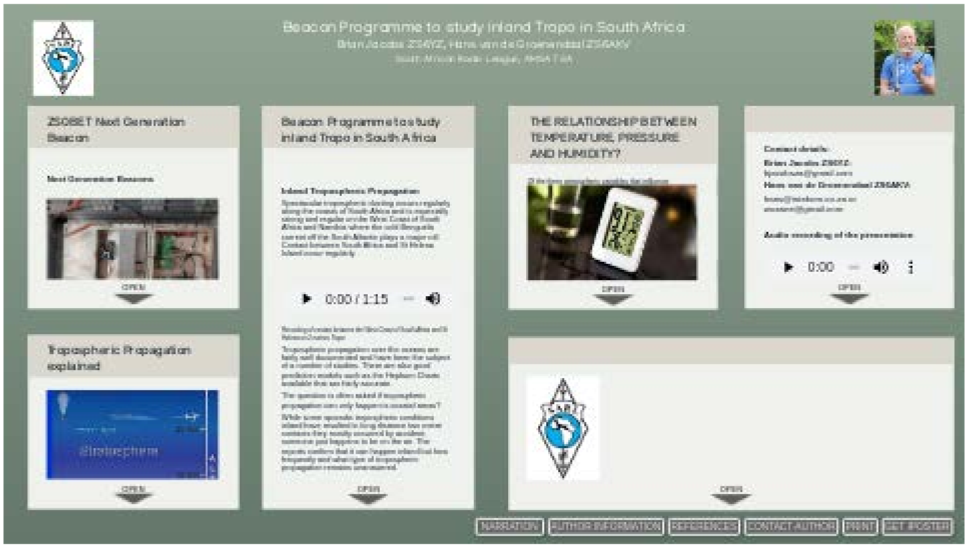
Beacon Programme to study inland Tropo in South Africa



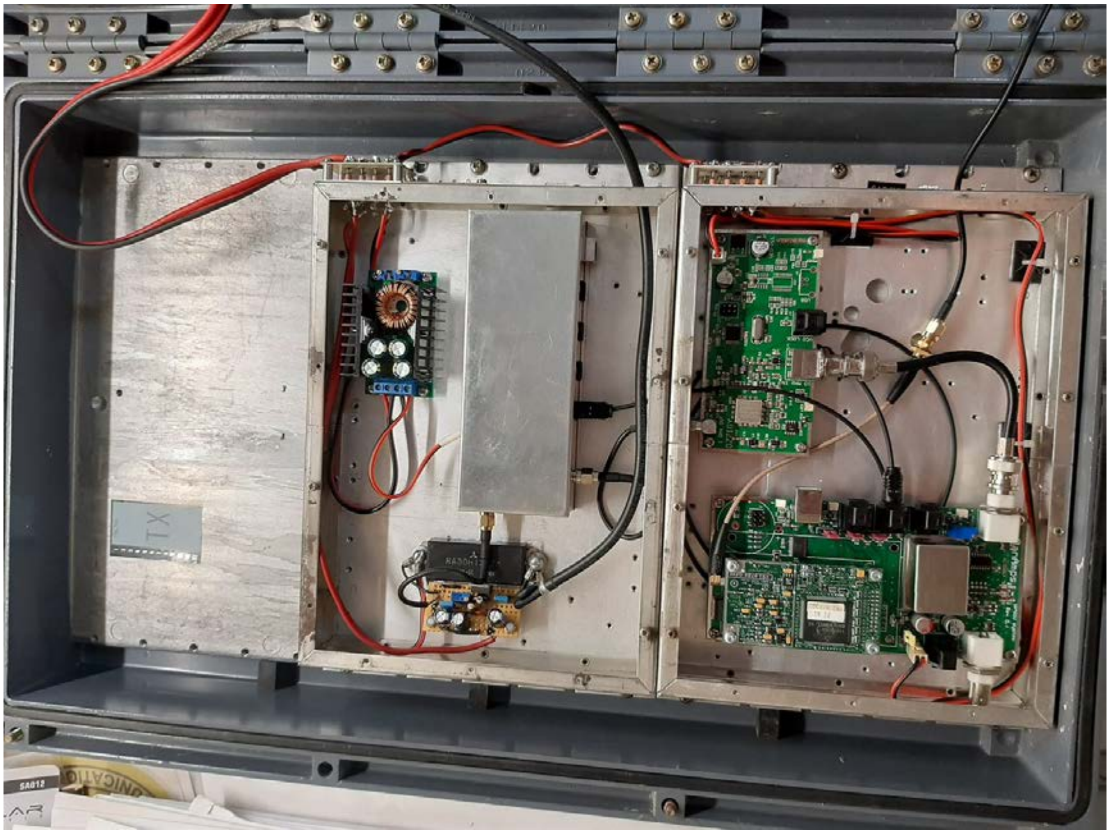
Brian Jacobs ZS6YZ, Hans van de Groenendaal ZS6AKV

