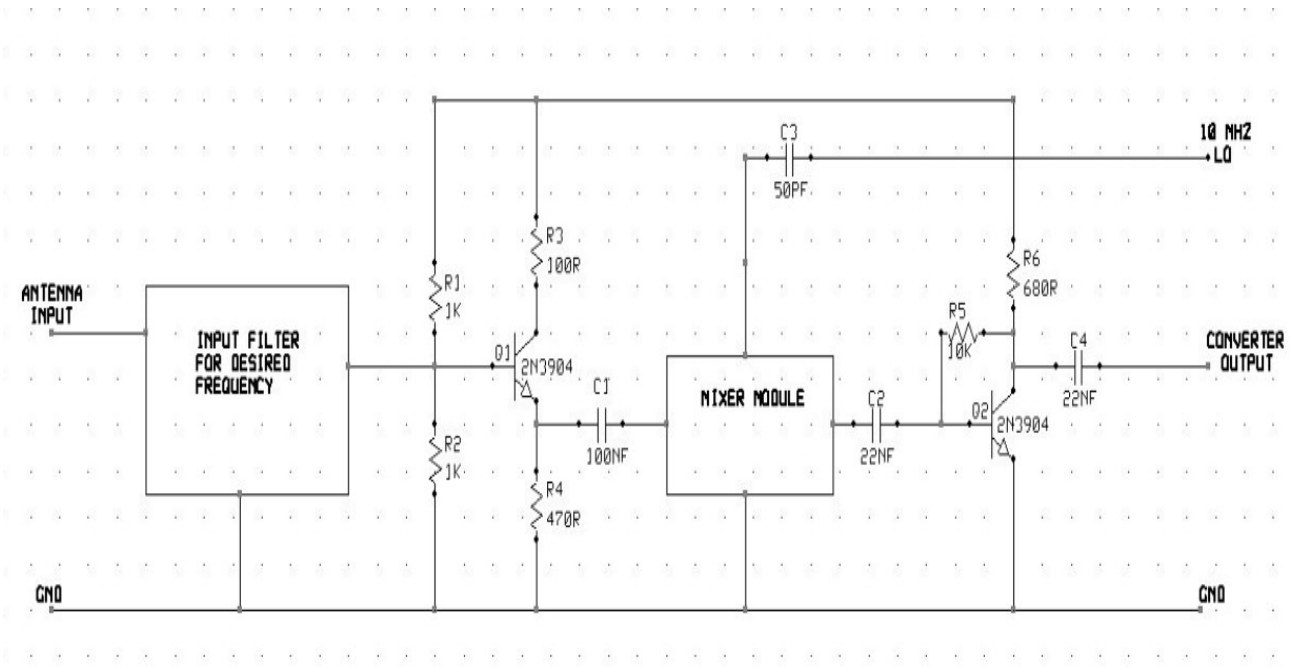
Mine didn't quite come out exactly like this and my deviation from the design were comical and yet it still worked. Instead of twisted pair wire, I used army field phone parallel conductor wire. The main transformer I wound exactly like the picture and my vertical wire was only 17 feet long (some more Army field phone wire taped to a MFJ fiberglass collapsable pole.

I connected the other end of the Army field phone wire to a PREAMP. (a standard 2N2179 design from all over the internet). The one I used as a guide was http://www.mtmscientific.com/preamp.pdf and using the T1 transformer design from N1BUG and the input transformer for the preamp. It was really great to now hear signals on these two bands almost immediatly as the sun went down.

THE UP CONVERTERS FOR THE LF BANDS: There are a lot of radios that are made these days to receive 630M and a few others that will also copy 2200M. But my SUPER GRABBER uses a QCX+ by choice as the receiver. So, I devised a method of up converting the 2200M band and the 630M band using my 10MHz frequency standard signal as the Local Oscillator into a mixer module and that allowed to receive 136KHz on 10,136,000 Hz and 474Khz on 10,474,000Hz on a 30M QCX Transceiver.

The mixing is quite conventional, with a simple LC filter to pre-select the LF bands and a pre-amo into the mixer, which has the second port fed with the high stability 10Mhz oscillator.

This is not anything new in technology circles but there didn't seem to be any commercial up converters to do that conversion. There were a couple of kit ones that I tried with mixed results so it was back to the work bench to build my own. I ended up with this from notes in one of my favorite W1FB NOTEBOOK and others to end up with this schematic:



There are many LF and MF front end filter schemes that you can find on the internet that can be folded into this schematic, and there are other amplifier designs that can also be used. I settled on this one because I had a lot of the parts readily available in my HUGE JUNQUE BOX. The mixer module is an old **Mini Circuits SBL1,** but there exist many off the shelf products, such as SA602's. For a list of other example have a look at the links at the end of the article.

This design works well on the 2200M, 630M and the 160M SUPER GRABBER QCX and QCX+ receivers. This is not considered a end all design. My SUPER GRABBER is an engineering prototype and things change from time to time when I think it will improve performance.

THE REST OF THE SYSTEM: The rest of the receiving system described here now boils down to what receiver you have that you can hook the antenna and up converter up to.

You don't have to have an expensive 10MHz frequency standard for the Local Oscillator. On the internet there are a lot of 10MHZ TCXO oscillators that will work very well as the local oscillator for this converter. In fact I was using on that I had purchased for arround $10 when I was building and testing this system. Any radio that will tune the 10MHz frequency and is stable will work very well and if you can output the audio to a computer, there is a number of really great software to display the WSPR and QRSS data on your computer screens. At the present instant, the WSJTX software gang is working on a new mode for WSJTX to provide what they call FST4 and FST4W. It is a communications mode and a beacon mode for the LF and MF community and is in WSJTX version 2.3.0 and should be the standard version by the time this is published. So, by using this article as a guide, you to can be the first on your block to start copying LF and MF signals on your new setup.

73/4 de Dave WA5OJJ

Link to online front end filter designer - https://rf-tools.com/lc-filter/

Mixers and other useful RF parts - https://www.rf-microwave.com/en/mixers/477/

SEVEN YEARS OF QRSS PLUS. THOUGHTS AND MUSINGS OF AJ4VD

The QRSS hobby owes much of its success to the extraordinary efforts of amateur radio operators who run and maintain QRSS grabber stations. QRSS grabbers are built by pairing a radio receiver with a computer running software to continuously convert the received signals into spectrogram images which are uploaded to the internet every few minutes. QRSS Plus is a website that displays these spectrograms from active QRSS grabbers around the world. This article discusses the history of QRSS Plus, the technical details that make it possible, and highlights its most active contributors in 2020.

Early Days of QRSS Grabber Websites

In the early 2010s when I started to become active in the QRSS community, one of my favorite grabber websites was I2NDT's QRSS Knights Grabber Compendium. I remember checking that website from my laptop during class several times throughout the day to see if my signal was making it out of Gainesville, Florida. I also recall many nights at the bench tweaking my transmitter and looking at all the grabs from around the world trying to spot my signal.

A common problem with QRSS grabber websites was the persistance of outdated grabber images. Whenever a grabber uploaded a new spectrogram image it replaced the previous one, but when a grabber stopped uploading new images the old one would remain. Most uploaded spectrograms have a date written in small text in the corner, but at a glance (and especially in thumbnails) it was difficult to identify which grabber images were current and which were outdated.

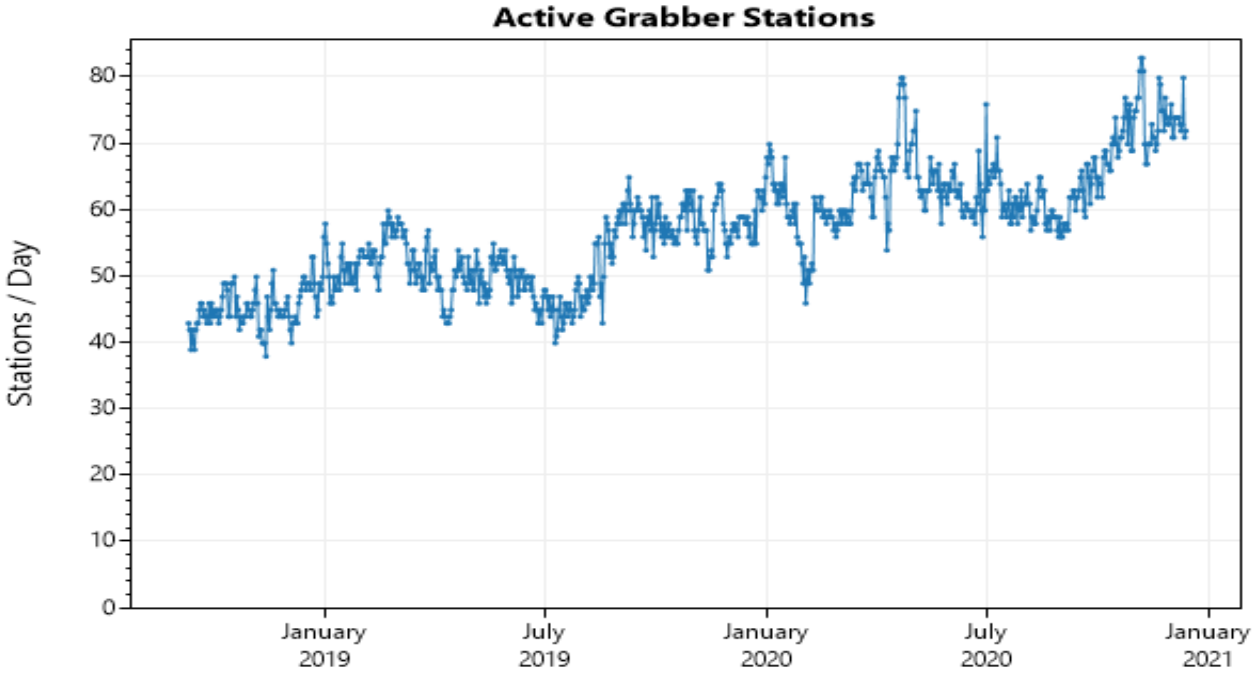
History of QRSS Plus

I created QRSS Plus in July 2013 to solve the problem of outdated spectrograms appearing on grabber websites. QRSS Plus works by downloading grabber images every 10 minutes and recording their MD5 hash (a way to convert an image into a unique set of letters such that when the image changes the letters change). Grabbers were marked "active" if the MD5 hash from their newest image was different than the one from the previous image. This original system was entirely operated as a PHP script which ran on the back-end of a web server triggered by a cron job to download new images and update a database every 10 minutes. The primary weakness of this method was that downloading all those images took a lot of time (they were downloaded sequentially on the server). PHP is famously single-threaded, and my web host limited how long PHP scripts could run, limiting the maximum number of supported grabbers.

