

1.0 Introduction

This report details the comparative advantages that land-based telecommunications or mobile telecommunications has in remote rural areas of Chile. As a case study for this exercise, one area of Chile has been selected for study. This area was chosen for its proximity to a major National Park and will begin with a small city and will look at telecommunications options for a remote cabin placed near the National Park. This cabin would be the centre of an eco-tourism business, and so would offer that business voice, data, and other telecommunications services. The idea is to understand the costs involved in bringing advanced telecommunications to a remote area.

2.0 Rural Area in Chile

As mentioned above, the area was chosen for its proximity to a major national park, and therefore to eco-tourism opportunities. The map below shows where this area is in relation to the rest of the country.

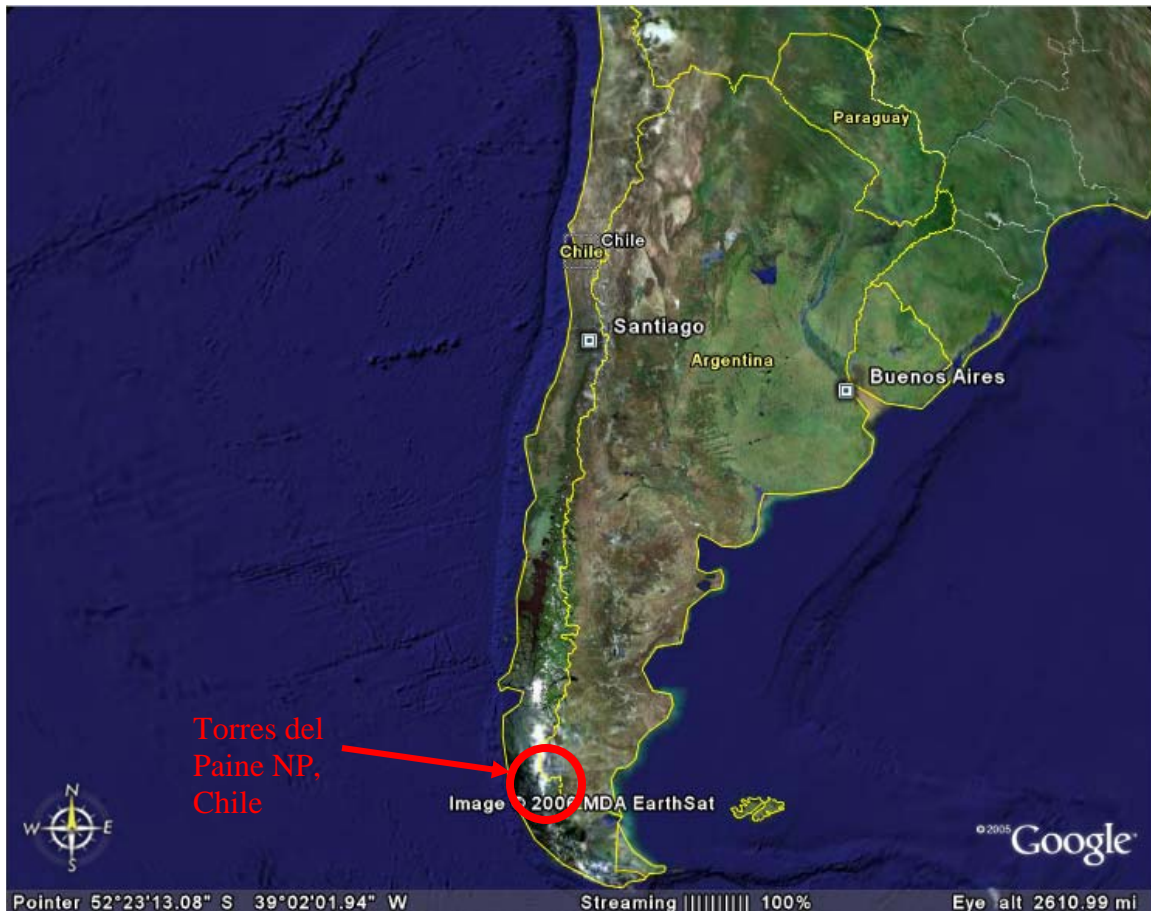


Figure 1 – Chile and Torres del Paine rural area

2.1 Punta Arenas – Torres del Paine National Park

This area will be discussed as to the technologies available for telecommunications, and the topography of the area.. Other areas could have equally been selected, such as Puerto Montt (PN de Peyuhue), Coihaique (PN de Laguna San Rafael), Arica (PN de Lauca).