South African Radio League, AMSAT SA

PRESENTED AT:

ZS0BET NEXT GENERATION BEACON

Next Generation Beacons



Next Generation Beacons generate a machine generation message (MGM) similar to WSJT-X and other digital modes. There are already numerous digital modes available, however testing and experience has shown that the various digital modes have been developed with specific types of propagation in mind and do not all work equally well for different propagation types.

Pi4 has been developed specifically by the Next Generation Beacon Project Team in Denmark for VHF and above propagation. Pi4 is short for PharusIgnis4. The name PharusIgnis4 comes from the ancient words for beacon, lighthouse and fire - Pharos (from Greek to Latin pharus and coming from the Lighthouse of Alexandria), Ignis (Latin: fire) and 4 for the four FSK tones.

PI4 is also compliant with the IARU Region 1 VHF Committee accepted 1 minute mixed mode beacon sequence.

PI4 is also makes use of four tones as does JT4 and WSPR, however there is a difference in the spacing of the tones and on which tones syncing takes place and those familiar with the modern weak signal digital modes know that they can very easily and reliably be received and decoded by software and reported on.

PI4 is FREE, allowing any amateur who is set up for digital modes to be able to easily receive, decode and report on the Next Generation Beacons received. It is available as a standalone package called PI-RX and has been incorporated in the MSHV software package also used by a number of VHF and above enthusiasts.

The MGM signal generated by the Next Generation Beacon does not only generate a PI4 sequence. It also generates the beacon ID is CW and sends out a frequency accurate tone that can be used to frequency checking. The beacon therefore caters for automated reception of the PI4 digital sequence, aural reception of the CW ID and a frequency accurate signal that can be used to check the accuracy of the receiver.

The license requirements are to have frequency measurement equipment, but the quality and accuracy of the frequency measurement equipment is not specified. Most affordable frequency checking equipment are fine for HF frequencies, however as one moves up to the higher VHF, UHF and Microwave bands, frequency accuracy and stability becomes critical and can be the difference between making a contact or not. Most operators have know idea how far off frequency their radios actually are and having a method to check their equipment against a frequency accurate signal is an added bonus.