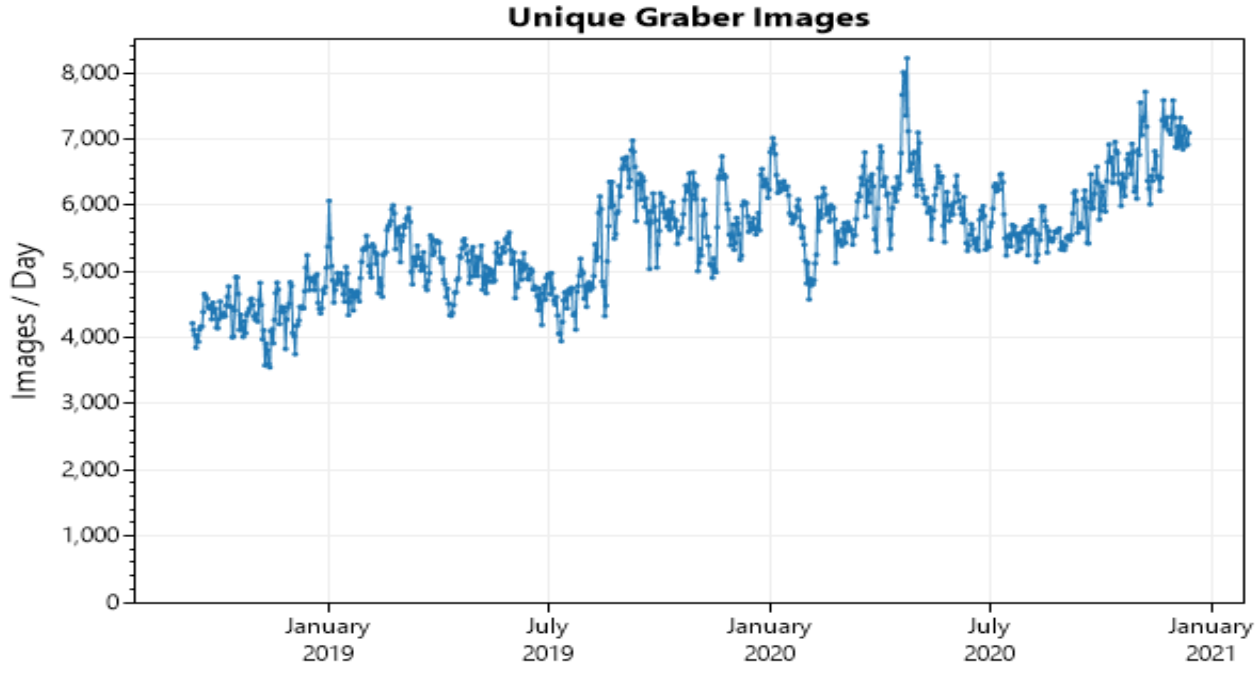
The back-end of QRSS Plus was redesigned in 2016 when I changed hosting companies. The new company allowed me to execute python scripts on the server, so I was no longer limited by the constraints of PHP. I redesigned QRSS Plus to download, hash, and store images every 10 minutes. This allowed QRSS Plus to display a running history of the last several grabs for each grabber, as well as support automated image stacking (averaging the last several images together to improve visualization of weak, repetitive signals). This solution is still limited by CPU time (the number of CPU seconds per day is capped by my hosting company), but continuously operating QRSS Plus does not occupy a large portion of that time.

QRSS Plus Activity in 2020

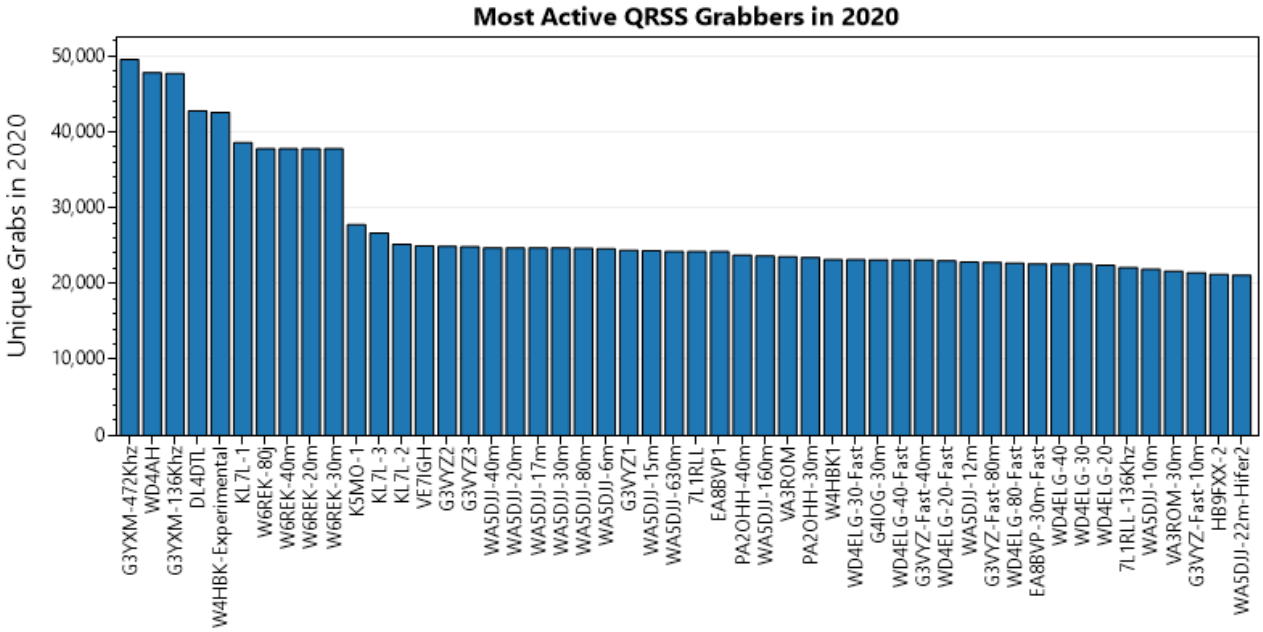
I started logging grabber updates in September 2018, allowing me to reflect on the last few years of grabber activity. It takes a lot of effort to set-up and maintain a quality QRSS grabber, and the enthusiasm and dedication of the QRSS community is impressive and inspiring!



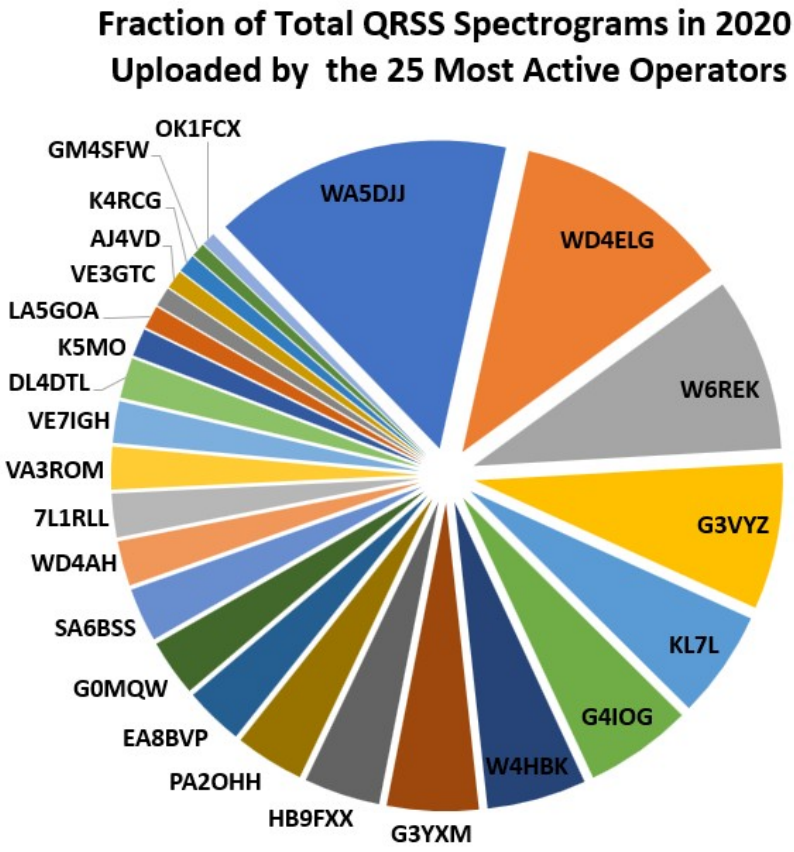
In 2020 our community saw 155 active grabber stations! On average there were more than 60 active stations running on any given day, and the number of active stations is visibly increasing with time.



In 2020 QRSS Plus analyzed a mean of 6,041 spectrograms per day. In total, QRSS Plus analyzed over 2.2 million spectrograms this year!



This bar graph depicts the top 50 most active grabber stations ranked according to their total unique spectrogram upload count. Using this metric grabbers that update once every 10 minutes will appear to have twice as many unique grabber images as those which upload a unique image every 20 minutes.



Many QRSS grabber operators maintain multiple stations, and I think those operators deserve special attention! This year's winner for the most active contributor goes to David Hassall (WA5DJJ) who alone is responsible for 15.26% of the total number of uploaded spectrograms in 2020

The top 25 contributors with the greatest number of unique uploads in 2020 were (in order): WA5DJJ, WD4ELG, W6REK, G3VYZ, KL7L, G4IOG, W4HBK, G3YXM, HB9FXX, PA2OHH, EA8BVP, G0MQW, SA6BSS, WD4AH, 7L1RLL, VA3ROM, VE7IGH, DL4DTL, K5MO, LA5GOA, VE3GTC, AJ4VD, K4RCG, GM4SFW, and OK1FCX.

Maintaining QRSS Plus

I want to recognize Andy (G0FTD) for doing an extraordinary job maintaining the QRSS Plus website over the last several years! Although I (AJ4VD) created and maintain the QRSS Plus back-end, once it is set-up it largely operates itself. The QRSS grabber list, on the other hand, requires frequent curation. Andy has done a fantastic job monitoring the QRSS Knights mailing list and updating the grabber list in response to updates posted there so it always contains the newest grabbers and uses the latest URLs. On behalf of everyone who enjoys using QRSS Plus, thank you for your work Andy!

The Future of QRSS Plus

Today QRSS Plus is functional, but I think its front-end could be greatly improved. It is written using vanilla JavaScript, but I think moving to a front-end framework like React makes a lot of sense. Currently PHP generates HTML containing grabber data when the page is requested, but a public JSON API would make a lot of sense and make QRSS Plus it easier to develop and test. From a UX standpoint, the front-end could benefit from a simpler design that displays well on mobile and desktop browsers. I think the usability of historical grabs could be greatly improved as well. From a back-end perspective, I'd much prefer to run the application using a service like Azure or AWS rather than lean on a traditional personal website hosting plan to manage the downloads and image processing. Automatic creation of 8-hour (stitched and compressed) grabber frames seems feasible as well. It is unlikely I will work toward these improvements soon, but if you are a front-end web developer interested in working on a public open-source project, send me an email and I'd be happy to discuss how we can improve QRSS Plus together!

QRSS is a growing hobby, and if the rise in grabbers over the last few years is an indication of what the next few years will look like, I'm excited to see where the hobby continues to go! I encourage you to consider running a grabber (and to encourage others to do the same), and to continue to thank all the grabber operators and maintainers out there who make this hobby possible.

73/4 de Scott

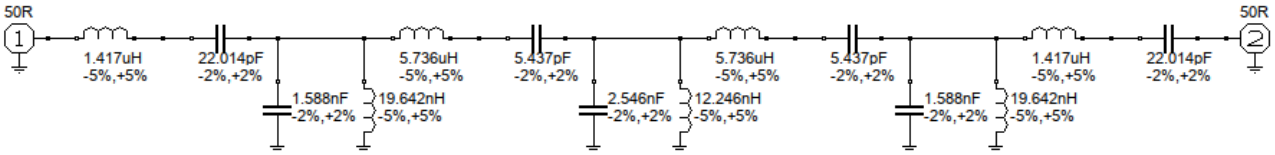
Notes and resources:

Data includes Jan 1 2020 through Dec 11 2020
Stations with <1000 unique uploads were excluded from most analyses
Summary data (table of unique images per day per station) is available: qrss-plus-2020.xlsx
Bar graphs, scatter plots, and line charts were created with ScottPlot
QRSS Plus is open source on GitHub
A modern introduction to QRSS: The New Age of QRSS
FSKview is a new QRSS and WSPR Spectrogram Viewer for Windows

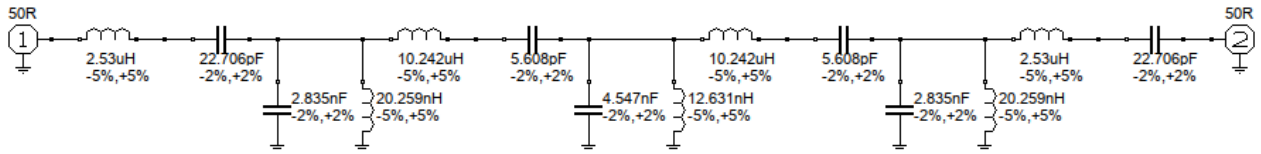
Filters for RTL Dongles.

