Abstract

Radio telephone surveying at the end of World War 2 was physically challenging, as well as technically demanding. The historic paper describes the extraordinary challenges faced by technical and lines personnel conducting propagation measurements for a radio telephone link from Victoria to Tasmania between 1947 and 1949.

Introduction

The propagation principles of point-to-point radio telecommunications have been long understood; however the environmental effects in new uncharted locations were difficult to quantify without field measurements.

Fast forward to today and modern software design tools, accurate terrain feature and climate databases, as well as years of transmission design experience, have almost eliminated the need for field surveys. Today’s equipment also contains features such as adaptive modulation that can reduce the effects of extreme environmental conditions on transmission quality.

The historic paper (Moriarty 1949 [5]) describes the need to establish a new radio telephone link to Tasmania to provide diversity from the existing submarine cable laid in 1935, given the back-up radio link from Tanybryn to King Island and then to Stanley had variable quality. A theoretical two-hop path which could provide a more reliable circuit was identified, from Wilsons Promontory to Flinders Island, and then to Launceston.

The field survey had to identify suitable repeater sites with elevations to meet the theoretical design requirements. They then undertook propagation measurements over a period of time to ensure performance was acceptable in a variety of environmental conditions that can cause degradation, for example through ducting and refraction.

The survey party had to cut their own track through thick scrub up to Mt Oberon from the lighthouse track on Wilsons Promontory. They carried their equipment by pack horses (or 4WDs where rough roads existed), then on their backs up to the chosen sites. The party had to rig VHF antennas on long poles and sleep in A-frame army tents in the scrub. On Flinders Island, the site at Walkers Lookout was so windy that the party also had to fabricate a wind break around their tents.

Their perseverance paid off and the survey collected a number of successful recordings which confirmed that the
live performance was more than satisfactory and matched the theoretical design. The tests also proved that if two frequencies (58Mhz and 158Mhz) were used for diversity, they would all but eliminate the effects of deep fades. The historic paper provides a number of interesting photographs, path profiles, calculated and measured field strengths, receiver input voltages and copies of receiver chart recordings.

The paper concludes with acknowledgement of the personnel involved, including Mr. A Irving and his lines staff at Foster who cut the track to Mt Oberon and Mr H Ternes and his staff from the Research Labs who manned the equipment in rough conditions in very remote locations.

References

to crawl through in the gloom beneath. Figs. 6 and 7 are typical of some of the conditions of the search for a site. Fig. 8 shows the Lineman’s hut used as a headquarters in the scrub. Mount Boulder had to be dismissed as impractical of access. Mount Oberon was found to be much less densely covered with scrub, and there were several gradual grades for a truck from the end of the road to the summit, and it was selected as the most suitable site. Fig. 9 is a view of the mountain. Fig. 10 is a photo of the summit. Fig. 11 shows a view from the top of the mountain looking in the direction of Melbourne, while Fig. 12 is a view looking over the promontory to the sea, in the direction of Flinders Island. It is fortunate that there is a low gap in the ranges on the eastern side of the Promontory; all paths from Flinders Island, as viewed from Mount Oberon, lie within the arc bounded by this gap, so that any possible path is unobstructed at the Wilson’s Promontory end.

The only settlement near the road in the Promontory is at Tidal River, at the north-
western base of Mount Oberon. Having decided on a site on the summit of Mount Oberon, an attempt was made by linemen from Foster to cut a track up the north-western slopes. It was found, however, that the slopes near the summit were too steep and slippery to permit of equipment being carried up by this route. The aim was to make a track to take up equipment to make radio propagation tests with Flinders Island. A new track was then cut up a long ridge from the end of the road on the eastern side of the mountain.

![Mount Oberon Summit](image)

![Mount Oberon View](image)

It had been intended that this track be wide enough for the use of a horse and sledge or a pack horse. It was difficult enough, however, to make a narrow foot track, and it was obvious that all equipment would have to be carried by men up the 900 feet of ascent between the end of the road and the summit. As will be described later, the considerable amount of equipment required was carried up the mountain by members of the testing parties assisted by local linemen.

Visibility of Flinders Island from Mount Oberon. The north-western side of Flinders Island is the closest to Wilson’s Promontory. While examining the summit of Mount Boulia, two high peaks, about one degree apart, were observed on Flinders Island. The same peaks would be in unobstructed range from Mount Oberon, and only about another four miles further away. The bearing from Mount Boulia on the more southerly and more visible peak, was 116° which, on the map, passed through North West Peak in Flinders Island. The other visible peak was presumed to be Mount Killarney, slightly to the north of North West Peak on Flinders Island.

The distance from Mount Boulia to North West Peak is 93 miles. The height of the peak is given as 1800 feet. The geometrical limit of the horizon between heights of 1850 feet, the height of Mount Boulia, and 1880 feet, the height of North West Peak, is 90 miles, which is less than the distance between the two points. If allowance is made for refraction of optical waves in the atmosphere (see Admiralty Navigation Manual, 1884, Volume III, pages 219-222) the distance to the horizon is 1.88 times the distance to the geometrical horizon. With this allowance a height of 870 feet at North West Peak would reach the horizon from a site at 1650 feet at a distance of 90 miles. With the allowance for visual refraction, therefore, North West Peak should have projected about 210 feet above the horizon, as was observed.