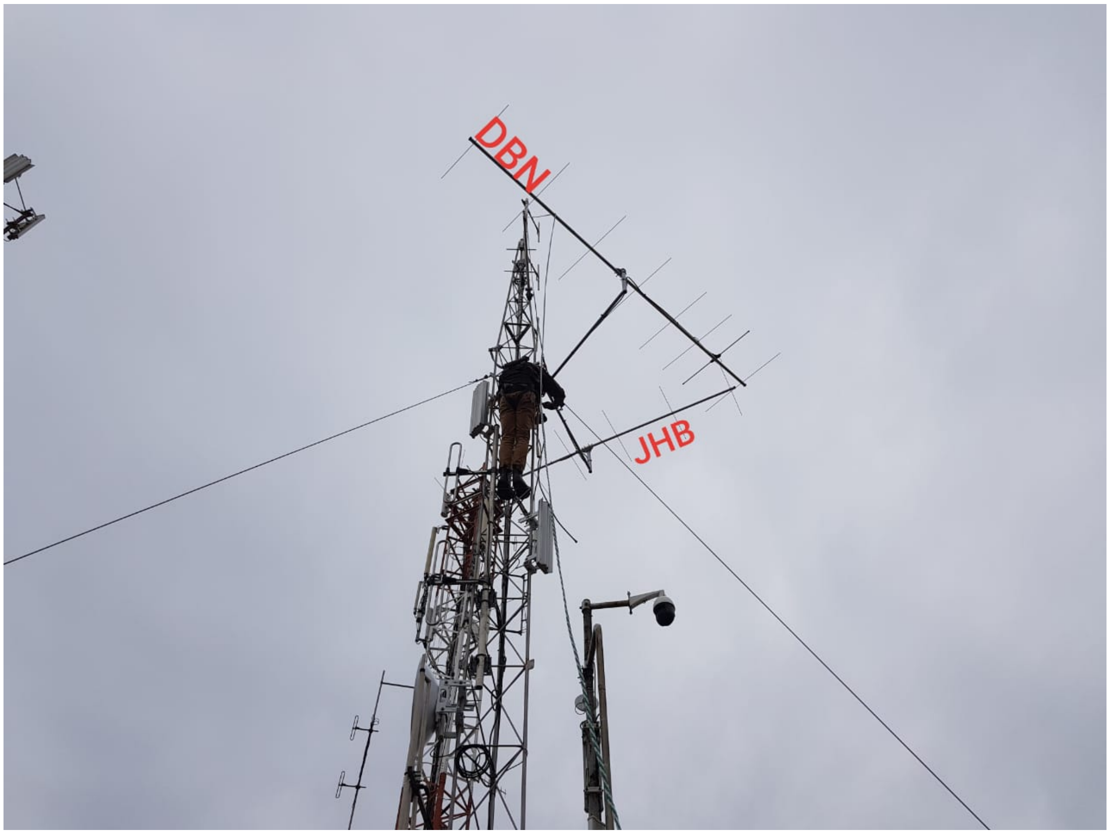
Next Generation Beacon Hardware

The NGNB platform consists of the following functional blocks:

- VCO-PLL which provides a stable GPS disciplined frequency reference to the DDS.
- The DDS (Direct Digital Synthesizer) generates the modulated signal at the desired frequency.
- GPS is used to provide a reference frequency to the VCO-PLL as well as timing for the DDS to ensure that accurate timing of the message being generated by the DDS.
- RF Amplifier to amplify the DDS output along with the necessary RF filtering as required in any RF power chain.

Project Progress

The first Next Generation Beacon is currently being tested in Pretoria. It is fully operational at grid square KG44CH on a frequency of 144.425 MHz. The output power is 25 W into 2x14 element stacked Yagi antennas with approximately 15 dB gain point in a direction of 222 degrees,



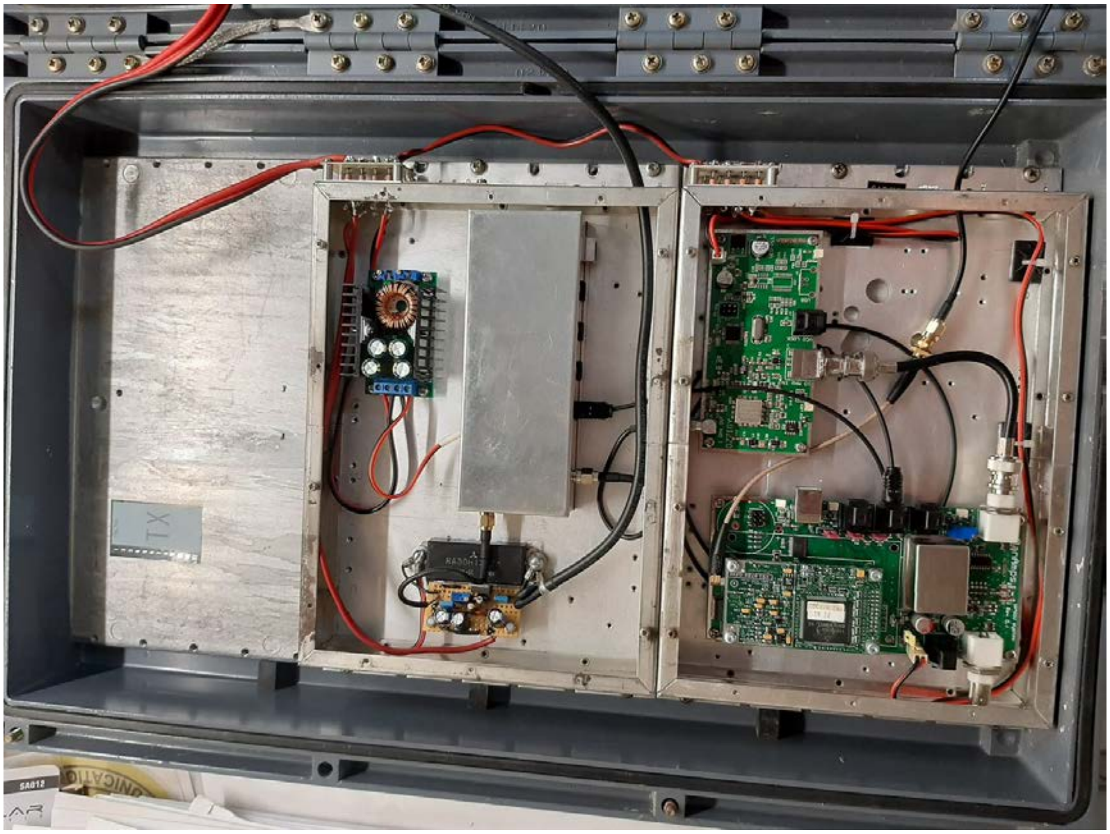
Final beacon site in Berhlehem FreeSate Province of South Africa