Having an RTL dongle on it's own is only part of the story. They still require some pre-selection of signals to be really effective especially for QRSS, where any imperfections can easily be seen and ruin reception. Without filtering, the dongle can appear to be deaf, usually caused by chronic reciprocal mixing of signals, creating an artificial noise floor, or what have become termed as the "lines of death". The lines of death can usually be seen especially on the 10.1Mhz band once darkness arrives. This is because broadcast signals on the lowers bands have now drastically increased in signal strength, and mixing products occur. Those products result in weak carrier signals that make unwanted QRM lines on the grabber. But they are not restricted to being seen only on the 10.1Mhz band, but any band. Presented here are some no nonsense filters that are perfect for QRSS grabbers and protection again broadcast band overload. There are two versions for 20m.

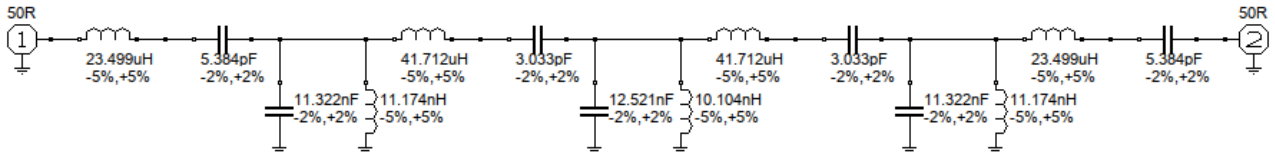
10m band filter. A passband 27.500 – 29.700MHz with -40db @ 26.200 and 31.000 MHz



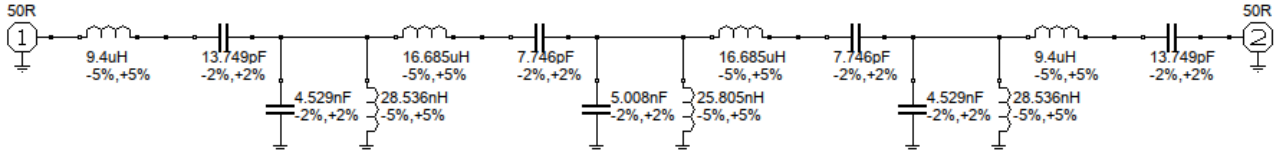
15m band filter. A passband 20.500 – 21.500MHz with -40db @ 19.700 and 22.400 MHz



20m band filter. A passband 14.000 – 14.350MHz with -40db @ 13.830 and 14.470 MHz

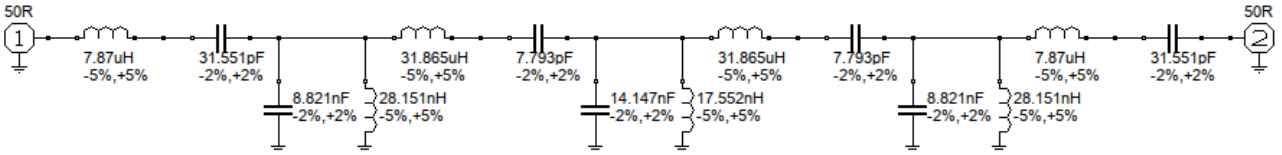


22m band filter. A passband 13.520 - 14.500MHz with -40db @ 13.200 and 14.800 MHz

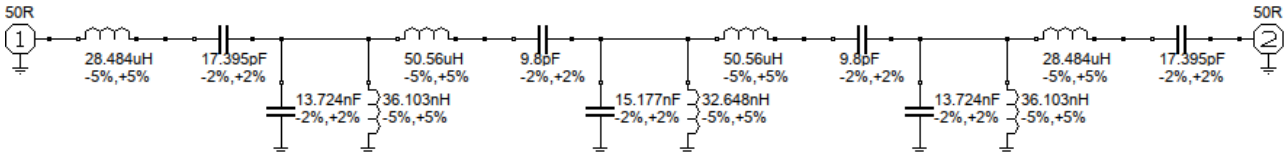


Filters for RTL Dongles.

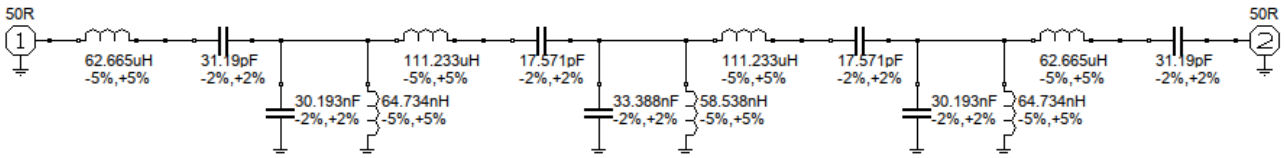
30m band filter. A passband 9.900 – 10.280Mhz with -40db @ 9.700 and 10.250 MHz



40m band filter. A passband 7.000 - 7.300Mhz with -40db @ 6.900 and 7.415 MHz



80m band filter. A passband 3.500 - 3.700Mhz with -40db @ 3.450 and 3.720 MHz



As you can see, these filters are sharp, but have an almost flat response in their passband. The in band ripple is less than 0.5db, with about 0.1db loss. This is what sets them apart from simpler filters. But of course, they need more components. It's also a good idea to test them on a VNA, something that is so cheap these days that there's no excuse not to have one. The filters were designed using RFSIM99, software that I have used for many years. It has ALWAYS produced 100% accurate designs. When constructing these filters, be sure to use excellent quality inductances They are best would on small ferrite rings. Yes, it's true that making high quality filters might involve spending a little money on small toroids but it's worth it. Never ever ever use those dreadful small moulded inductances. The Q is terrible and will totally ruin any narrowband quality of these filters. You have been warned ! Filters should be individually optimised with a VNA.

Poor for RF filters !

Good for RF filters

Martin G8JNJ is well known for his excellent work with SDR radio, as well as many other aspects of RF. His website also includes some useful information too, relevent to RTL dongles and front end filters etc.

See here -

https://www.g8jnj.net/softwaredefinedradio.htm

So just how sensitive is an RTL dongle ? Surprisingly it's been hard to obtain any useful data, especially for the **direct sampling mode** that is used on HF by some grabber operators. I asked G8JNJ this question, and Martin had the answer within minutes. At 10Mhz, a figure of **-115dbm** was required to produce a 3db quieting within a 3Khz bandwidth. My understanding is that this figure should hold good across the HF range. This figure is for direct sample mode only. Most tuner dongles have an additional preamplifer inserted when used above 24Mhz, and can be more sensitive. This is why a dongle will run a lot cooler, and use less power in direct sample mode.

Chart of natural noise levels (SSB)

160m	-93dbm (S6)
80m	-101dbm
40m	-106dbm
30m	-110dbm (S3)
20m	-114dbm
15m	-118dbm
10m	-121dbm (S1)

Certainly up to the 20m band we have enough sensitivity. It could be argued that on the lower bands, we could actually do with losing 10-15db. This would greatly assist in preventing overloading and spurious signals which can be a real problem with these dongles. Above 20m we are a bit on the borderline of sensitivity. A small pre-amp could be useful, or we could switch to using the non direct sample mode (normal mode) on the RTL Dongle once we reach 24Mhz. In the real world, all this means is that on the 17m and 15m we might be a few db below optimum. Is that couple of db really that band ?

One could argue that normal galactic / atmospheric noise is the baseline, but perhaps on top of that you may well already be exceeding this level due to everyday noise from computers, internet over telephone lines, noisy switch mode PSU's and battery chargers, and numerous other electrical devices. [Chart shows ITU derived figures] But if you are a purist then you might want to add a pre-amp to the set up. My preference for pre-amps comes in the form of the Mini Circuits MAR devices. The are so simple. Add volts, an input and an output connector and that is it. No impedance matching components etc. Something like an MAR6 would be a good start. Look here https://qsl.net/g0ftd/other/misc/mini-circuits-mar-amp-devices-mmics.pdf

Typical cost is about $5 each. Of course, you should still be using an excellent quality front end filter too, with or without a pre-amp.

Grabber home page naming. It seems that the default naming convention by HTML editors these days ends up naming files as .html (you should always use lower case). But it may be better for grabber operators (or simply qsl.net users) to have their home pages renamed to .htm instead. It's all to do with the way modern browsers overide some display settings . The three letter extension will allow the end user to shorten the URL and view the directories on your site. That way, if you're having problems displaying your grabs and ask for help, we can see where they are landing and assist you. It also means that if you wish to create a small file repository for your users then you can do so (a bit like Google drive), and the end user can see those directories and download from them. Don't abuse it though. Radio files only and stick to a sensible limit is all that qsl.net ask for.

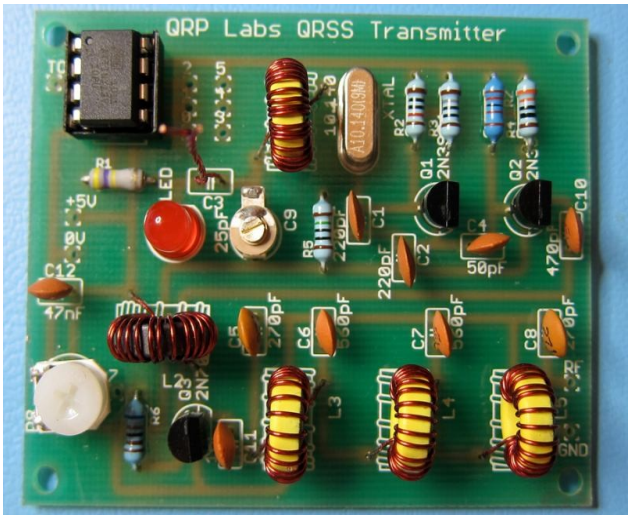
High Altitude Weak Signal Adventures
Development of telemetry over WSPR system
Hans Summers, GOUPL (QRP Labs)

This article is about the invention of a system for sending telemetry over WSPR for use on tracking long distance balloon flights for a QRP Labs tracker development; variations of the concept have since been used by other balloonists in their own developments.

Some history

I first started playing with QRSS in late 2003. Back then, there was no WSPR. There was only a very small gang known as QRSS Knights, gathered together on a mailing list, experimenting with various weak-signal mode variants of QRSS, plain slow on/off CW with typically ~5 second dit time.

I had a lot of fun designing and operating simple transmitting beacons, and more complex message encoding beacons; even a simple receiver. You can read about some of these on my website: http://hanssummers.com. In 2010 that led to the first QRP Labs kit (pictured below), a simple low cost FSKCW callsign beacon with about 100mW power output. It was the start of a thriving kit business, which since 2016 has become my full-time job, and filling my mind every waking (and sleeping) moment.



Roll along 2009 or 2010 or so, I had an idea to build an ocean-going buoy which would have some solar panels and a QRSS transmitter. It would have a bunch of sensors on board, and a GPS, and report back its location and the sensor values. Every day I used to walk to work along the river Thames in London and I'd be looking at the water and imagine my drain-pipe type of buoy bobbing along in the water (though really, practically speaking, you'd have to drop it off a boat miles off the coast, to avoid it getting stuck somewhere).

I called the project "Voyager", after the two NASA space probes launched in the 70's which still send back signals from the far outer reaches of our solar system. I had always been fascinated by spacecraft exploring the solar system. To me, a buoy floating around in the North Sea would be kind of like a poor-man's personal explorer. Some of the challenges are even similar, but on a much smaller, more hobbyist-solvable scale: sensors, long distance communications, low power. I actually built a transmitter and a 40m receiver to operate the project, but never got far with it. You can read more here http://hanssummers.com/voyager.