During several series of inspections and measurements it was only on about three occasions that the atmosphere was free enough from haze to allow of visibility from Mount Oberon to Flinders Island.

Selection of Site on Flinders Island

An inspection was made of Flinders Island to find an accessible site from which to work to Mount Oberon. The highest sites, namely Strzelecki Peaks, the Sugarloaf, North West Peak and
Mount Killarney, were found to be too inaccessible, although they would have given paths within the radio horizon from Mount Obery. A site at Walker’s Lookout, in the Darling Range, was finally selected.

The site at Walker’s Lookout is on a clear grassy hill (see Fig. 13), close to the end of a road from Whitemark, which is the post office centre of the island. The distance from Whitemark is 7 miles, and the grade of the road is gradual. The slope from the site to the end of the road was, however, steep without a road being cut, but it was possible to negotiate it with four-wheel drive vehicles, and this was done during the subsequent measurements.

The height of the site at Walker’s Lookout is 1350 feet above sea level. A profile of the path to Mount Obery is shown in Fig. 14. The path length is 1.68 times the radio-optical range for the heights of the sites. There might be an additional slight obstruction in the path at Cape Franklin, about 17 miles from Walker’s Lookout. It was difficult to obtain the height of this obstruction, but the maximum height was estimated to be 600 feet.

Selection of Site in Tasmania
A number of sites in the vicinity of Launceston were investigated for the Tasmanian end of the circuit. The sites examined were:
(a) Mount Barrow which was rejected because of the nature of the road leading to the summit. In some weather conditions this road would be very unsafe and could lead to a fatality among maintenance staff.
(b) Brown Mountain, near Lilydale, which had no road to the possible site.
(c) Mount Direction, which is not readily accessible, and is remote from power.
(d) Wealaby, the existing terminal of a link from Flinders Island. This site is farther from Launceston and more remote from power supply than the site finally selected.
(e) A site on the lower slopes of Mount Arthur, at what is known as Kelp’s Paddock. This site was considered suitable.

The site at Kelp’s Paddock is at a height of 1700 feet above sea level. It is 2½ miles from the township of Lilydale, and about 14 miles from the outskirts of Launceston. The road to the site was good and low tension power supply was being extended along the road from Lilydale towards the site.

A profile of the path between Kelp’s Paddock and Walker’s Lookout is shown in Fig. 14, where the path is seen to be well within the radio-optical range for the heights of the sites.

CALCULATION OF SIGNAL STRENGTH AND SIGNAL-TO-NOISE RATIO

Reference Radio System
The strength of the received signals over the paths selected was calculated early in 1948 for several frequencies. The calculated signal strengths were then used to estimate the signal-to-noise ratio, which would be obtained with a multi-channel radio-telephone system.

An actual radio system which was developed and proven for long paths is that operated by the British Post Office between England and the Channel Islands, and is known as the Guernsey-Chaldon Link (1). This link is of length 85 miles, and its length is 1.51 times the radio-optical range for the heights of the sites. The system used on this link is taken as a reference for performance of a system over the Bass Strait paths.

Six channels are operated with modulating frequencies between 60 and 50 kc/s. The carrier frequencies are about 45 Mc/s, and frequency modulation with a maximum deviation of 300 kc/s is used. The deviation per channel is about 20% of the maximum deviation.

For a check on the methods of calculating the signal-to-noise ratio for the Bass Strait paths,
The signal-to-noise ratio of the Guernsey-Chaldon link was calculated by the same methods to be 96 db. The performance analysis of the circuit published by the British Post Office (4) shows that the median value of signal-to-noise ratio for days of low signal is 54 db, and for an average over 8 weeks the median value is 59 db. The methods of calculation were, therefore, considered to be sufficiently accurate for the present purpose. The evidence of all the measurements which were made on the long paths across Bass Strait was that the calculated value of signal corresponded closely with the median value on days of low signal, which are taken to be days of normal propagation in a well-mixed atmosphere. The days of high signal are considered to be days on which there is abnormal propagation produced by a strong bending downwards of the radio rays, this condition being known as super-refraction. Apparently on the Guernsey-Chaldon link also the calculated value of signal is the median value on days of low signal, while days of high signal correspond to super-refraction conditions.

It is of interest to note that for 99% of the time on the Guernsey-Chaldon link, when signal strengths were averaged over eight weeks, the signal-to-noise ratio was not more than 18.5 db below the value calculated here, and for not more than 1% of the time was the signal-to-noise ratio more than 10 db above the value calculated here.
Frankland. The results of the calculations are shown in Fig. 15. It is obvious from Fig. 15 that the effect of the radio-horizon on the probable error of the obstruction of Cape Frankland is appreciably greater than at 60 Mc/s. The probable error of measured voltages shown in Fig. 15 referred to variations of mean signal due to diffraction with and without an obstacle at Cape Frankland and to fluctuations due to variable refraction.

