Minutes of the Propagation Studies Committee

4 May 2019

Attendees:

Steve Nichols	G0KYA	Chairman
Chris Deacon	G4IFX	Secretary
Alan Melia	G3NYK	
Ron Smith	G3SVW	
Dr Peter Duffett-Smith	G3XJE	
Sam Jewell	G4DDK	
Prof Barry Chambers	G8AGN	

1. Apologies for absence

Apologies had been received from full members G4BAO, G4LOH and G0HSV, RSGB Board Liaison M0BOX and corresponding members G0IJZ, G3YLA and G4FKH.

2. Matters arising from the minutes of the meeting held on 3 November 2018

These minutes had previously been approved via email and posted on the RSGB website. Matters arising will be dealt with under other agenda items.

3. PSC membership

3.1. New members

It was agreed that there is no need to look actively for new members at the moment.

3.2. Membership list

It was noted that, from a GDPR point of view, it is necessary to secure permission from all full, corresponding and associate members for their personal details to be included in the PSC membership list.

Action: G4IFX c/f

4. Topics for discussion

4.1. RSGB website updates

PSC webmaster Alan, G3NYK has made a lot of progress cleaning up the PSC pages (https://rsgb.org/main/technical/propagation/). There are considerably fewer links now but they are focused on the more relevant sites as well as removing the considerable number

of ‘dead’ links. It was agreed that this represents a huge improvement. Currently Alan has one additional article to add – an introduction to ionosondes by Gwyn, G4FKH.

The current content was agreed to be excellent although there are naturally gaps. There ensued a discussion about future direction and some suggestions about how the propagation landing page could be made more useful to the average RSGB member.

Suggestions to Alan for additional items to feature on the PSC pages.

Action: All

4.2. 28 / 50 MHz beacon lists

Martin Harrison G3USF has indicated that he may wish to pass his beacon lists on to a new home and has asked whether PSC would take it on. In the discussion, it was suggested that the UKuG’s beaconspot website (www.beaconspot.uk) is probably currently the most reliable source of up to date information. It covers 50 MHz but not currently 28 MHz.

Action: G4DDK to follow up with the owners of beaconspot to see whether it could be updated to include our areas of interest.

Post-meeting note: In response to G4DDK’s enquiry, the initial response from the beaconspot owner was that he does not want to add HF beacons due to difficulties he has experienced trying to verify beacons on lower bands. Beaconspot was originally devised for spotting the microwave beacons. In the meantime, Steve G0KYA has asked Martin G3USF to send the latest lists to him as he is keen to put the 28 MHz list on the RSGB website.

4.3. Possible RadCom features and book ideas

Possible RadCom features and book ideas were discussed.

Corresponding member Jim Bacon, G3YLA had reported by email that he plans to start work on his weather and propagation book now that he has retired. He would welcome any views on what needs to be in it, because although he has a plan it is always useful to get outsiders’ views on gaps that need filling. The book is designed for the average amateur who is curious about why the weather affects some bands and not others.

Action: All

4.4. Newark Hamfest 2019

Steve G0KYA confirmed that there will be a PSC stand this year. Steve himself is a confirmed attendee but he would welcome an additional PSC member to join him. Peter G3XJE indicated that he would join Steve on the Friday of the event.

5. Projects and potential projects

5.1. Propagation prediction models and RadCom predictions

G0KYA reported that two online propagation tools have been developed, one based on VOACAP (thanks to Jari, OH6BG) and the other based on ITURHFprop (thanks to James Watson, HZ1JW). There have been some issues over the basic circuit reliability parameter of ITURHFprop but these are expected to be resolved soon. Once that has been done, Steve will write an update for RadCom.

Action: G0KYA

Post-meeting note: the ITURHFPROP RadCom tool went live w/e 24 May 2019 (access via http://rsgb.org/proppy)

5.2. Goonhilly HF Web SDR

The Goonhilly HF Web SDR is up and running (http://kernow.hopto.org:8073/) although it is not known whether it is fully operational yet.