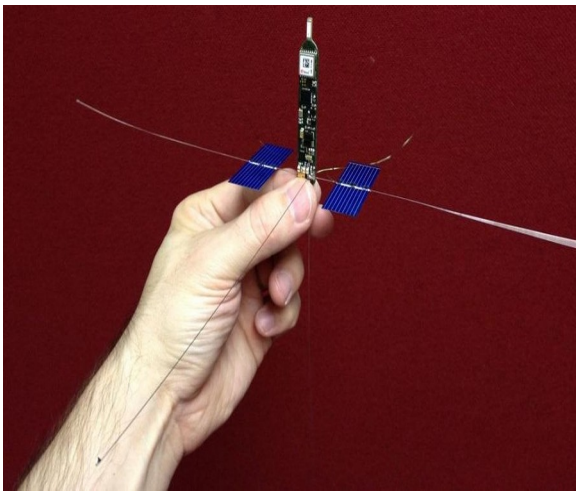
The next thing I found really interesting was the High Altitude Balloon (HAB) launches, which often seemed to be an engineering project in US universities.

These use weather balloons filled with helium and ascend to up to around 30-35,000m altitude, where they burst, deploy a parachute and come back to Earth. At that altitude, the sky looks black and the curvature of space is easily visible. So it's popular to take along video cameras, as well as GPS and radio equipment for communicating the altitude and position, and batteries to run all that.

Since these large balloons 2-5m in diameter can carry quite a significant payload, around 500 grams, they don't have to try to miniaturize anything. The flights last a few hours, during which time they typically have line of sight radio communication with the balloon, so UHF telemetry is feasible e.g. on 70m bands. They often use integrated UHF telemetry modules for the communication. The chase is as much fun as the launch – teams enjoy driving sometimes a couple of hundred miles to hunt the balloon, to retrieve their equipment and precious photography and videos (see right).

Exciting though that all is – what REALLY made me sit up to attention, was when I came across the so-called floater or pico balloons in 2014. They're a fraction of the size, a fraction of the weight, and a fraction of the cost (see right). Leo M0XER made the news in July 2014 with his first circumnavigation. It was the 64th flight in Leo's balloon obsession that had started just over a year earlier. Leo had two more circumnavigation flights, B-63 and B66. He then appears to have retired from ballooning. Leo's flights are all detailed here: http://leobodnar.com/balloons/

A weather balloon is made from latex (rubber), which stretches and stretches as it rises through the atmosphere and the air pressure decreases. Eventually it can stretch no more and BOOM it bursts, and down it comes. Some latex balloon flights have succeeded in judging the amount of gas required at launch very precisely, and achieving an equilibrium altitude where the pressures balance but the balloon envelope doesn't burst. Then they can travel quite long distances. The sun's strong ultraviolet radiation attacks the Latex though and as far as I know, they can't last more than a few days.



Floater balloons are different. They're made from a mylar film (plastic) material. You've all seen the shiny foil balloons at parties, with helium inside. This is what is used for floater balloon flights. The mylar doesn't stretch (much). The balloon is launched only partially gas-filled; as the altitude increases the gas expands, and eventually fills the entire available volume of the balloon. If you didn't over-fill it at the launch site, then an equilibrium altitude is reached, where the balloon can just float along in the wind. The mylar film is inelastic and can withstand a certain pressure without bursting. It's a lot easier to target an equilibrium state than with a latex balloon, and the mylar film is much more UV-resistant. The flights can last days or even months.

The main risk to floater balloons is the weather. High altitude clouds deposit ice on the balloon envelope. It doesn't take many grams of ice to bring it down. We've seen many cases where as the balloon came down, weighed down by ice, the temperature warmed up, melting the ice; and in some cases even evaporating it before the balloon reached the ground, then we could observe a miraculous recovery and the flight continued. But really, if you want a long distance flight, with minimum or no risk of high altitude weather, you have to get above the clouds. 11,000m should be considered a minimum, preferably even more.

The difficulty is – to get to 11,000m you need a very light payload. Typical floater balloon payloads are around 10 grams. 10 grams isn't much, to carry a radio transmitter, power supply (solar panels), antenna, GPS receiver, and some computation capability to tie it all together. Yet, this thing is going to fly around the world. Over wide oceans, desolate landmasses devoid of many radio amateurs. We will want to know where it is, and ideally also something about its altitude, and perhaps other interesting parameters such as temperature and battery voltage.

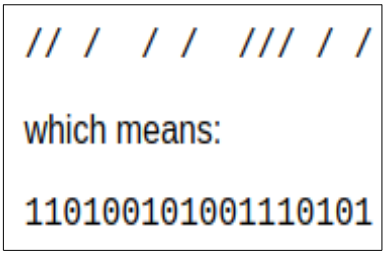
Which brings us to the crux of the matter, and the reason we're all here: RADIO COMMUNICATION. The weather balloon crowd don't have so much of a problem because their balloons travel a couple of hundred miles at most, and the flights are all over in a few hours. Several watts of VHF or UHF will be easy to power with batteries, and they can carry ½ a kg or more; although it isn't trivial, neither is it particularly challenging. APRS is a popular tracking solution.

But for floater balloons the situation is entirely different. Not only do we need radio communications capable of spanning thousands of kilometers, but we can only carry a few grams. There's no possibility of carrying enough batteries for a flight lasting weeks, so solar cells are in order. And we certainly can't carry enough solar panels to generate several watts of RF. How can this be resolved?

Leo M0XER had used VHF modes mainly. The problem there is that as soon as your balloon flies over an ocean, or a sparsely inhabited part of the planet without lots of radio amateurs monitoring, everything goes quiet. You have no idea where the balloon is, until (if you're lucky), it files within a few hundred km of a radio amateur who happens to be monitoring whatever mode and frequency you're transmitting on.

I came across various US flights using APRS http://www.aprs.org/ and they have exactly the same problem. With APRS, matters are complicated by the fact that different parts of the world use different APRS frequencies, so your balloon transmitter needs to be programmed to automatically adjust its transmission frequency depending on its location.

The solution to the communications problem must be weak signal modes on HF. Weak signal modes because we just don't have enough power capability, or enough payload carrying capability, for anything more than a few milliwatts of RF. And HF for the beyond line-of-sight range. I had recognized this back when I'd been thinking about the "Voyager" ocean buoy project, and had planned to use a telemetry system involving slanted dashes, whose presence would indicate a 1 and absence, a 0. The problem with that would have been painstakingly slow and tedious manual decoding. Example BELOW.



The next great innovation as far as I was concerned, was by Andy VK3YT who launched a series of flights from Melbourne, Australia, documented on his website http://picospace.net/. Andy's "balloon phase" appears to have lasted from February 2014 to his 73rd flight which was in December 2019. Many of Andy's flights used JT9 mode and WSPR on 30m and 20m HF bands.

JT9 is a weak signal communications mode with powerful error correction. 13 characters of text are encoded into a series of 9-tones. These are transmitted typically in a 1-minute transmission (though the protocol also supports slower transmission rates for higher SNR).

Andy VK3YT developed a special telemetry protocol in which he encoded the various parameters such as location, altitude, battery voltage etc into a 13-character transmission for JT9. One important detail to mention, is that Andy didn't just take each character of the JT9 transmission and make it mean something, for example for altitude, A means 500m, B means 1000m, C means 1500m etc. Instead, he decided the resolution he wanted on each telemetry parameter, and encoded that into bits that were then reversed out into the 13 character transmission for JT9. This allowed him a lot more flexibility on data resolution.

Andy VK3YT actually needed TWO JT9 transmissions to transfer all the data he wanted. For decoding and collecting the data from tracking stations, he modified the WSJT-X software package, which is Open Source, to be able to decode his two JT9 telemetry packet styles, and upload the decoded data to his own server. Use of HF weak signal modes allowed Andy to reliably track his balloons even across the largest ocean of all, the Pacific ocean. He had several circumnavigation flights.

I followed all these flights avidly around 2014/2015. Around that time, I was also developing firmware improvements for the Ultimate3S http://qrp-labs.com/ultimate3/u3s which is a QRSS and WSPR and other weak-signal modes transmitter you probably know of, and is standalone with no PC required. I had had some requests to include JT9 in the list of supported modes and was working on that.

In late 2013 I had been discussing an ocean floater with tracker with a group of South African radio amateurs. Then around Feb 2014 I had an email from Dave VE3KCL, which really was what kicked my balloon dreams into a whole new gear.

Dave had taken an interest in high altitude “floater” balloons and thought it would be fun to launch an Ultimate3S on a balloon; he was excited to hear that I planned to implement Andy VK3YT’s JT9 balloon telemetry messages.

It was the start of a long friendship between Dave and I that has generated thousands of emails of correspondence, long IM chats, phone calls, meeting in person at Dayton hamvention when Dave came to help me man the QRP Labs booth. Dave has tremendous energy and enthusiasm which is incredibly infectious. In April 2015 I officially included JT9 in the Ultimate3S firmware, and not long after, shared with Dave a series of beta versions that included things like Andy’s JT9 telemetry for balloon tracking.

VE3KCL’s first flight

So it was that in June 2015, Dave VE3KCL launched his first balloon, carrying an Ultimate3S, transmitting WSPR and JT9 telemetry, just as Andy VK3YT did on his balloon flights. It reached an altitude of 4,233m and flew for 2.5 hours, covering 68km. The second balloon flight the following month, had a very similar flight profile. These two flights are detailed at http://qrp-labs.com/flights/s1 and http://qrp-labs.com/flights/s2 . I recall a funny discussion from around this time, where Dave and I were discussing what to call the flights. After all, Leo M0XER used the prefix “B” as in B-1, B-2, B-3 etc., presumably the B was for either Balloon or Bodnar (Leo’s surname), who knows. And Andy VK3YT used PS e.g. PS-1, PS-2 etc., clearly the PS for picospace after his website http://picospace.net. Dave suggested “S” for short, since 2½ hours was evidently as long as they could fly, and so S it was, starting with S-1, then S-2 etc.

By the third flight, Dave had uncovered the cause of the early demise – some heavy gas sitting in the bottom of his hydrogen tank meant that he was over-filling the balloons to get the calculated lift. Once properly emptied out and starting again with fresh, pure hydrogen, the flight durations increased dramatically.

Inventing a protocol for telemetry over WSPR

Meanwhile I continued observing the flights of Andy VK3YT and observed two sort-of problems with the tracking.

