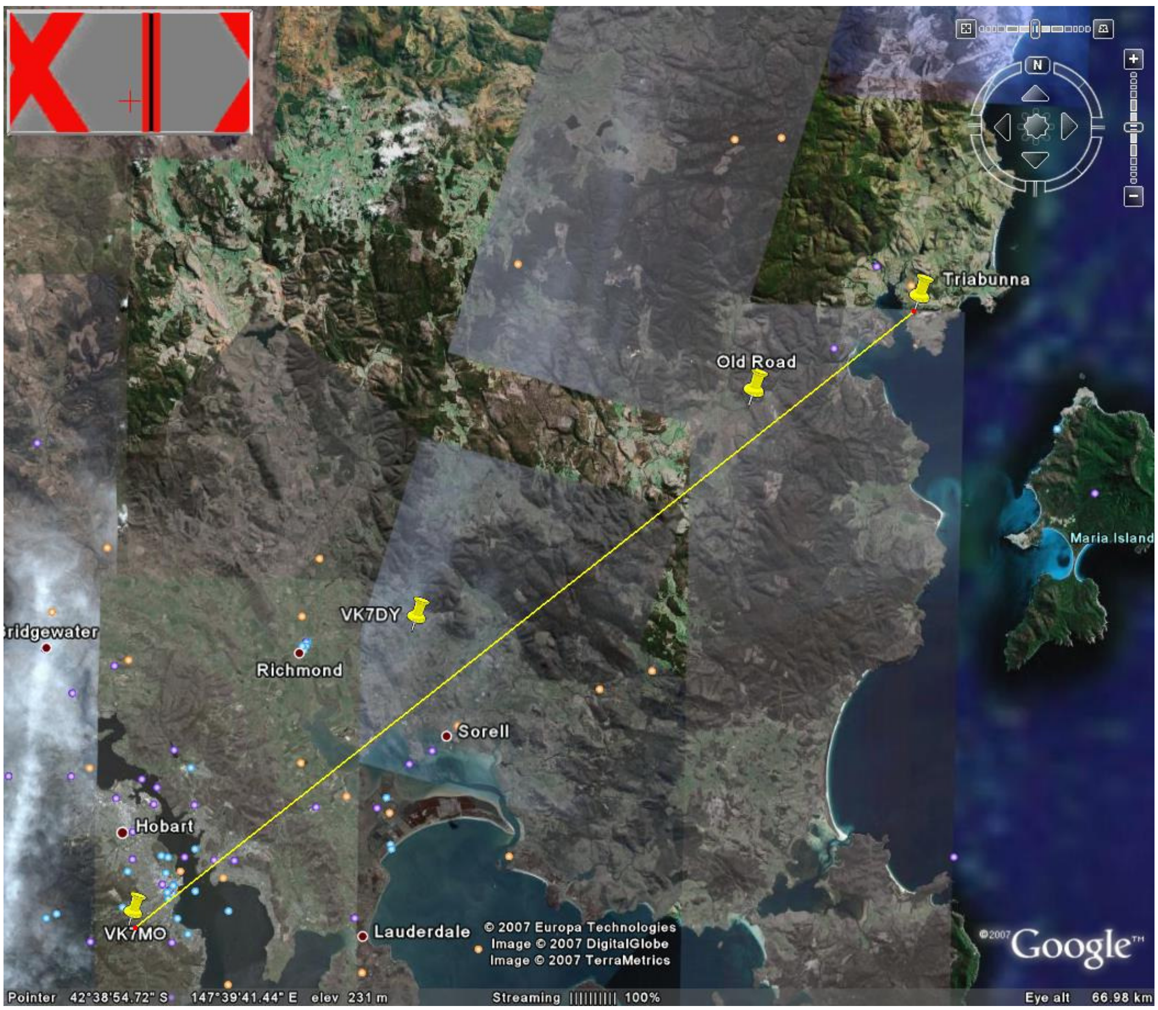
Extending the Distance of Optical Cloudbounce to 66 km

By Rex Moncur VK7MO, Ken Sulman VK7XDY and Justin Giles-Clark VK7TW

On the evening of 22 December 2007 signals from VK7MO to VK7XDY's QTH reached -6 dB on the WSJT scale, close to the best we have ever achieved. This suggested conditions were right to extend the optical cloudbounce distance beyond the 48 km reported earlier on 22 November. Ken went portable to locations which we call the Old Road (54 km) and Triabunna (66 km) from Rex's QTH.