As the path from Walker's Lookout to Kelp's Paddock is clear of the earth's surface, there is no refraction loss except that due to the approach to the radio-horizon. The results of the calculations on 160 Mc/s and 60 Mc/s are shown in Figs. 16 and 17 respectively.

**Calculated Signal-to-Noise Ratio on Bass Strait Paths**

In order to indicate the likelihood of a multi-channel V.H.F. radio system being satisfactory on this route an estimate of the probable overall performance was made, based on current English (British Post Office) designs. Using the calculated field strengths obtained in the foregoing, the values given below of calculated signal-to-noise ratio were assessed for a system similar to the reference British Post Office system described previously, but with aerial gains and transmitted powers as assumed for the calculations of field strength:

(a) **Carrier Frequency 60 Mc/s.**

(i) **Mount Oberon-Walker's Lookout.**

With diffraction around the earth and Cape Frankland, and without fading due to variable refraction, the calculated signal-to-noise ratio was 50 db.

(ii) **Walker's Lookout-Kelp's Paddock.**

The aerial gain for which the calculation of field strength was made on this path was 6 db, whereas it was 10 db on the Mount Oberon path. With this aerial gain, and without fading due to variable refraction, the calculated signal-to-noise ratio was 65 db.

(b) **Carrier Frequency 160 Mc/s.**

(i) **Mount Oberon-Walker's Lookout.**

With diffraction around the earth and Cape Frankland, and without fading due to variable refraction, the calculated signal-to-noise ratio was 47 db.

(ii) **Walker's Lookout-Kelp's Paddock.**

With aerial gains of 10 db as on the Mount Oberon-Walker's Lookout path, and without fading due to variable refraction, the calculated signal-to-noise ratio was 70 db.

From these calculations it was decided that propagation measurements should be made on 60 and 160 Mc/s to verify the calculated median received signal strengths and to permit an estimate of probable fading to be made. With this information it would be possible to carry out a detailed design of the radio equipment aspects of the complete system. The criterion for a satisfactory circuit was one that would give a signal-to-noise ratio above at least 50 db.

**ESTABLISHMENT OF TESTING STATIONS**

**Testing Station at Mount Oberon**

Severe physical difficulties faced the parties setting up and maintaining the test site at Mount Oberon. The linemen from Foster had cut a foot-track up the eastern ridge of the mountain from the end of the road (see Fig. 5). This track was very steep in places, and climbed 900 feet in a little more than a mile, which was the distance to the summit from the end of the road. The grade of the ridge was suitable for the formation of a road but, as Wilson's Promontory is a National Park, permission was not likely to be given for a wide track to be cleared unless the case for establishing a station were proved.

It was necessary to carry all the testing gear by manpower to the summit. It is a great tribute to an enthusiastic staff that the gear was carried and a substantial test station was set up. Figs. 18 and 19 show some of the gear being carried up in the more open parts of the track at the be...
gaining and end of the ascent. The last one hundred feet of the ascent to the summit was up a rock wall, and one part of this climb was usually negotiated with the help of a rope.

**First Test Station at Mount Orroroon.** The first test station on Mount Orroroon was on the highest point of the mountain, with the equipment housed in tents. Figs. 20 and 21 show this station, which was for testing on 160 Mc/s only. Recordings for seven days were made at this site, and then the aerial mast and tents were blown over in a heavy gale. The radio gear was salvaged and carried down the mountain to the accommodation centre in the tourist camp below.
element Yagi on 104 Me/s. Fig. 25 shows the location of three of the six aerials which were erected on one or two pieces of 3 by 2 inch soft-wood bolted together if two were used, each piece being twenty feet long. Fig. 26 shows the location of the test station, this being also the recommended location for the terminal of the projected new radio link. The hut is shown in Figs. 22 to 26 with a tarpaulin draped over it for additional protection in wet weather, particularly for the opened doorways.

Because of the difficulty of carrying the gear up Mount Oberon it was used as a receiving station. When completed it had receivers for 60 Me/s and 160 Me/s and a spare for each, a calibrating signal generator for each of these two frequencies, a transceiver for communication, an electronic voltage stabiliser, three petrol generator sets of 250 watt, 230 volt output, and six aerials. For ventilation purposes the petrol-electric sets were operated in a large tent.

Even when the test station was completed the difficulties of the staff were not over, for each day of the test they had to make the long climb from their quarters at Tidal River up the steep and often slippery track, carrying with them food and water and the daily supply of petrol for the generating sets.

Test Station at Walker's Lookout

The obstacle to access to the site at Walker's Lookout was the last steep climb up the gravel hill. This was overcome by shipping into the island a small four-wheel-drive vehicle. As shipping to the island is spasmodic by small vessels, there was much trouble in getting this vehicle shipped. The vehicle is shown in Fig. 27 arriving on the site with timber with which to erect a