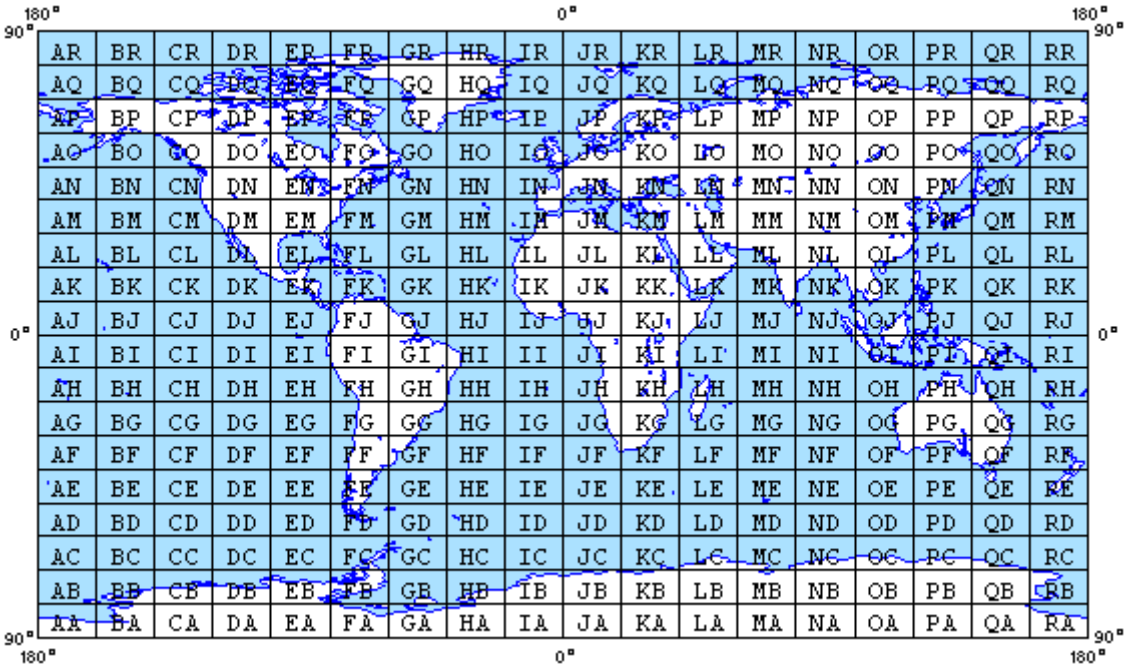
Firstly, by using JT9 for tracking, and a customized version of WSJT-X to decode it and upload the reports to his server, Andy had to recruit his own network of volunteer tracking stations to install the special WSJT-X version and listen for his balloon. This necessarily limited the number of stations globally that could receive the tiny signals from his flights, so there were at times, gaps in the tracking capability.

Secondly, Andy VK3YT was also using WSPR on his balloons. I observed that there were many occasions when no JT9 was decoded, but WSPR was – even by the same receiving stations – which eliminates any effect due to the much larger WSPR receiving network.

This is as you would theoretically expect too, since the bandwidth of JT9, data payload (13 characters) and the bit-rate, are all higher – leading to lower Signal to Noise Ratio (SNR). In other words, more power would be necessary to achieve the same reception reports as WSPR. This is completely normal.

So it appeared, theoretically and practically, that WSPR would be a better solution for tracking balloons. However, a significant problem exists with using WSPR for tracking, too. This is due the fact that unlike the free-format 13-character text message carried by JT9 (and some other JT-modes), WSPR has a fixed-format:

6-character station callsign
4-character Maidenhead grid-square
Power in dBm (19 different levels available)



The power level is one of 19 values from 0 to 60dBm, 0, 3, 7, 10, 13, 17, 20dBm etc. The problem is that a Maidenhead grid square measures 1° latitude by 2° longitude. According to ARRL at http://www.arrl.org/grid-squares, that is “approximately 70 × 100 miles in the continental US” (110 x 160km). Not only is the location precision very coarse, but we also lack that most crucial of parameters watched by any balloonist: the altitude!

I believe Andy VK3YT had started mapping altitude levels to the 19 power levels of the WSPR transmission, so that as a backup, if JT9 was unavailable – and if he had WSPR reports – then he could at least determine approximately where his balloon was and roughly at what altitude. But really, 19 levels is again a very coarse measure, and ideally we’d like more data from the balloon including battery level, temperature and speed. So WSPR in its intended state, isn’t a great tracking tool. The enormous advantage of WSPR is the worldwide tracking network! WSPR has been very popular, and is ever-growing in popularity, since it was first created in 2008. If it were possible to use WSPR for the tracking, then it would solve the first fundamental problem of Andy VK3YT’s HF weak signal tracking, that of recruiting volunteers to install his special software for JT9 decoding.

If the limitations of the protocol could be overcome, we would end up with the PERFECT tracking system for long distance “floater” balloons:

• Long range coverage by using HF
• Weak signal mode works fine with a few milliwatts
• Powerful error correction telemetry
• Worldwide existing network of monitoring stations
• Automatic tracking

Dave VE3KCL and I discussed all this frantically for several weeks and months, with various ideas on how to use the locator field of WSPR transmissions as well as the power level, to carry some of the data we wanted. We called it “WSPR abuse”!

A big breakthrough came when I noticed that NO official amateur radio callsigns ever exist with prefixes 0, 1 or Q, and had the idea that we could make use of this. The International Telecommunications Union (ITU) simply doesn’t allocate any callsigns with these prefixes, according to their published policy. There have been some unofficial operations with callsign prefix, generally operations in states that have no official prefix of their own, or a number of troubled states (that I shall not provide examples of, for fear of somehow upsetting somebody somewhere) around the world whose existence, independence or sovereignty is disputed.

I started to design a telemetry packet, re-encoding our additional data into a second WSPR transmission, which was identified as telemetry, not a real amateur radio station, by using a callsign with 0 or Q as the first of the six characters. I also used the third callsign character, which is by the definition of the WSPR protocol, a numeric digit in the range 0-9. Each balloon telemetry would be identified by its callsign being of the format CxNxxx where:

- C is character ‘0’ (zero) or ‘Q’
- N is a number in the range 0-9
- x are characters repurposed for our telemetry

Therefore 20 different “channels” were created, allowing 20 different balloon flights to use the telemetry system, without interference with each other. Later, inclusion of the ‘1’ prefix increased the number of available channels to 30.

The four characters of the Maidenhead grid square, and the 19 levels of power, were also re-purposed to carry telemetry. A complete WSPR transmission consisting of station callsign, locator and power was therefore represented:

CxNxxx xxxx xx (callsign, grid-square, power)

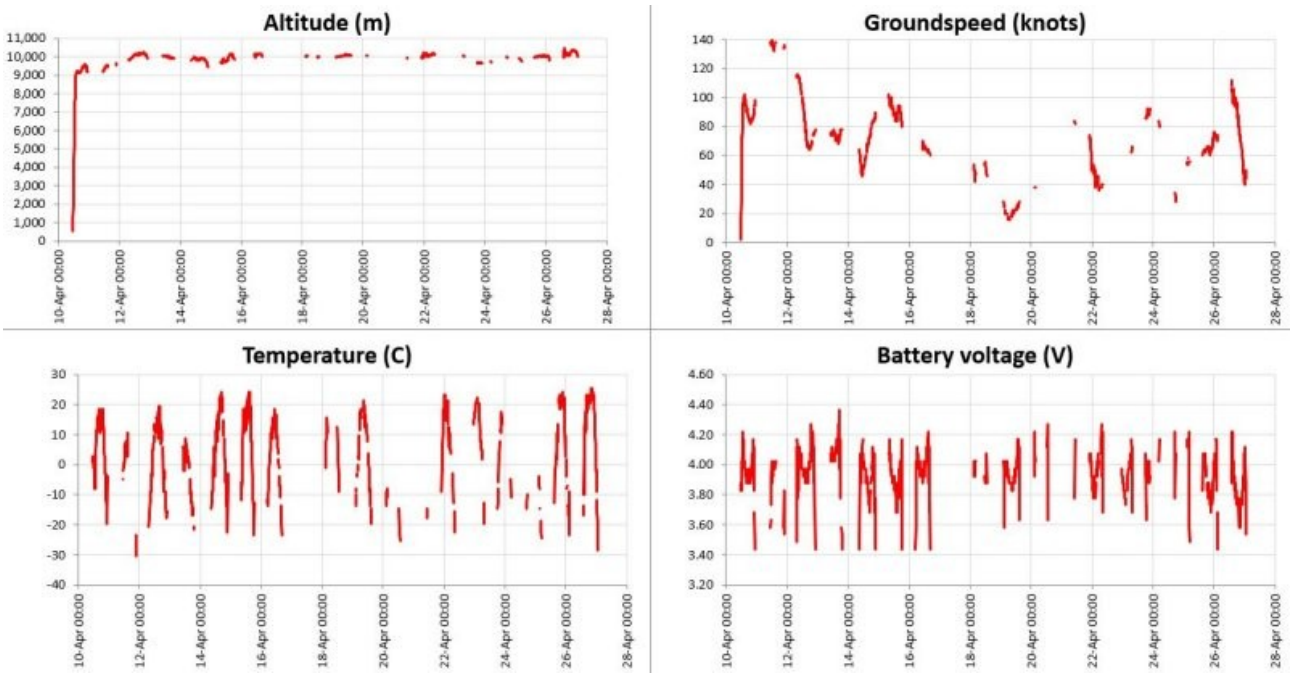
where x are the parts of the standard message whose bits are re-purposed to carry telemetry. A WSPR message contains only 50 bits to start with. These are encoded with forward error correction into 162 symbols, each of which is one frequency transmission (tone), spaced 1.46Hz apart. The symbols are transmitted in just under 2 minutes. After deducting the first callsign character (always 0, 1 or Q), the 3rd (always a number), and allowing for the fact that there are wasted un-used bits in the power field, which cannot be reclaimed – in the end we have only 39 binary bits of data to carry our desired telemetry. So careful thought is required as to the required resolution of data. What I designed for the WSPR telemetry protocol was:

Maidenhead grid subsquare 5'th and 6'th characters, which are letters in the range 'A' to 'X'. In addition to the 4-character gridsquare sent in the main WSPR transmission, this gives us a location resolution of a few kilometers, which is adequate for tracking.

Altitude: range 0 to 21,340m with a resolution of 20m. This altitude resolution of 20m is plenty fine enough!

Temperature: -50C to +39C with a resolution of 1C (90 possible values)
Battery voltage: 3.00 to 4.95V with a resolution of 0.05V (90 possible values)
Ground speed in knots: 0 to 82 knots with a resolution of 2 knots
GPS satellite status bit: 1 if we have a healthy good GPS lock
GPS number of satellites: 1 if there are at least 8 tracked satellites

Altitude, temperature, battery voltage and ground speed "wrap" - by this I mean that for example, if the ground speed reported by the GPS is 86 knots, the telemetry will report it as 2 knots. 88 knots would be reported as 4 knots, and so on. This is important because when the balloons get in the powerful jetstream winds they can certainly exceed 84 knots and do so frequently. It is normally easy to know whether 84 needs to be added to the reported number, because of the difference in position which is easily calculated in kilometers, allowing an approximate speed to be determined, at least well enough to know whether it is above or below 84 knots.

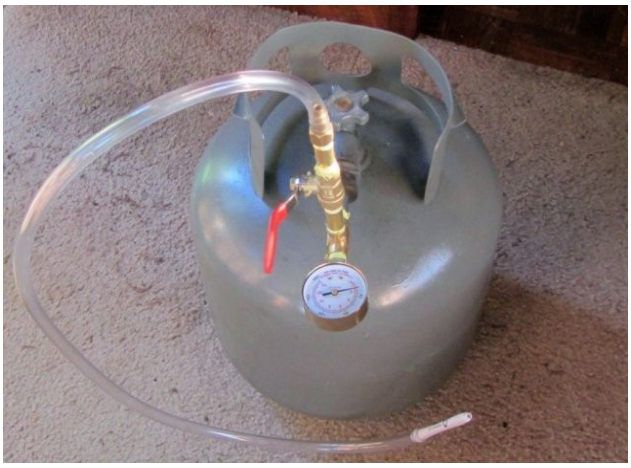


This system is described in detail here http://qrp-labs.com/flights/s4#protocol with an example encoding/decoding spreadsheet. It has proven very reliable and robust. During many test flights with power level of about 10-20mW, communication has been possible across all the oceans and land masses of the world. Probably the longest distance achieved was long-path reception in New Zealand, when one of the test balloon flights was in Europe, a distance of 22,000km!