5.3. Possible research projects using WSPR (G3XJE)

Peter believes WSPR is not suitable for the sort of research projects he wants to do because of the infrequent transmissions and limited time resolution. Also the characteristics of the stations in terms of power, antenna and so on are very variable. But he suggests that it could be used for improving the usability of the normal 'average' ionospheric propagation prediction programmes by adjusting the predictions to suit "today's" conditions more realistically. Some sort of simple relative calibration between stations would be possible, although difficult. The problem would be that with WSPR, all one really knows is that there was a signal present on a particular frequency at a particular time, one doesn't know whether other stations were on the air at the time but not received. On consideration, his conclusion was that this is not an avenue worth pursuing.

5.4. Other projects for the next 12 months

None submitted.

6. Chairman's report (G0KYA)

Steve noted that no update has been received about the potential WPSR beacon at the Poldhu club. Other items have been covered elsewhere in the agenda.

Steve has prepared a 'Radio Propagation Q&A' sheet for the NRC at Bletchley Park. He has also given a number of talks to radio clubs.

7. Other member reports

7.1. Barry, G8AGN put forward a discussion paper looking at the possibility of extended access to the QO100 geostationary satellite through (e.g.) tropo ducting from the west coast of Australia. Any predictions could be tested out by encouraging someone to install a QO100 uplink beacon in Australia. It was agreed this was a very interesting project to pursue (see attachment).

7.2. Ron, G3SVW reported that he got a lot of interest from his joint South Manchester Club/PSC stand at the Blackpool rally but unfortunately health problems have constrained

his other activities. He will, however, be displaying information about space weather at a public event in the summer..

7.3. Alan, G3NYK put forward his ideas for looking at ionospheric birefringence at 136 kHz. The group agreed this sounded like a very interesting topic for investigation.

7.4. Sam, G4DDK has written a series of articles for Practical Wireless about 23cm. He is also writing a review for PW about the new Icom 9700 VHF/UHF/SHF rig.

7.5. Chris, G4IFX reported that the data analysis of his 2018 sporadic-E polarisation recordings is continuing. It's too early to be definitive but it does appear, after calibrating out instrumental and antenna effects, that at least some 50 MHz sporadic-E signals are elliptically (rather than linearly) polarised. Chris gave a presentation on his Es research at the UK URSI Symposium in January and will be delivering a paper on the same topic at the Nordic HF Conference HF19 in Sweden, 12 – 14 August 2019.

7.6. Jim, G3YLA, in addition to beginning to develop his book as mentioned above, is continuing with his work on an Es index, distilling the various parameters into a single guidance value and plotted as a 'dart board' style display of index v/s azimuth.

7.7. Gwyn, G4FKH has for the last month been working on a new project called the Propagation Prediction Comparison Program (PPCP). Those familiar with ITU-R P.1148-1 know that this describes a method of collecting data and using it to compare the prediction engines ITURHFProp, VOACAP, REC533 and ICEPAC. In support of this he is collecting data using the FAROS, NCDXF Beacon Monitoring Program and storing it in a database. He has written a routine to analyse the data and output it in a similar fashion to that described in the ITU recommendation.

7.8. Tomas, NW7US has written the propagation outlook for the Summer Edition of the Global Radio Guide (on Amazon).

8. Any other business

It was agreed to formally record the thanks of the committee to the Leicester Radio Society and particularly to Tony Webb 2E0DBT for his most helpful support for our meetings over the last few years.

Action: G4IFX to pass the message on.

9. Date of next meeting

Provisionally Saturday 19th October 2019.