2.2 Punta Arenas – Urban area

Punta Arenas is the major urban area in the Magallanes region of southern Chile, sitting at 53° 10' S, 70° 56' W. It is the southernmost city on Earth, overlooking the straits of Magellan. It has a population of 115,000 and is approx 3000 km south of the capital of Chile, Santiago.



Figure 2 – City of Punta Arenas, with a view to the Torres mountains

2.3 Puerto Natales – Urban area

Puerto Natales is a smaller city, closer to the National Park and is the capital of the Province of Ultima Esperanza. It has a population of 15,500 people and is 247 km from Punta Arenas. Puerto Natales is connected by road to Argentina (Rio Turbio), by ferry to Puerto Montt, and by air to the rest of the world. The city is situated at 51° 43' 60 S 72° 31' 0 W



Figure 3 – City of Puerto Natales showing the mountainous terrain

2.4 Topography of Magallanes area – Rural area

In order to understand the costs of connecting this part of the world, it is important to understand the topography of the landscape. As a way to illustrate the travel from Puerto Natales to Punta Arenas, figure 4 shows a satellite image of this area with the geographic coordinates of each city illustrated. As well, in orange are the major roads in the area.

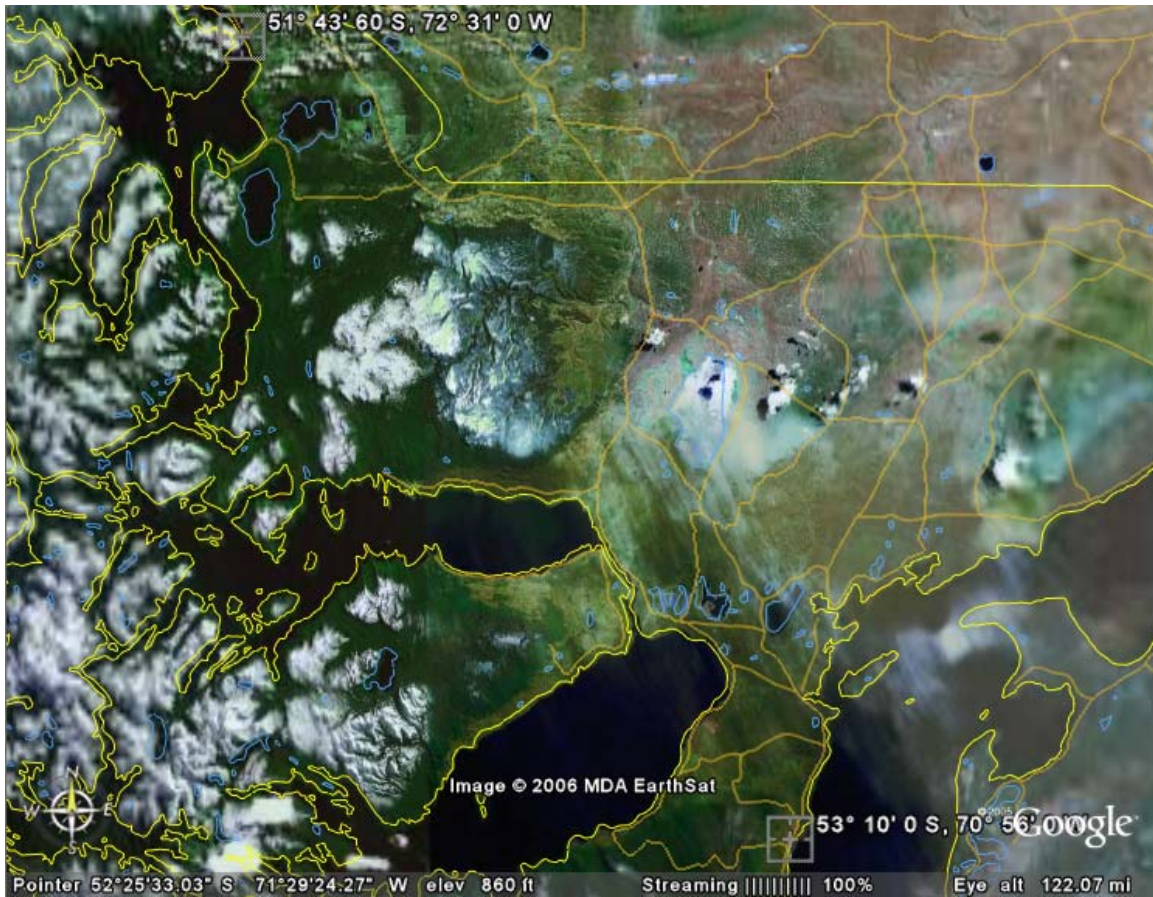


Figure 4 – Route from Punta Arenas to Puerto Natales, Chile

The distance from Punta Arenas to Puerto Natales is 247 km and it is possible to travel from one city to the next without traveling into Argentina (border seen above in yellow). This road is reasonably passable and a major fixed link is connected here.