Dave VE3KCL S-series flight payloads

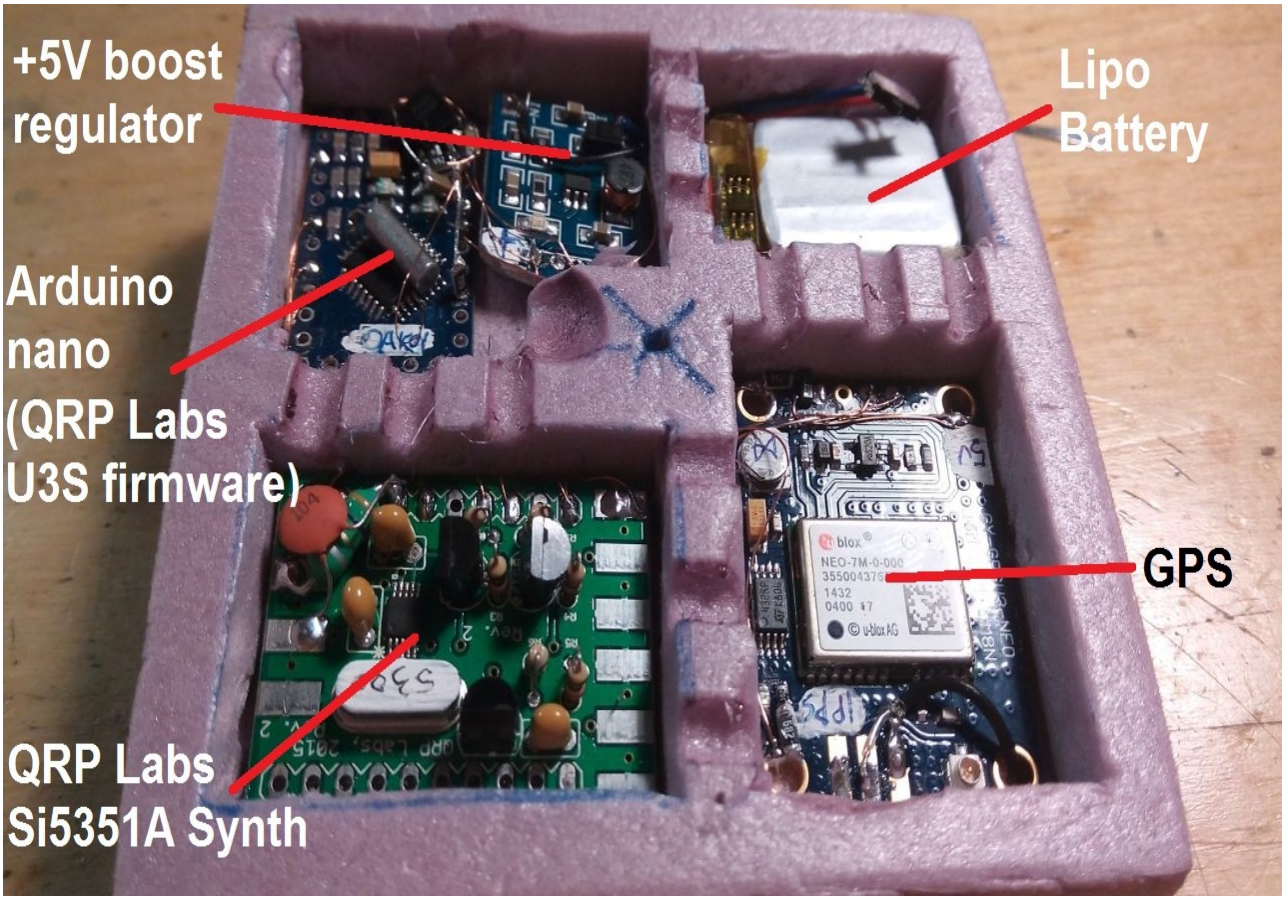
Some details are due, regarding Dave VE3KCL's balloon hardware. The early flights used inexpensive mylar "party balloons" printed with the message "Over The Hill"… which is of course, about as far as they managed to fly.

Hydrogen is a bit better at lifting than helium, has slower leakage rate due to the larger hydrogen molecule, and is also more environmentally friendly (since helium is a non-renewable resource). However hydrogen is also an explosive gas so some care in handling is required, with all due attention to necessary safety measures. Dave VE3KCL's early flights consisted of a collection of off-the-shelf hardware modules, packaged in a polystyrene enclosure. The parts of the system are:



QRP Labs Si5351A Synth kit http://qrp-labs.com/synth
Arduino Nano
uBlox GPS board
Voltage regulator module
LiPo battery

The Arduino Nano was not used as an Arduino. It was only used because it contains the same ATmega328 processor as the Ultimate3S, but in a much smaller SMD package which saves weight. Dave flashed the 'nano's processor with the Ultimate3S firmware, the special version of the firmware that implements the WSPR telemetry system. Changing the Arduino nano's crystal to 20MHz to match the Ultimate3S was also needed. Eventually, Dave designed his own PCB to hold the necessary components, resulting in further weight savings.



Dave's S-series flights based on the Ultimate3S consisted of 26 flights in total. The 11th, in June 2016, was the first circumnavigation Dave achieved, about a year after his first 2.5-hour, 68km flight. What a scale of improvement in one year!

Tracking Spreadsheet

At the other end of the tracking system, was an Excel spreadsheet that I wrote. Every two minutes, the spreadsheet connected to WSPRnet and loaded the entire 5,000 last spots for 20m and 30m bands. The sheet then went through the list and parsed the spots to find any balloon telemetry spots, which were decoded and matched to the normal WSPR transmission reports in the preceding two-minute slots. The two pieces of information (4-character Maidenhead grid from the main WSPR transmission, and the 5th and 6th character grid subsquare information from the telemetry transmission) were pieced together and converted to latitude and longitude, which was written into an HTML file in Google Map format and FTPed to my website. The result was a live tracking map on the website that updated every 5 minutes, with the latest decoded information from the balloon (that was sent every 12 minutes or 10 minutes).

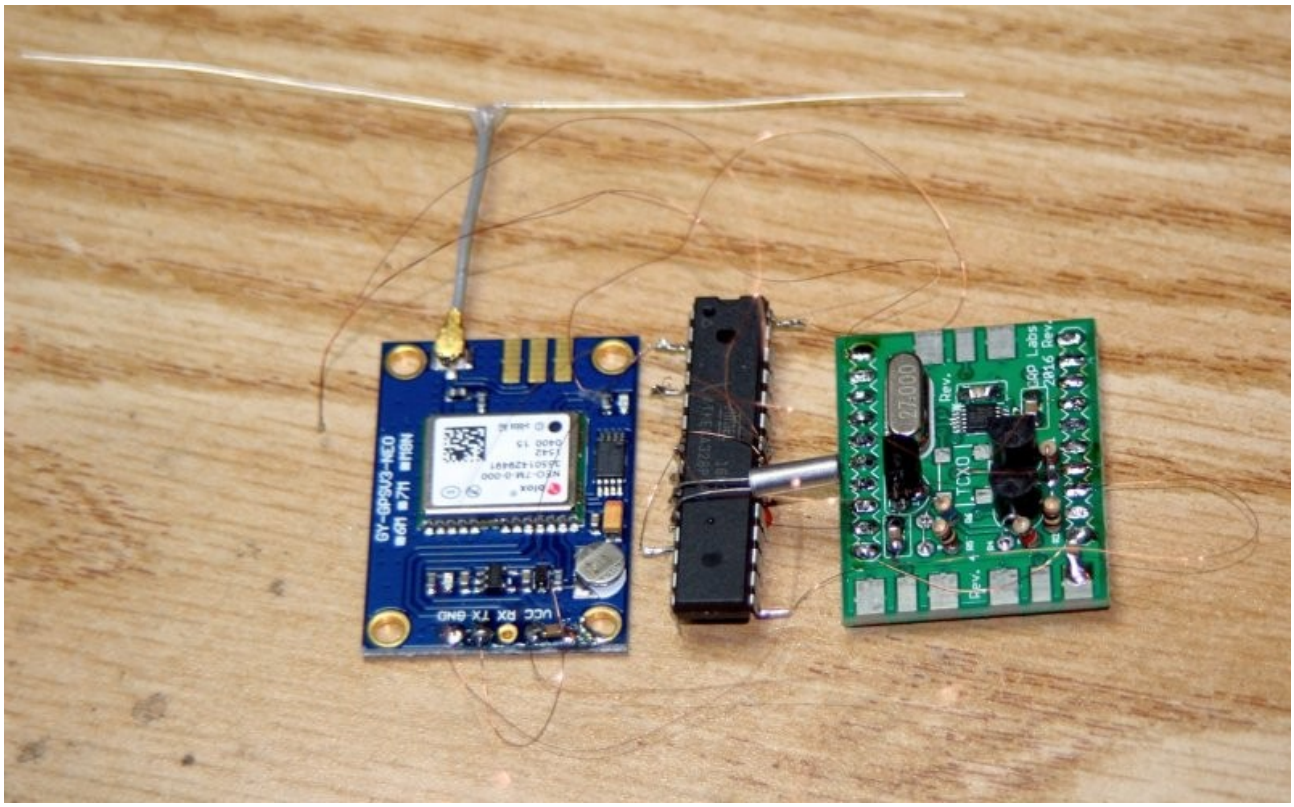
Balloon flights by Jim N2NXZ

Mention is due to other balloon celebrities who have also been involved with flying the special QRP Labs Ultimate3S code with the WSPR telemetry tracking system.

Prominent and indeed foremost among these is Jim N2NXZ who has his own particular style and enthusiasm. I particularly liked Jim's low-tech way of implementing a low weight version of the Ultimate3S, which was simply using an existing set-up Ultimate3S ATmega328 chip, full-size DIP28 package, and soldering the wires of the GPS and Si5351A Synth kit directly to the chip! No PCB at all for the processor.

Jim had been experimenting with balloon flights for a number of years. But then started his own series of flights with prefix U3S since they were all based on the Ultimate3S kit, running the standard Ultimate3S firmware, not the special telemetry version. Somewhat later on, Jim did also run the special version with the WSPR telemetry. We even have a photograph of Jim launching his U3S-7 flight from the roof of his house!

Jim's contribution is notable and commendable for his enthusiasm and non-traditional way of looking at things, which was always interesting to discuss, and we learned many things form these U3S-series flights too. In total Jim N2NXZ launched 33 balloons in his U3S-series, and they were always fun to watch and learn from.



Bob ZL1RS

Bob is notable not just for running several balloon flights, BB-01 to BB-05 using the special WSPR telemetry, the first time it was used in the southern hemisphere – but also for actually realizing in real life, my dream of an ocean buoy! You can read much more about this voyage here https://www.qsl.net/zl1rs/oceanfloater.html

Somewhat like my original "Voyager" plan, Bob used D-cell batteries in a drain pipe; but of course the JT9 and WSPR tracking was much more advanced than I had ever imagined back then. Bob's Ocean Floater project drifted around in the South Pacific Ocean for 407 days, reporting its position and condition continuously during that time.

Bob ZL1RS' 5th balloon launch BB-05, achieved circumnavigation with two laps around the world, finally coming down in the South Atlantic ocean half way around its third lap.

Daniel DL6OW

Then there is Daniel DL6OW and his friends flying the flag for Europe, with WSPR telemetry balloons called Stella-1, Stella-2 and so on up to Stella-22. Stella is the name of Daniel's daughter! Daniel's first flights, like Dave VE3KCL's, were on multiple connected off-the-shelf modules but subsequently he designed his own PCB to reduce the size and weight.