Once fully tested the beacon hardware will replace the current modified CW beacon in Bethlehem.

Monitoring and reporting of the beacon can now be automated using either PI-RX or the MSHV software package and automated reporting will be able to be done to any of the Reverse Beacon Networks that are currently operational.

The new South African Radio League next generation beacon was installed on a temperarory site in Pretoria for test purposes and will be moved to the Bethlehem site in the Free State province of South Africa in the next few weeks

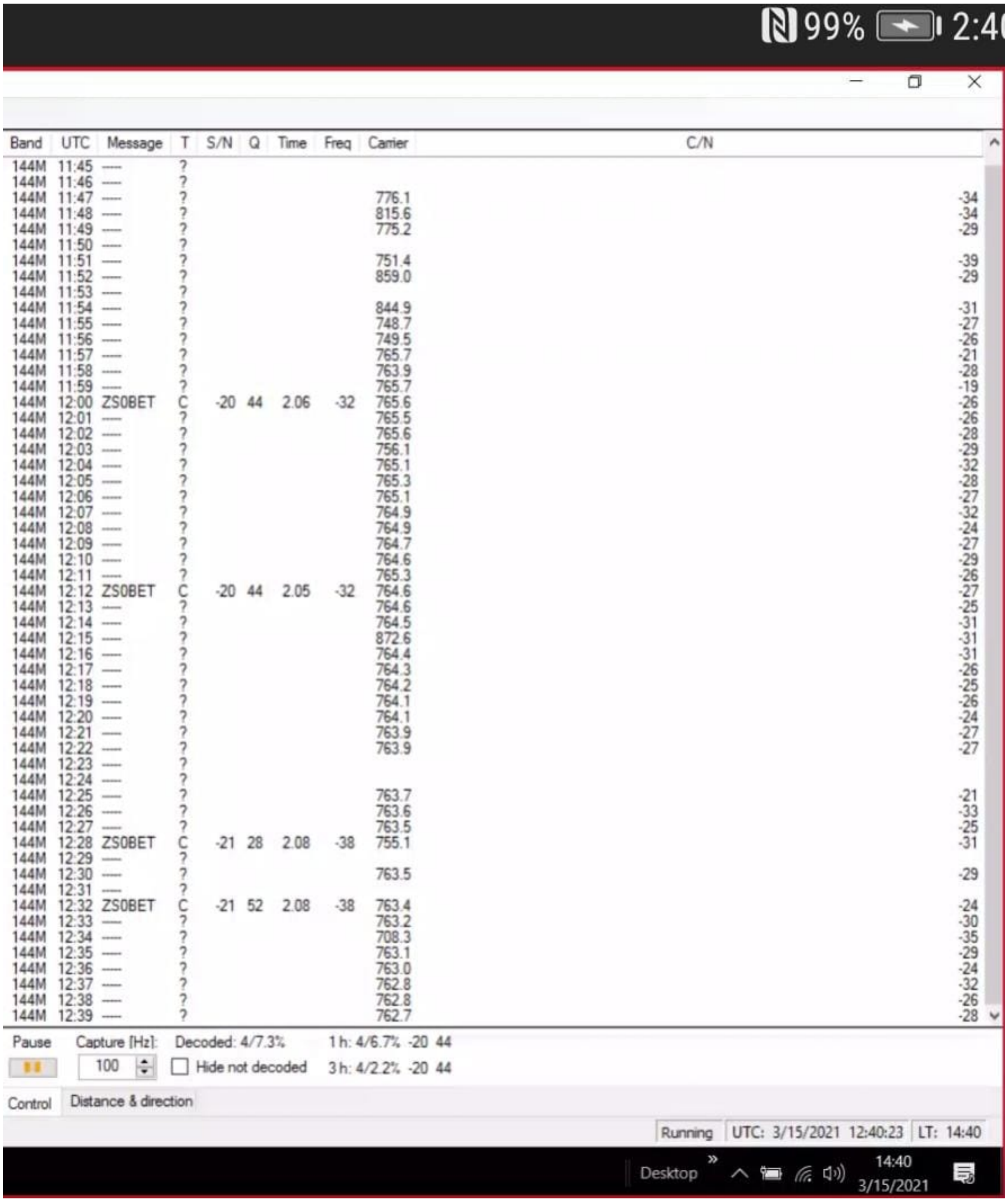
This is what it sounds like



Beacon installed in cabinet

During first few days of testing the beacons

was heard in many unexpected areas of South Africa

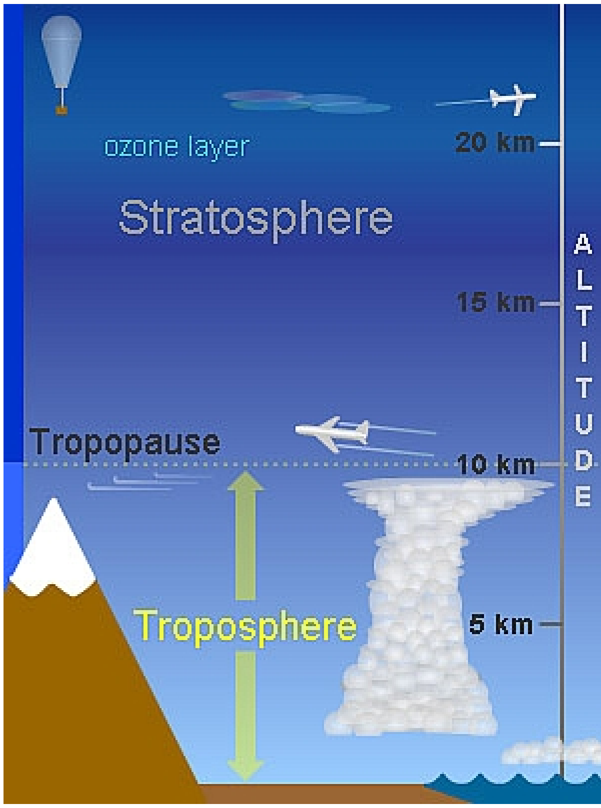


Band	UTC	Message	T	S/N	Q	Time	Freq	Carrier	C/N
144M	11:45	----	?						
144M	11:46	----	?						
144M	11:47	----	?					776.1	-34
144M	11:48	----	?					815.6	-34
144M	11:49	----	?					775.2	-29
144M	11:50	----	?						
144M	11:51	----	?					751.4	-39
144M	11:52	----	?					859.0	-29
144M	11:53	----	?						
144M	11:54	----	?					844.9	-31
144M	11:55	----	?					748.7	-27
144M	11:56	----	?					749.5	-26
144M	11:57	----	?					765.7	-21
144M	11:58	----	?					763.9	-28
144M	11:59	----	?					765.7	-19
144M	12:00	ZS0BET	C	-20	44	2.06	-32	765.6	-26
144M	12:01	----	?					765.5	-26
144M	12:02	----	?					765.6	-28
144M	12:03	----	?					756.1	-29
144M	12:04	----	?					765.1	-32
144M	12:05	----	?					765.3	-28
144M	12:06	----	?					765.1	-27
144M	12:07	----	?					764.9	-32
144M	12:08	----	?					764.9	-24
144M	12:09	----	?					764.7	-27
144M	12:10	----	?					764.6	-29
144M	12:11	----	?					765.3	-26
144M	12:12	ZS0BET	C	-20	44	2.05	-32	764.6	-27
144M	12:13	----	?					764.6	-25
144M	12:14	----	?					764.5	-31
144M	12:15	----	?					872.6	-31
144M	12:16	----	?					764.4	-31
144M	12:17	----	?					764.3	-26
144M	12:18	----	?					764.2	-25
144M	12:19	----	?					764.1	-26
144M	12:20	----	?					764.1	-24
144M	12:21	----	?					763.9	-27
144M	12:22	----	?					763.9	-27
144M	12:23	----	?						
144M	12:24	----	?						
144M	12:25	----	?					763.7	-21