10. Close

Chris Deacon G4IFX
PSC Secretary

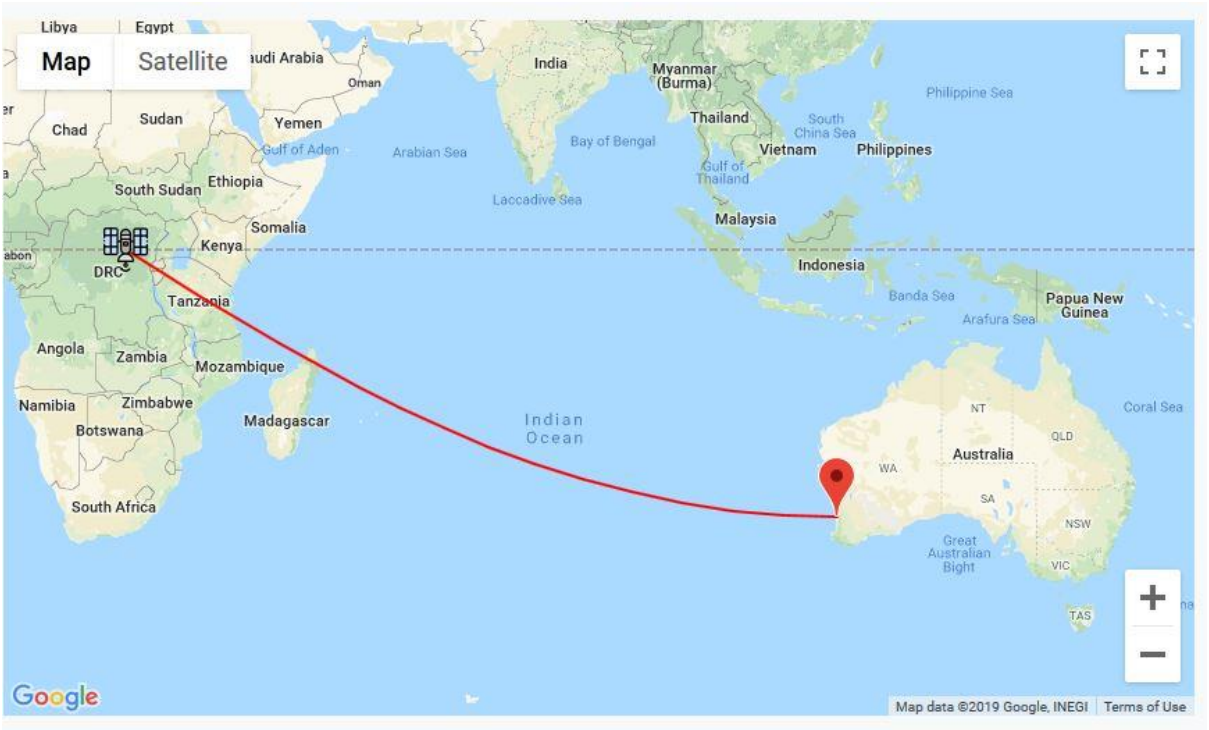
ATTACHMENT

The possibility of extended coverage operation for QO100

Draft 2, Barry Chambers G8AGN, 8 May 2019

The nominal coverage area of QO100 would seem to indicate that operation from VK should not be possible. This note explores whether under certain propagation conditions, this may not be the case.

The most obvious location in VK to consider is Perth. Using the BATC dish pointer application at https://eshail.batc.org.uk/point/ gives the required dish pointing data: Azimuth 270°, Elevation -8.6° and LNB skew -58°.



The required elevation angle may be increased by moving further North on the coast to Carnarvon.