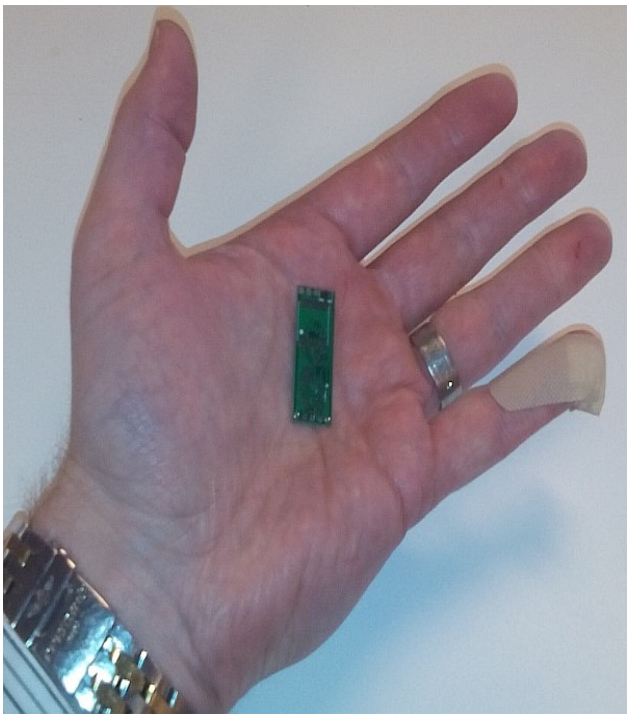
Others

Eventually the special Ultimate3S firmware found its way outside the small group noted above and several others have also flown it, or variations of it. Apologies for not listing in full all the names and details here, which would require a lot of research for which time is lacking.

QRP Labs U3B tracker development

Right from the beginning in my conversations with Dave VE3KCL, I had been considering how nice it would be to produce and market a small tracker board. There are people who can design their own PCBs and assemble the SMD components, write the firmware and so on. But for every person like that, there must be 10 or 20 times more people who don't have the resources (experience, time) to do that. An assembled board would make it possible for many more people to participate in this interesting and crazy hobby of high altitude long distance ballooning!

I called my tracker "U3B", since it was based on the Ultimate3S kit http://qrp-labs.com/ultimate3/u3s with the "B" suffix standing for Balloon. The size was 38.0 x 12.7mm, including transmitter, voltage regulator, GPS and ATmega328 processor. Components on both sides included 0402 size resistors and capacitors.



For fun and the extreme deliciously and un-neccessarily over-the-top-ness of it, the U3B did not use the standard or even a modified version of the Ultimate3S firmware. Instead I wrote a 32-bit virtual machine, that ran inside the 8-bit AVR processor (ATmega328), with a BASIC interpreter and compiler, storing the program in the 2K EEPROM of the processor. The idea behind this, was that the experimenter would be free of the constraints of the Ultimate3S system.

In the Ultimate3S, one configures a number of transmission slots, including specifying the mode and message to be transmitted. But in the U3B, the BASIC programming language statements included commands to transmit a message in CW, FSKCW, WSPR, or the Telemetry etc. Even JT9.

But the U3B system could be configured with a very very simple BASIC program for a really basic (pun not intended) flight. Or a more advanced user could write his program to customize the flight to his requirements. U3B had a number of I/O pins which could be read as analog or digital pins, or other sensors on the I2C bus could be read, and so on.

U3B was programmed via a 9600-baud serial port, using a USB-to-Serial converter and a terminal emulator program on a PC.

Dave VE3KCL assembled and flew the first prototype U3B on 16-Jun-2016 and so started the U3B-series of balloon flights, with U3B-1. The BASIC program listing of that first flight was:

```
  5 LET FR = 26999800
  6 GPS 300
  7 PRINT FS , FR
 10 SLEEP 10 0
 20 PRINT FS , FR
 25 PRINT BT
 30 TELE 2 10140260 10 "G0UPL"
 35 PRINT BT
 38 PRINT FS , FR
 47 TELE 2 14097130 10 "G0UPL"
 50 PRINT BT
 70 PRINT FS , FR
 75 JT9 1 10140400 "G0UPL #M6"
 80 PRINT FS , FR
 90 GPS 300
 95 PRINT FS , FR
100 GOTO 10
```

Variables FS, FR and BT are system variables holding the system crystal frequency (20MHz), Si5351A reference frequency (27MHz) and Battery voltage respectively. You can see that there are commands for transmitting telemetry, JT9, and doing the GPS calibration.

In total there were 28 U3B test flights, each one experimenting with different aspects of the hardware, the firmware, or the software (BASIC flight program), and with varying degrees of success.

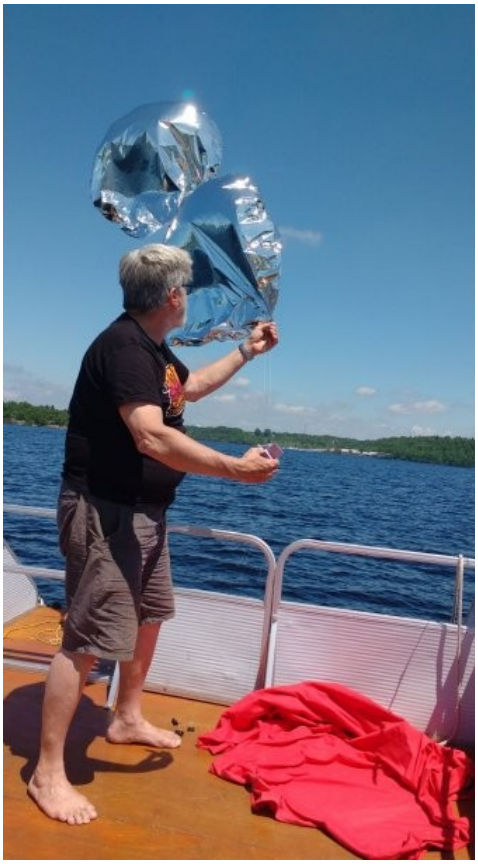
Dave VE3KCL and all the balloon technicalities

Throughout nearly 6 years of collaboration on the balloon flights, Dave VE3KCL and I have worked closely together. I designed hardware, PCB layouts and wrote firmware and the tracking spreadsheet Dave assembled the units to fly. Dave may be 2 decades my senior but he's not afraid of hand-soldering 0402-size SMD components!

Dave has endless enthusiasm and has gone deep into many aspects of flying balloons, other than just the tracker hardware, firmware and software.

Just the launch of one of these tiny balloons has many perils of its own. Zero or very low wind is necessary, since the lift is so low that any wind will blow the balloon sideways and gusts may throw it into the ground and destroy it.

You also need clear skies and not just at the launch, but also forecast for the next two or three hours it will take for the balloon to ascend to its target altitude above all the clouds. You need to not tangle up the terribly fine antenna wire, nor break it, nor do anything that could break the extremely fragile glass solar panel cells. There's a lot to think about and Dave has mastered it all, now nearly all the flights are launched successfully.



Dave even built his own cooler system to test the behaviour of the tracker in the extreme low temperatures found at 12,000m. There comes a time when the -16 or -20C in your domestic fridge freezer just doesn't do it. That's when it's time to bring in Peltier effect devices. They transfer heat at the junction of two different materials, effectively sucking heat from one side to the other. It's a rather inefficient cooling method compared to ordinary refrigeration techniques seen in consumer appliances. But by nesting three sets of Peltier-cooled chambers inside each other, with water cooling to extract the large amounts of heat generated by the outer one, Dave was able to reach temperatures below -50C, which provided very valuable test data on the required temperatures for the electronics to work properly.

Dave knows how to perform the almost unbelievable feat of slicing the incredibly fragile glass solar cells in half without breaking them.

Balloon pre-stretching and filling is another important area that Dave has investigated. The mylar film balloons are inelastic but not perfectly so. By stretching them under pressure on the ground, Dave has been able to expand the volume and achieve higher float altitudes.

Dave VE3KCL has launched from a moving boat; dodged dogs having their morning walk on the launch beach, and even successfully and repeatably persuaded his better half to provide photography services for the documentary record!

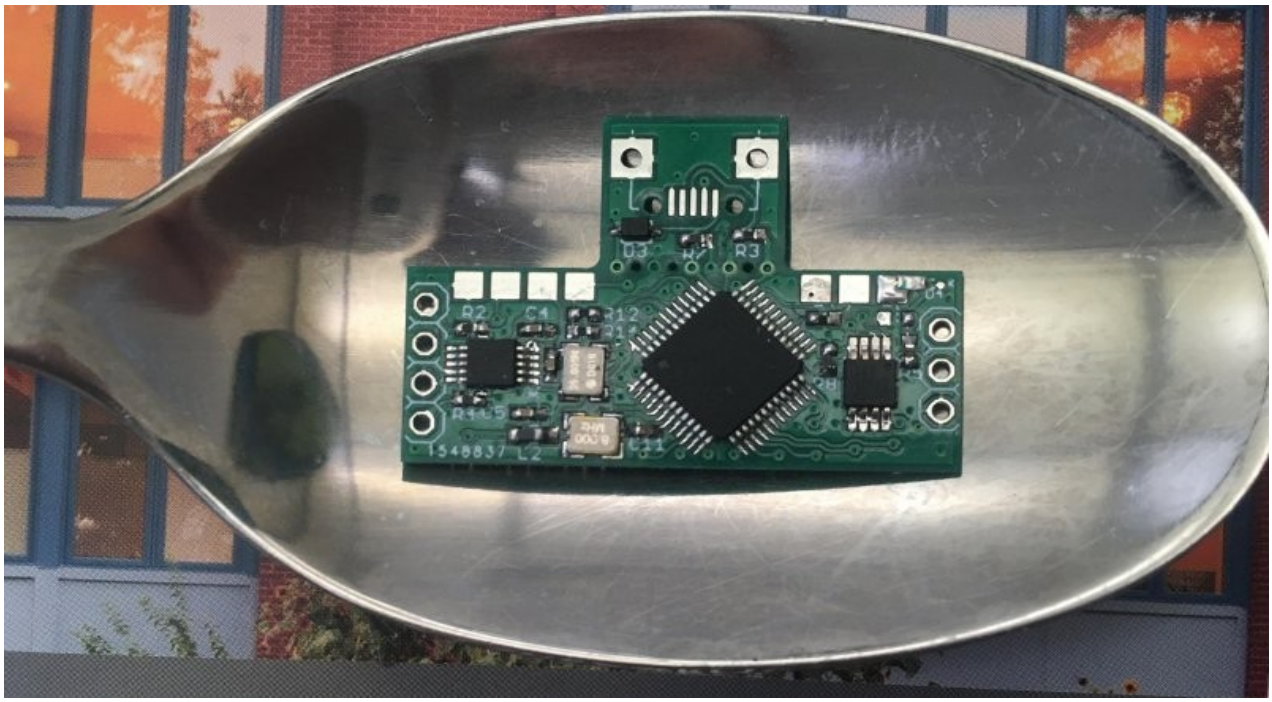
Above all Dave has an enduring, quietly understated enthusiasm that is infectious and inescapable; he has been endlessly patient with me while waiting for me to be distracted in all the other QRP Labs projects I've got lost in over the intervening years, a great help at Dayton hamvention… just an awesome guy, ya can't love Dave enough!

U4B – at last…

Then as my room-mate at the Dayton hamvention in May 2019, we got to discussing how to finally finish up the U3B project, Dave said if I allocate a whole week to it I could finish it (yeah-right!) and somehow during those discussions, it mutated into the U4B. “4” because now I have changed the processor to a 32-bit STM32 ARM processor. These have very much more raw power, peripherals and functions compared to an ATmega328 AVR processor, and yet have a very low price.

The U4B will be the final tracker, the one that that enters production. The first prototypes were on a double-sized board, with components on one side only, just like the U3B. There is a micro-USB connector on a protruding section of the PCB that is designed to snap off before flight, for weight-saving. Like the U3B, the U4B tracker weighs around 1.5 grams, it is a 33.0 x 12.7mm PCB with GPS, processor, Si5351A (synthesizer/transmitter), voltage regulator and 128K EEPROM chip.

The final board is pictured below.