144M	12:26	----	?					763.6	-33
144M	12:27	----	?					763.5	-25
144M	12:28	ZS0BET	C	-21	28	2.08	-38	755.1	-31
144M	12:29	----	?						
144M	12:30	----	?					763.5	-29
144M	12:31	----	?						
144M	12:32	ZS0BET	C	-21	52	2.08	-38	763.4	-24
144M	12:33	----	?					763.2	-30
144M	12:34	----	?					708.3	-35
144M	12:35	----	?					763.1	-29
144M	12:36	----	?					763.0	-24
144M	12:37	----	?					762.8	-32
144M	12:38	----	?					762.8	-26
144M	12:39	----	?					762.7	-28

BEACON CROWD FUNDING

AMSAT SA has launced a crownd funding campaign to fund the next to SARL Next generation beacon. The first beacon was funded from SARL funds. . AMSAT SA also contrubuted R5000 from its own funds. To contribute to the SARL Beacon fund visit www.amsatsa.org.za and click on one of the fund buttons to contribute by credit card

TROPOSPHERIC PROPAGATION EXPLAINED



Tropospheric ducting occurs when a radio signal is reflected off the troposphere and continues a path that allows the signal to travel beyond line of sight. This occurs when the temperature in the atmosphere experiences a shift called an inversion. When a temperature inversion occurs, radio waves that would normally continue into space beyond the Earth's atmosphere are instead reflected and continue to follow the curvature of the planet. Radio waves have been able to travel in excess of 1,600 km because of tropospheric ducting. The Earth's troposphere is the lowest layer of the atmosphere. It extends from six to 60 km above the surface. During normal conditions, this layer allows radio waves to pass through into the upper atmosphere. During times of meteorological instability, the properties of the troposphere can change. When cold air that is low to the ground has a warmer air mass pass over the top of it, it causes a condition called a temperature inversion. The cool air near the ground is moving slower than the warm air. This means radio waves that encounter a temperature inversion will be carried faster over the cold mass, bending the path of the wave downward and allowing it to curve with the surface. Tropospheric ducting is most often experienced during periods of relatively calm weather