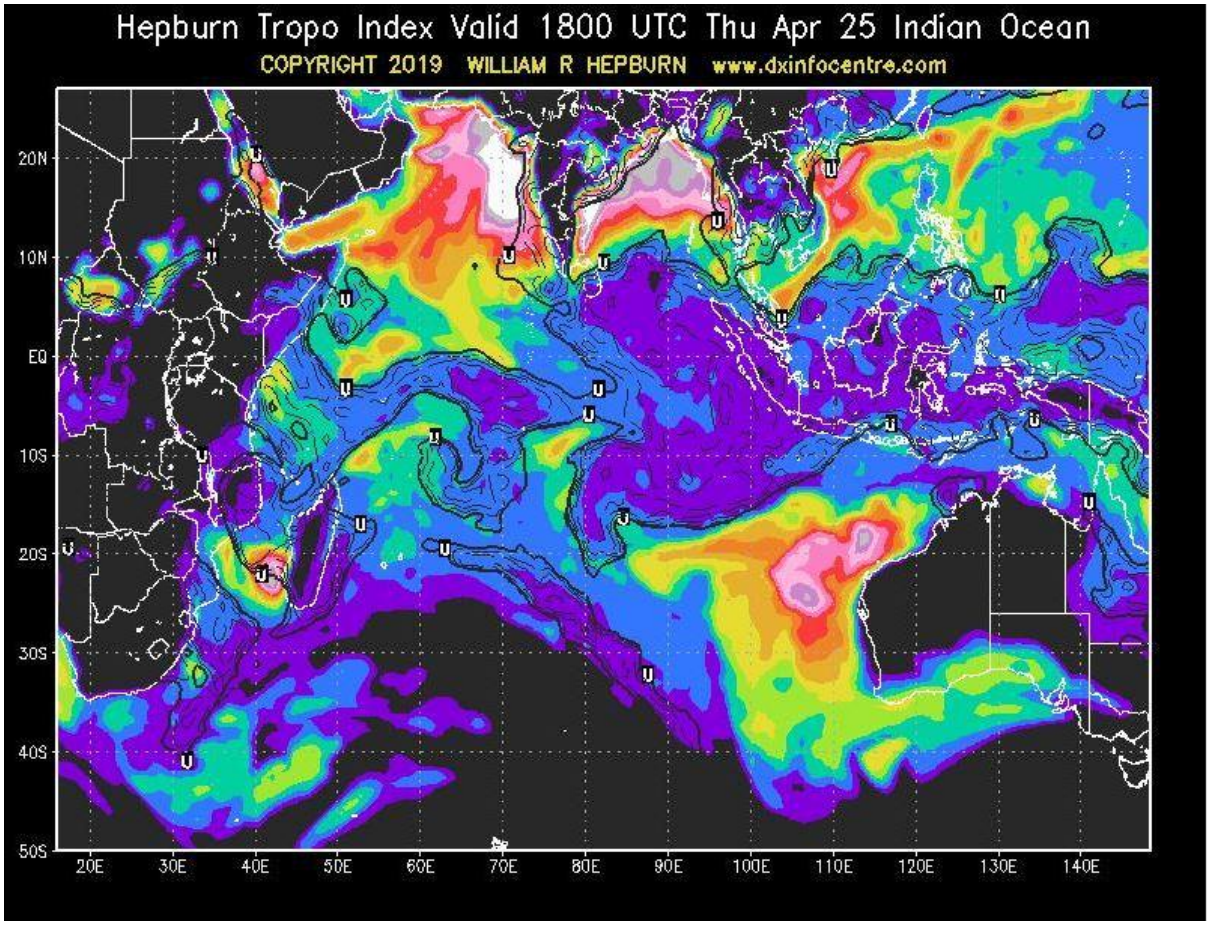
This gives the required dish pointing data: Azimuth 270.9^{o}, Elevation -6.7^{o} and LNB skew -65.1^{o}.

At both locations, the negative value for dish elevation indicates that QO100 is below the horizon but in the calculations, no allowance has been made for refraction and/or anomalous propagation effects. A starting point, therefore, was to look at a recent Hepburn Index chart at http://www.dxinfocentre.com/tropo_ino.html for the region of interest (Indian Ocean).

Australia is situated in the bottom RH corner of the chart shown below and it can be seen that strong anomalous propagation conditions were present stretching from the west coast to at least 100^{o}E. This is the longitude of Bangkok in Thailand, which is well within the coverage area of QO100 and corresponds to a dish elevation angle of about 6^{o}.

Thus, the question which needs to be considered is whether uplink and/or downlink signal transmission between QO100 and western VK is possible?

Anomalous propagation is usually explained in terms of so-called “ducts” which are regions in which the variation of radio refractive index, **n**, with height is abnormal and usually discontinuous. Ducts may form adjacent to the Earth’s surface, especially over the sea (surface ducts) or at some height above the surface (elevated ducts). Ducts can act as a type of “leaky waveguide” in which the propagation losses (proportional to path length) can be much lower than for the more usual case of free-space propagation (proportional to path length^{2}) and the crucial question to be examined is whether radio waves can be coupled into and out of such waveguides and what are the requirements for such coupling to take place?