The firmware contains a customized operating system called QDOS (QRP Labs Disk Operating System) with a command prompt, FAT12 file system on the 128K EEPROM, file manager, full-screen editor application, BASIC compiler and integrated debugger. All of this is hosted on the device itself, there is no special software running on a PC downloading code into the U4B. The only thing needed is a terminal emulator, for example on Linux we use PuTTY. The U4B presents itself to the PC as a Virtual COM port serial device.

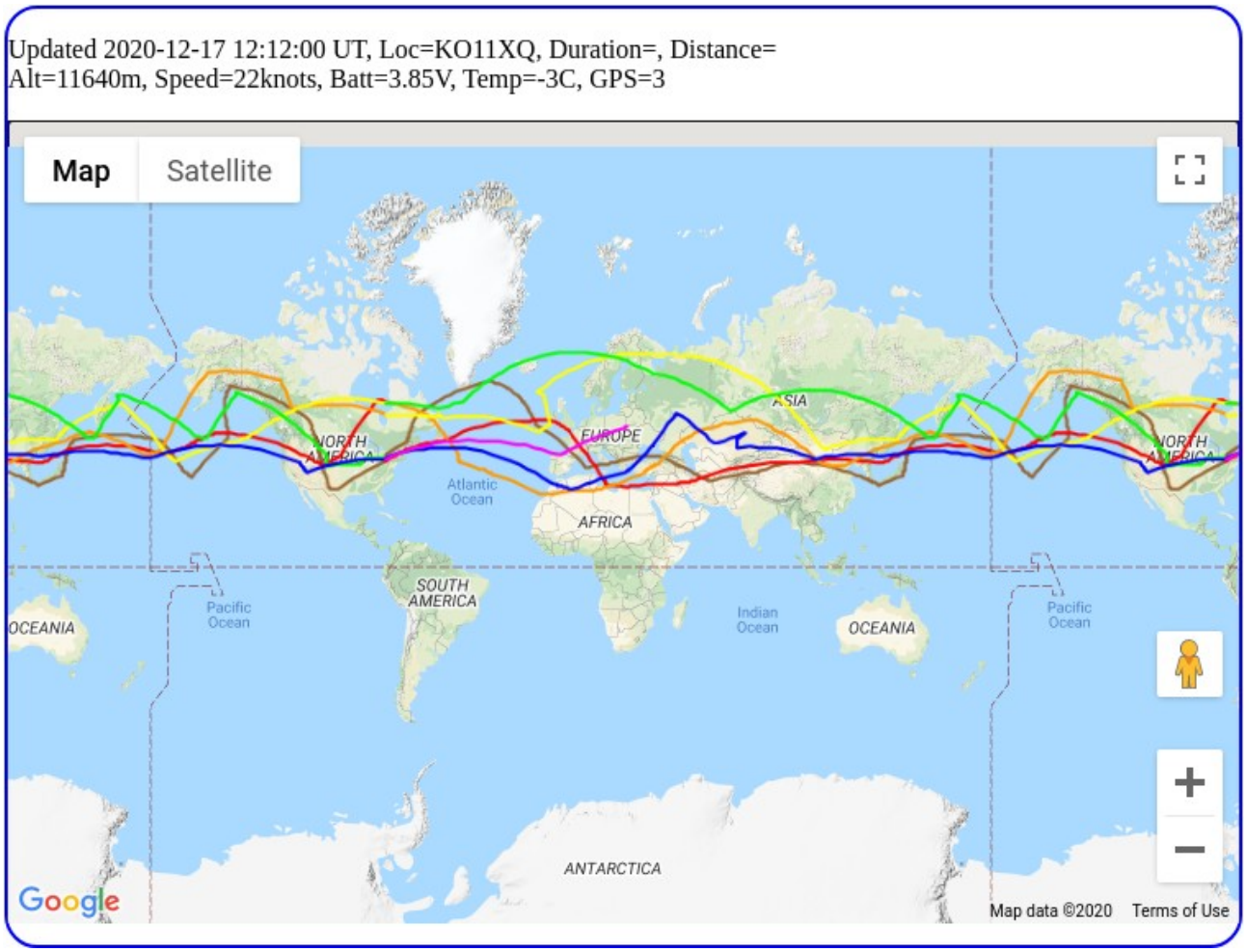
The BASIC programs have similar capabilities to the U3B. Which is to say, almost all the modes the Ultimate3S is capable of, as well as the WSPR telemetry type.

Modifications to the telemetry protocol allow up to 600 telemetry channels, and additional data fields for your own sensor data (8 general purpose analog/digital I/O pins, I2C bus sensors, and more).

At time of writing (17-Dec-2020) there have been 13 test flights of the U4B. The latest one U4B-13 uses an actual real-size final PCB layout that will be used for the production batch. It is currently on its first lap around the world, having traveled from Toronto Canada, to China so far.

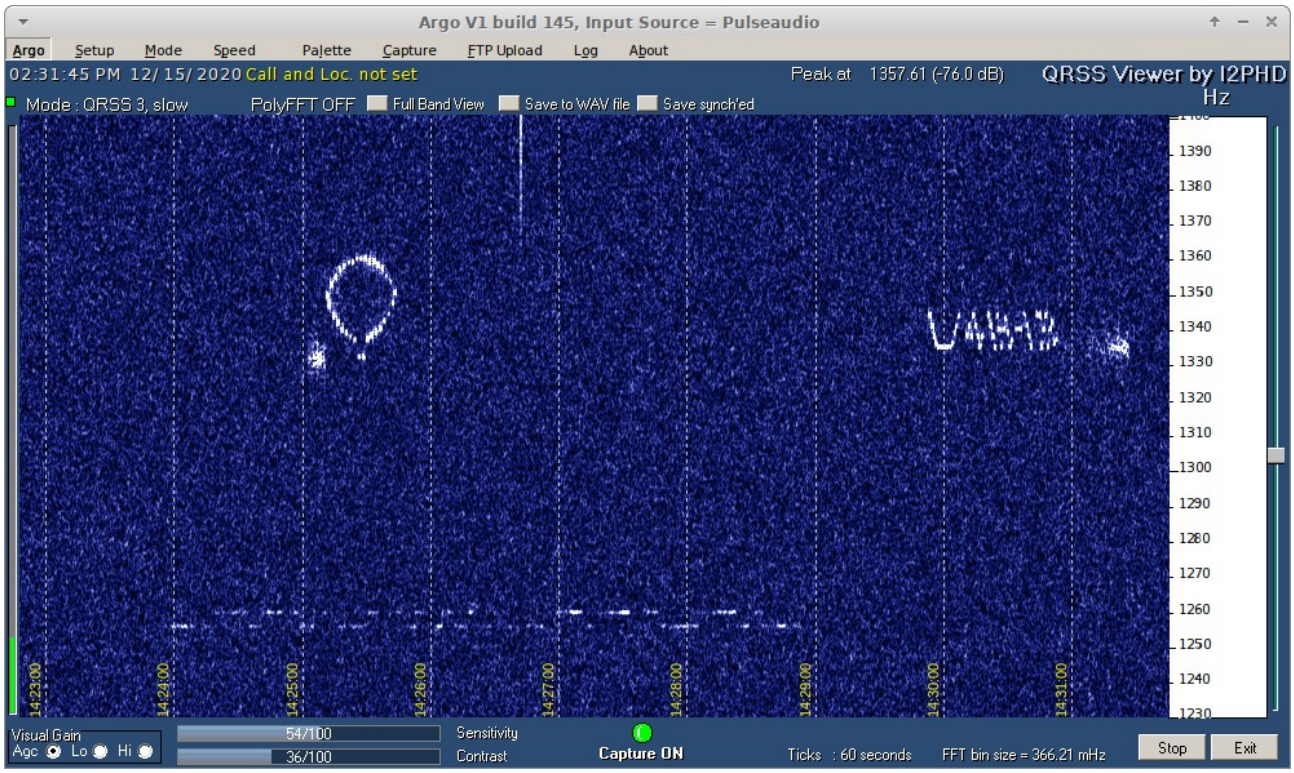
The U4B-12 flight was launched in September and has been up now for almost three months; it is on its 7th lap around the world!

On the map below, the colours indicate the lap of our planet, according to the standard resistor colour code. In its current position over Austria the line ending is purple, indicating the 7th lap.



To return to more traditional QRSS for a moment – many of the flights have included, as part of their transmission schedule, traditional QRSS modes such as FSKCW, and Slow-Helshreiber (shifted tones that produce character patterns). More recent flights include a charming balloon glyph.

It shows the balloon glyph and the “U4B13” text. Note that this text is produced by a series of custom shifts; text can also be produced using slow-Helshreiber which uses the original font from the Hellshreiber machines developed by Rudolf Hell in the 1920’s.



One wonders what Rudolf Hellshreiber, or Samuel Morse, would have made of all this. 1.5 gram transmitters circling the globe, transmitting milliwatts?

Weak signal modes are what makes it all possible!

Acknowledgments

My sincere thanks are due to all the radio amateurs involved in this adventure, particularly Dave VE3KCL but also including Jim N2NXZ, Daniel DL6OW and Bob ZL1RS; as well as the giants on whose shoulders we stand, Leo M0XER and Andy VK3YT. The WSPR tracking protocol development described here have made tracking floater balloons worldwide possible. The protocol has since been used and modified by other balloon enthusiasts too, including Alan W7QO, Michael KD2EAT and Bill WB8ELK.

Further reading:

http://qrp-labs.com/flights for details of all the QRP Labs test flights (67 flights in the S, U3B and U4B series launched by VE3KCL; as well as the N2NXZ, DL6OW and ZL1RS flights)

http://qrp-labs.com/circumnavigators.html “The Circumnavigators”: a page devoted to the early floater balloon circumnavigation flights, starting with M0XER in July 2014, which I believe to be the first circumnavigation flight.

https://groups.io/g/picoballoon a discussion group devoted to floater (pico) ballooning.

The Last Word

Well here we are again, it's the end of school report as G6GN calls it (I like that!). Member ship of Knights is at an all time high and we've started a new solar cycle that IS making a difference. We have only ever had one solar cycle where QRSS rigs were available in any sensible form thanks to the sterling efforts of G0UPL and QRP Labs. But that was only the start. We were all still finding our way back then and only half got the chance to experience QRSS. Especially on the higher bands. Our mission was never complete. Now we have a real opportunity to do it for real. Many members have now got their rigs, solved the teething problems and stand ready for the real thing. There's no time to waste. Lets do it !

So what have we seen this year in QRSS ? Well we've been given FSKVIEW by Scott AJ4VD, a QRSS and WSPR decoder all in one. We've had both Scott and Dave WA5DJJ doing Zoom conferences with clubs to promote QRSS. Scott and Dave have been excellent ambassadors for QRSS especially in the USA. Well done chaps ! We've had newcomers to QRSS join us, and a **Christmas present from QRP Labs in the form of a firmware upgrade for the QCX rigs to allow QRSS transmissions**. Not to mention that my inbox exploded with emails from old and new friends, as a result of new interest in QRSS.

It's been great fun this year as always searching for new grabbers to add to websites like AJ4VD's QRSS Plus. Once again this year we have increased the score once again with new grabbers coming on to the scene. But also a MASSIVE thank you (and I really mean MASSIVE) to those of you who have been running your grabbers without for about 10 years without fail. I sometimes wonder who has the oldest and most continuous running grabber. I think it maybe LA5GOA, but does anyone have other suggestions ? My thanks go to Scott AJ4VD for his efforts to bring an easy way to view grabbers in the most convenient way possible. Life would be a lot harder without the auto updating system.

Please don't forget that 74*!* needs your input. It needs your reports or articles (sent directly to me of the Knights forum) in order to exist. And finally, whatever happens in 2021 - **Illegitimi non carborundum !**

74

DE ANDY G0FTD