with clear skies. This is indicative of high pressure fronts that can cause temperature inversions. The air masses have a high refractive index, causing the radio waves to move more slowly and aiding in the bending of their trajectory. The actual landscape between the source of the signal and the horizon also can affect the distance it can travel, with flat land and water being the most effective.

BEACON PROGRAMME TO STUDY INLAND TROPO IN SOUTH AFRICA

Inland Tropospheric Propagation

Spectacular tropospheric ducting occurs regularly along the coasts of South Africa and is especially strong and regular on the West Coast of South Africa and Namibia where the cold Benguela current off the South Atlantic plays a major roll. Contact between South Africa and St Helena Island occur regularly.

Recording of contact between the West Coast of South Africa and St Helena on 2 metres Tropo

Tropospheric propagation over the oceans are fairly well documented and have been the subject of a number of studies. There are also good prediction models such as the Hepburn Charts available that are fairly accurate.

The question is often asked if tropospheric propagation can only happen is coastal areas?

While some sporadic tropospheric conditions inland have resulted in long distance two metre contacts they mostly occurred by accident, someone just happens to be on the air. The reports confirm that it can happen inland but how frequently and what type of tropospheric propagation remains unanswered.

Ultimately, VHF and UHF radio propagation remains a mystery.

Most amateurs believe that the frequencies in the VHF and above bands are only used for FM repeater operations. This is not so and we can achieve very good distances using simplex and digital modes as well. Having the beacons to monitor will help us gather the data that we need to better understand VHF propagation and under what conditions we can achieve those really long distance contacts. We also believe that as we deploy more beacons and develop a better understanding of Tropospheric propagation, that more radio amateurs will become active on the VHF and above bands.