The figure below shows the variation with height of the modified radio refractive index, **M**, associated with a surface duct. (Here the radio refractive index has been modified so as to make the Earth's surface appear flat, rather than curved – see Appendix). The top of the duct is delineated by the horizontal dashed line corresponding to $\frac{dM}{dh} = 0$ and a transmitter is located above and outside the duct at point T. Also shown are the paths of several signals emitted from the transmitter at different elevation angles. It can be seen that at certain critical elevation angles, a signal from T can be trapped within the duct and guided along it to a ground based receiver R with a lower path loss than that for free-space propagation (because the signal energy is confined vertically). Since wave propagation effects are reciprocal the transmitter at location T could be replaced by a receiver R and the ground based receiver by a transmitter.

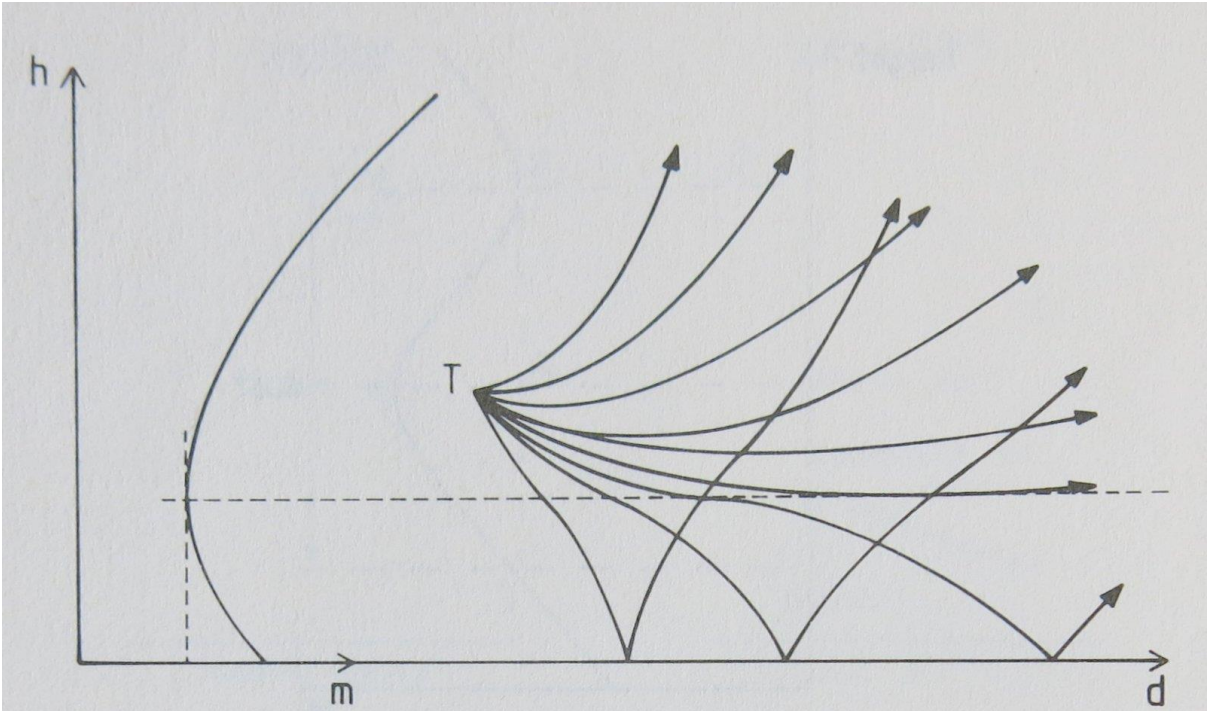
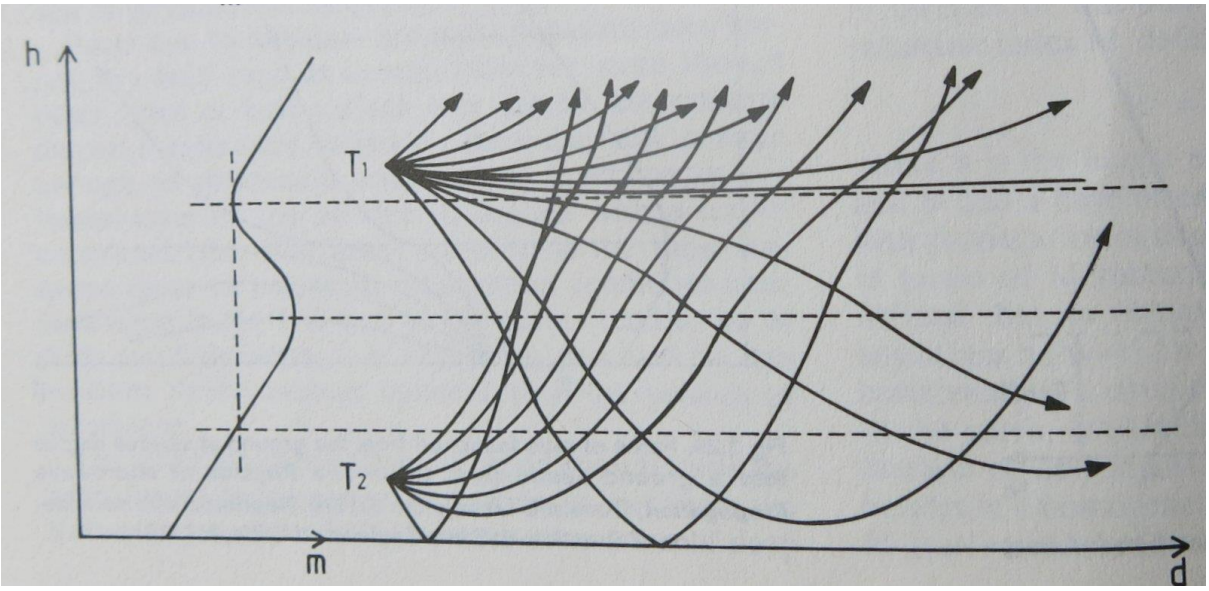