Locations

The following Google Earth diagram shows the locations. The path is blocked by Mountains at 2 or 3 points. Angles of take-off are close to zero at both locations.



Equipment

Ken used the 35 photo-diode array and Rex used the 60 Luxeon Transmitter which is the same set-up as for the earlier 48 km work.

Meteorological Conditions

As reported from Hobart Airport a few km from the path.

- Initial Tests at Ken's Home: Cloud FEW at 450 meters, Relative Humidity 82%
- Old Road: Cloud FEW at 1000 meters, Relative Humidity 54%
- Triabunna: Cloud FEW at 1300 meters, Relative Humidity 51%

The drop in Relative Humidity and increase in cloud height probably both helped improve the propagation over the period of the tests.

Results

Ken's home QTH 27 km at 10:30 pm
-6 dB on WSJT with 2 bays of 30 Luxeons running at 10 amps per bay
-12 dB on WSJT with 1 bay 30 Luxeons running at 3 amps.

Old road 54 km at 12:30 am
-8 dB on WSJT with 2 bays of 30 Luxeons running at 10 amps per bay
Voice communication was weak but just sufficient to allow an unknown word to be identified by using phonetics.

Triabunna 66 km at 1:45 am
-10 dB on WSJT with 2 bays of 30 Luxeons running at 10 amps per bay
-24 to -27 dB with 1 bay of 30 Luxeons running at 3 Amps.
Voice was attempted and a whistle could be heard as well as evidence of voice but nothing could be identified.

Signal Levels with Distance

With the earlier tests signal levels dropped very rapidly with distance where-as for these tests signal levels dropped only 4 dB for an increase of from 27 to 66 km. In part this is a function of WSJT saturating at high signal levels and the variation on lower power from of around 14 dB is more meaningful.

Our view is that signal level drops with distance due to the following:

- Inverse Square Law if the beamwidth is smaller than the target.
- A further reduction of the 2nd power if the beamwidth is larger than the target giving the 4th power reduction as per the normal radar equation.

- A further reduction of the 2^{nd} power due to the fact that light detectors work on the basis of voltage and we are measuring signal to noise ratio as a power ratio.

Our view, based on observation, is that even a few clouds at long distances act as an almost continuous reflecting surface and thus in the horizontal dimension act as a reflecting surface wider than the beamwidth. However the vertical dimension is restricted by cloud height and thus is always smaller than the beamwidth at distances of more than a few km. On this basis we would expect a reduction with distance based on the 5^{th} power.

If we compare the Low Power (single bay at 3 Amps) tests between Ken's QTH and Triabunna the increased distance from 27 to 66 km would suggest the following reductions in signal level.

Inverse Square Law -7.8 dB
Inverse to the 4^{th} power - 15.5 dB
Inverse to the 5^{th} power -19.4
Inverse to the 6^{th} power -23.3 dB

The measured drop of only 14 dB is thus around 5 dB less than our hypothesis. A 5 dB variation could well be explained by changes in conditions over the 3 hours of the tests – particularly as the meteorological conditions changed significantly during the period.

Given that we achieved -10 dB signal levels at Triabunna there was ample reserve as WSJT can decode well at -28 dB. Application of the 5^{th} power law would suggest we could achieve around 150 km although this is on the assumption that absorption losses can be neglected.

Conclusion

While we need much more data to understand the variation in conditions the results of these tests do indicate that cloudbounce has the potential in the right conditions to allow WSJT communication well beyond 66 km. This conclusion is at odds with our conclusion of 22 November where we thought that 48 km was very close to the limit.