The enquiring nature of radio amateurs has over many years resulted in informal research with setting up beacons and monitoring signals. But this hand – mouth way of doing this has not really delivered the kind of data to make meaningful and scientific findings. All it really is showing that long distance communication of frequencies above 30 MHz is possible and does regularly occur.

Not one of us are in front of our radios 24/7 so we do not know when the bands are open.

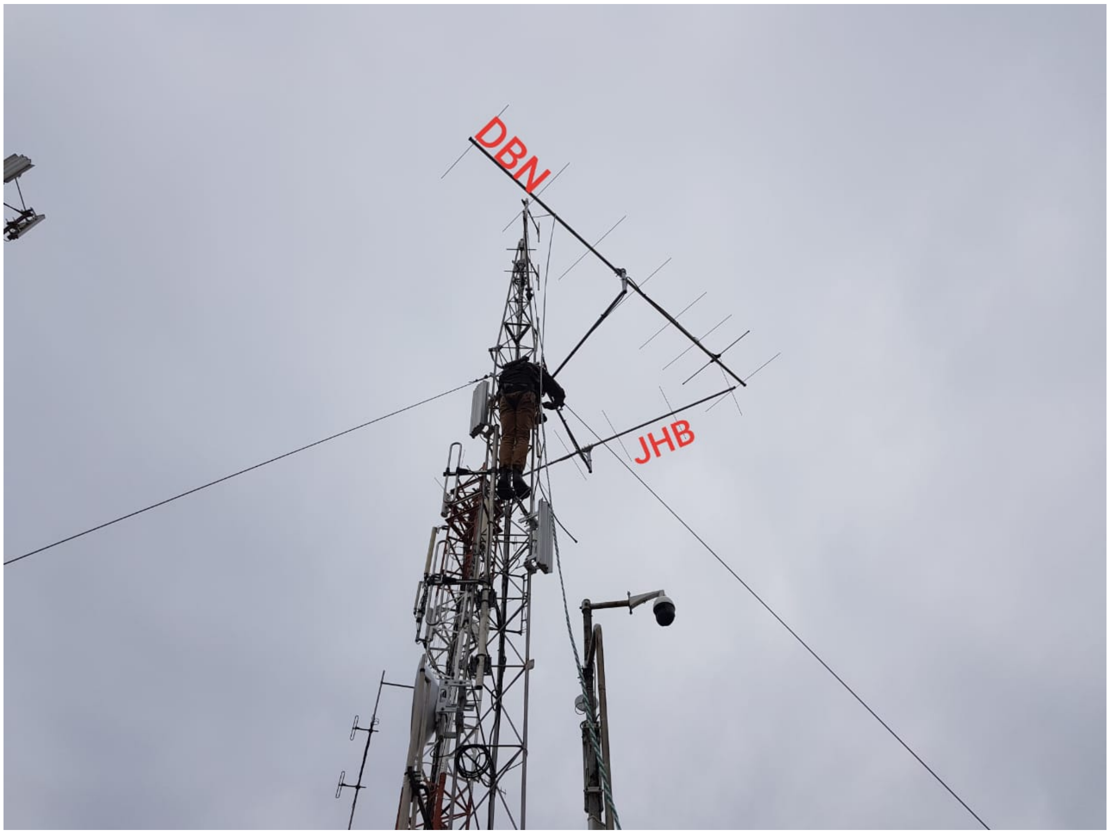
There are tools that can be used to tell you when and where the bands are open, but in order to know when the band is open someone must transmit a signal and some else must receive that signal and report that the signal has been received.

This is why beacons are so important. The beacon continuously sends out a signal 24/7 and you can listen for the beacons and when received then you know which path is open and how strong the opening is.

Beacons are a method to be able to monitor propagation on the VHF and above bands.

Properly coordinated omni-directional beacons that follow the IARU recommendations will make it easier to monitor the beacons electronically, allowing us to continuously collect data that can be used to analyse how the propagation changes over time for example as weather patterns move across the country. At the same time having this information readily available will enable you to quickly get on air to exploit the propagation openings as they occur.