Fig 3.30. Paths of rays launched at various angles from a point above a ground-based duct (from *The Physics of Microwave Propagation*, Donald C Livingston. ©1970. Reprinted with permission of Prentice-Hall Inc, Englewood Cliffs, NJ, USA)

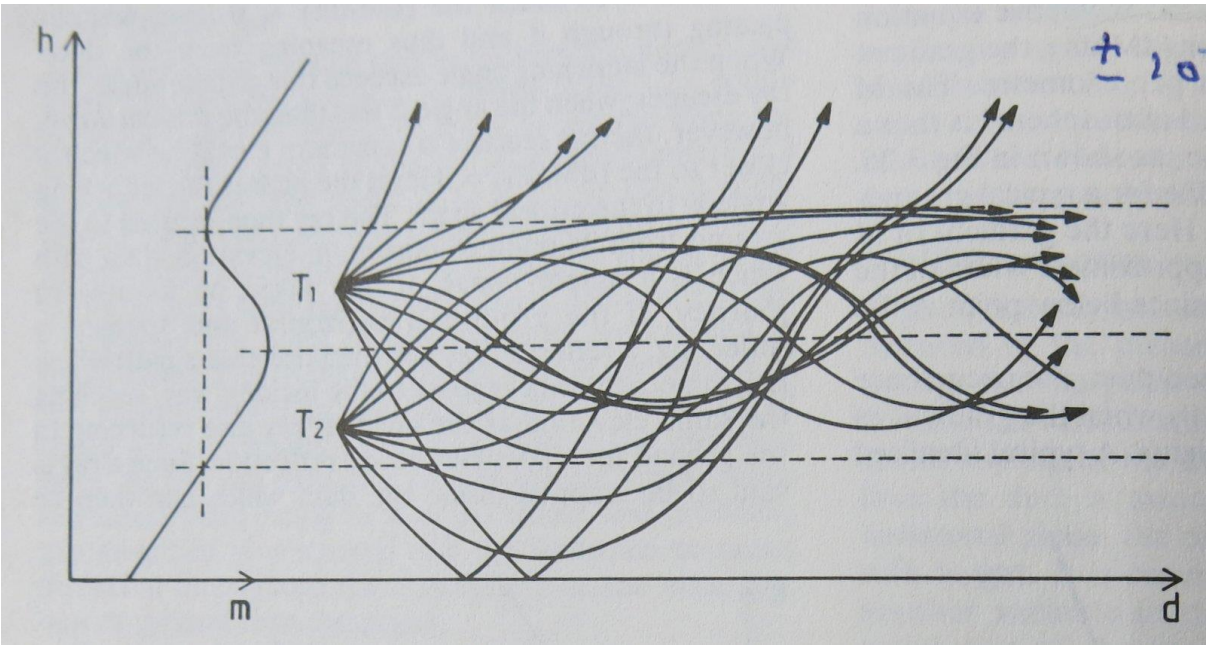
(Source RSGB Microwave Manual, vol 1, 1989)

The next case to be considered is the corresponding situation for an elevated duct and this is shown the following two figures.



(Source RSGB Microwave Manual, vol 1, 1989)

The first of these shows the paths of radio signals rays from transmitters T_1 and T_2 situated above and below the duct respectively. T_1 corresponds to the QO100 downlink transmitter and T_2 the uplink transmitter. It can be seen that downlink signals from T_1 can be trapped by the duct but uplink signals from T_2 cannot. This case is not reciprocal since a ground based receiver situated at T_2 will not benefit from the presence of an elevated duct whereas an elevated receiver at position T_1 might (i.e. situated on a high mountain).



(Source RSGB Microwave Manual, vol 1, 1989)

The figure above shows the cases of two transmitters T_1 and T_2 situated within an elevated duct. In both cases these might correspond to a signal which is already trapped within the duct. Since real ducts are not bounded by "perfectly" reflecting walls as in a metallic waveguide, phenomena such as wind shear and turbulence "roughen" the duct boundaries and this might enable signals to leak out of the duct and be captured by a ground based receiver.

Two questions remained to be explored. The first of these concerns the choice of critical elevation angle for a signal ray to be captured by a duct. This will depend on the so-called "lapse rate" which is the rate at which the radio refractive index changes with height within the duct. For the case of the surface duct, the duct height is taken as the distance between the Earth's surface and the horizontal dashed line shown in the previous figure at the top of Page 4. An estimate of the critical angle, **θ**, can be obtained from

$$\theta = \pm 10^{-3}\sqrt{2\Delta N} \text{ radians}$$

Where ΔN is the total change in refractivity **N** across the duct thickness and $N = (n-1) \times 10^6$.