SARL Beacon Project



The current analogue beacon in Bethlehem (FreeState Province) The beacon will be replaced with the next generation beacon

The SARL Beacon Project was born out of an idea that was suggested during a

VHF Workshop in October 2018 at the National Amateur Radio Centre. At this workshop it was decided to form a VHF Work Group to drive the development of a beacon in the centre of the country to study the propagation path between Cape Town and Gauteng which are the two centres of VHF and above activity in the country. In December 2019 the test beacon ZS0BET went live from a location overlooking Bethlehem. This beacon was a modified commercial ICOM radio sending out a CW signal by way of keying the power amplifier stage. This beacon has really been performing very well and reception reports have come in from some unexpected areas. These unexpected reception reports have fuelled the quest to understand more about Tropospheric propagation, especially inland.

Beacon Monitoring

Having beacons are however only part of the solution and one needs to have a better reporting system than the hap hazard incidental reporting by a radio amateur who just happens to hear a beacon. This data needs to be collected in a more scientific way.

Reverse Beacon monitoring has always been a major requirement for monitoring a beacon and has been discussed over the past two plus years at various workshops.

The initial thoughts were to monitor CW beacons using software like CW Skimmer. Experience gained through actual testing has shown the following flaws with this approach.

1. CW Skimmer is not free software and at $75 per license it is out of the reach of most amateurs who want to monitor beacons.

2. It has been discovered that CW Skimmer is also not 100% reliable when it comes to decoding and a fairly strong signal needs to be received before the software actually begins decoding the received CW signal. Aural reception of a weak CW signal can already take place way before the Skimmer software starts to decode the signal.

These findings encouraged the members of the VHF Work Group to start experimenting with digital modes like FT8 and JS8Call on VHF and UHF and they found that the reception and reporting of the signals heard could take place at very low levels. This therefore seemed to be a much better solution for a beacon than continuing with a traditional CW beacon.

This experience led the Work Group to Next Generation Beacons that use the PI4 mode.

THE RELATIONSHIP BETWEEN TEMPERATURE, PRESSURE AND HUMIDITY?

Of the three atmospheric variables that influence

refraction, water vapour has the greatest effect. The more moisture there is, the more refraction there will be. Temperature on the other hand needs to be low. In other words, the higher the temperature, the less refraction. Moisture and temperature are the two factors that affect refraction the most. Pressure variations have a small influence on refraction. Normal refraction occurs under normal (standard) atmospheric conditions in which moisture, temperature and pressure all decrease with altitude. Normal refractive conditions are found in areas with very weak (or no) inversions, deep moisture, moderate to strong winds and very unstable, well-mixed conditions. There are often showers in the area, and distinct cloud elements (Cumulus or Cumulonimbus, open convective cells, wave clouds, streaks or convective cloud lines). Synoptic influences include a cyclonic influence, post-frontal or unstable prevailing conditions. Sub-refraction occurs when the temperature and moisture distribution create increased refractivity with height, the wave path bends upward and the energy travels away from the surface. In hot, dry areas (temperature > 30 degrees C, relative humidity (RH < 40%), solar heating produces a homogenous surface layer, sometimes hundreds of metres thick. Sub-refractive areas are also formed by warm, moist air moving over a cooler, drier surface and near warm fronts because of warmer temperatures and an influx of moisture. Ducting is an extension of super-refraction because the meteorological conditions for both are the same. The conditions that form a trapping layer

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Audio recording of the presentation

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Summary

Inland Tropospheric Propagation

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The South African Radio League is the National Body for Amateur Radio in South Africa. The orginisation is a member of the International Amateur Radio Union and like the international body was founded in 1925 as the South African Radio Relay Leaque (SARRL). In later years it was renamed the South African Radio League.

Website: www.sarl.org.za Email: admin@sarl.org.za

AMSAT SA is part of the international AMSAT amateur satellite community. AMSAT SA is currently building a one unit cubesat named AfriCUBE. It will include a linear transponder with an uplink on 2m and a downlink on 70cm. The transceiver development recently changed from analogue to SDR. The group designed and developed its own space frame. In cooperation with the SARL developed a dualband yagi for the YOTA project. It was later industrialised and is now sold worldwide and generates the funds for AfriCUBE.

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REFERENCES

Next Generation Beacon

https://www.rudius.net/oz2m/ngnb/index.htm