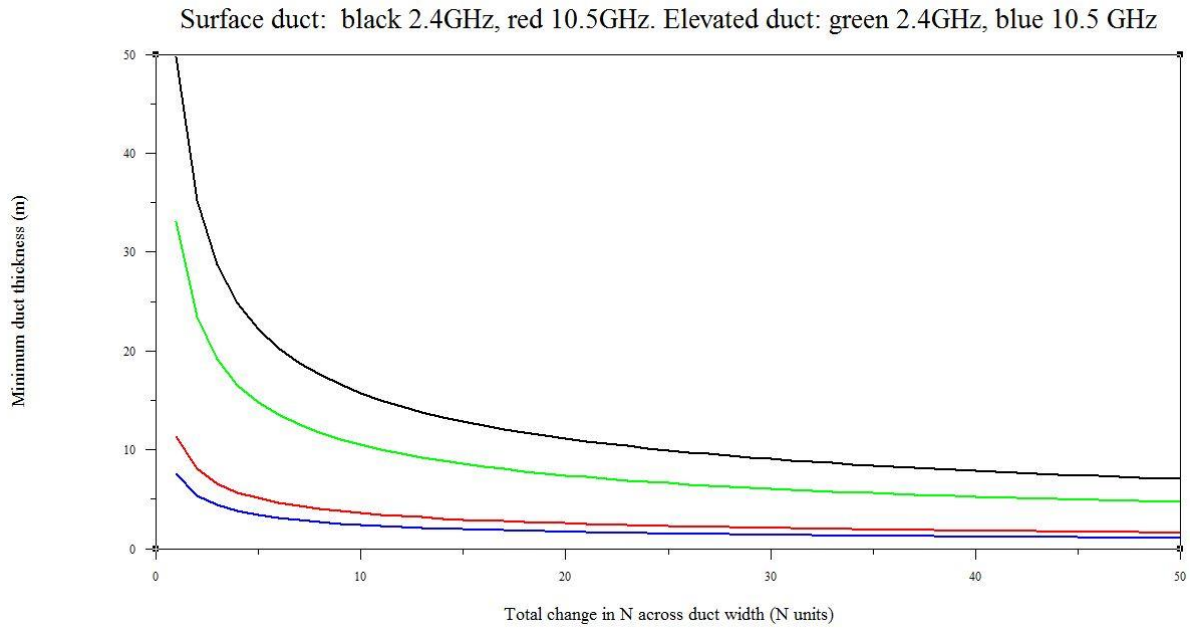
So, for example, if $\Delta N = 40$, θ is about ±0.5°. Thus in practice the coupling angles will be small and may also be dependent on frequency to some extent due to duct boundary "roughness".

The second question concerns the range of frequencies which can be trapped and guided by a duct of a given thickness. The situation with ducts is rather similar to that for the more familiar metallic waveguide in that both exhibit a cut-off frequency below which guiding cannot occur. In the case of a metallic waveguide, the cut-off frequency is well defined but in the case of a duct this is less so because the walls are "leaky"; nevertheless an estimate of the minimum thickness of a duct which is needed to guide a signal with a given wavelength can be deduced from a formula given by Turton ("An introduction to radio ducting", Met Mag, 117, 1988).

$$d = \frac{1.5\lambda}{k\sqrt{\Delta N}} \qquad \text{metres}$$

Here d is the duct thickness, ΔN is the change in N across the duct and $k = 3.77 \times 10^{-3}$ for a ground based duct and 5.66×10^{-3} for an elevated duct.

Typical results from this equation are shown in the figure below for the QO100 uplink and downlink frequencies of 2.4GHz and 10.5GHz.



For the frequencies of interest, it can be seen that the minimum required duct thicknesses are surprisingly small.

From data presented by Martin ("VHF and Microwave Propagation Characteristics of Ducts" Andrew L. Martin, VK3KAQ) and as indicated in Hepburn Index records, it would appear that both surface and elevated ducts of appropriate thickness are prevalent along the west coast of VK and this gives encouragement to the possibility of west coast VK amateurs being able to access QO100 under favourable conditions.

Appendix

The radio refractive index of the Earth's atmosphere**, n**, has a value which varies with the latter's pressure, temperature and water content. Since the value of **n** is very close to 1, it is usual to work with refractivity **N** instead, where

$$N = (n-1) \times 10^6 \qquad (1)$$

A typical value of N under normal atmospheric conditions would be approximately 300.

Because N varies with height, when considering ray tracing through the lower atmosphere, it is convenient to use **M**, the modified refractive index, since this enables the earth's surface to be depicted as flat rather than curved. Then for h << a,

$$M = N + \left(\frac{h}{a}\right) \times 10^6 \qquad (2)$$

Where **a** is the Earth's radius in m and **h** is the height above ground level in m

Hence to a good approximation

$$M = N + 157h \qquad (3)$$

The gradient of M is then

$$\frac{dM}{dh} = \frac{dN}{dh} + 157 \qquad (4)$$

When atmospheric conditions are such that at a certain height $\frac{dM}{dh} = 0$, a ray travels along a path which lies parallel to the surface of the Earth. "Ducting" is said to occur when $\frac{dM}{dh} < 0$ and this corresponds to $\frac{dN}{dh} < -157\ N\ {}^{units}/_{km}$.