From Puerto Natales, it is possible to envision a cabin into the National Park hinterland, which is only 150km from the city. The park itself is 181,000 hectares with 7 park guard stations. Choosing a location based on the geography at 51° 0' S, 72 ° 50' W, it is possible to determine the comparative costs of providing voice and data via fixed link or via mobile technologies. From Google Earth, one can see the distances involved from Puerto Natales.

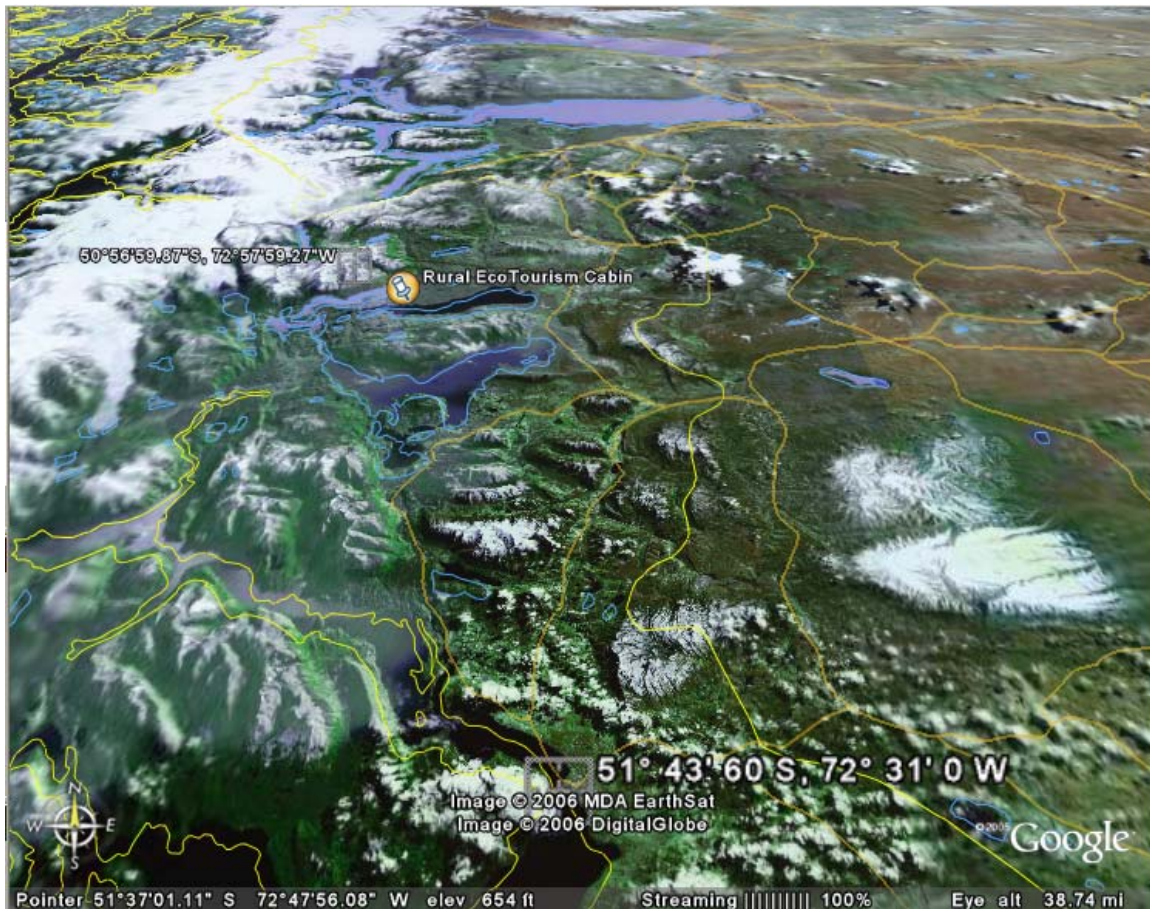


Figure 5 – Puerto Natales to Site of EcoTourism Cabin

2.5 Technologies

Looking at the topography, a direct microwave connection isn't a viable way to directly connect our ecotourism cabin to Puerto Natales. The mountains and rough terrain make both a line-of-sight connection and a fixed link connection difficult. We have two possibilities for methods to allow our solar-powered eco-tourism cabin to connect back to civilization:

- a) a microwave relay to a satellite receiver and then down to either Puerto Natales or Punta Arenas
- b) a fixed link connection back to the city of Puerto Natales

There are other ways to connect this site including a satellite feed back to other cities for hub connections, the erection of cell sites (difficult in mountainous areas with low population density), and a direct microwave relay back to Puerto Natales (difficult due to line of sight), but this report will examine only the two options above. It's also important to consider the next stage of this analysis, which would include other sites (including possibly the guard stations at the National Park or other cabins).

3.0 Direct Microwave Line of Sight to Puerto Natales

Using this technology involves placing a transponder within line-of-sight of the city of Puerto Natales. As seen in the above Google maps, the distance involved is at least 150 km from Puerto Natales to the National Park. One of the key parameters in making this type of solution work is being able to establish line-of-sight between the two transponders. Lacking data from the city of Puerto Natales of whether or not there exists a direct line-of-sight to our cabin, we will assume that this line of sight (including the Fresnel zones for additional clearance) does not exist. Figure 5 shows the topography which must be overcome in order to make a connection.

3.1 Microwave to Satellite Receiver

With a transponder directed up to the sky, the line-of-sight requirement no longer limits the use of this technology. No matter the mountainous valley, as long as the azimuth and elevation allow a path to the synchronous satellite, there is a connection path.

At our latitude (51 °S) and longitude (72 °W), we have a large number of satellites to choose from. However, it is important to keep in mind that if we're too far off the longitude of the satellite, the elevation of the satellite decreases. As we are trying to use this communications system for mountainous areas in the far southern hemisphere, too little elevation means that we have less flexibility in satellite transponder placement. If we assume that we're using the Anik C-1 satellite (was actually retired in 2003), then:

$Az = 0^\circ$ since the satellite is at the same longitude as the station and we're in the southern hemisphere.

$$Z = \arctan(\sin p / (h/Re + 1 - \cos p)) = \arctan(\sin 51 / (35,860/6,370 + 1 - \cos 51)) = 7.38^\circ$$

$$\text{Elev} = 180 - 90 - Z - p = 180 - 90 - 7.38 - 51 = 31.6^\circ$$

Thus, the receiver should be pointed due north at 31.6 ° in order to make line of sight connection with the satellite. This requirement will partially dictate the placement of the satellite if the valley walls are very large. Using any other satellite will only decrease the elevation angle for this system.

In terms of the costs of this type of solution, we will need some information on the satellite and the receiver. If we assume that the Anik C-1 satellite is being used, then the antenna diameter is 1.8m and the EIRP is 46.5 dBW. We will also assume C-band operation (4 GHz up, 6 GHz down), and 12 KHz BW (voice and/or data combined). This data requires 15 dB C/N. Since the Patagonian-Chile area is known for heavy rainfall, a rain margin of 3 dB will be used for calculation purposes. Taking satellite equipment cost data from page 42 of the course material, we will preliminarily select a system 6C with an LNA of 127° K noise temperature and 0.6 m antenna (G/T = 4.4 dB).

Calculating the required power transmitted from the satellite will give us an idea of the costs involved:

$$“C/kT” = B + C/N = 10 \cdot \log(12000) + 15 = 55.8 \text{ dB}$$

$$\text{ERP} = “C/kT” + k - G/T - L_{fs} + L_a = 55.8 + (-228.6) - (4.4) - (-196.5) + 3 = 22.3 \text{ dBW}$$

This will cost too much for the satellite power; instead, we will try a larger antenna at 1A (6.1 m, \$6680, 25.9 G/T) yields 0.8 dBW EIRP. Using 55% antenna efficiency yields an antenna gain of 34.95 dB from the satellite. Backing off the satellite power 5 dB yields a receive power of 0.8 dBW – 34.95 dB + 5 dB = -29.15 dBW. In power terms, this is 1.216 mW. With a \$1 M/ watt price tag on the antenna bandwidth, the cost for this much power is \$1216/ year.

The costs then are \$6680 at year 1 for the transponder, \$1216/year for satellite rental. Using a 5% interest rate for the present value calculations yields:

$$P_v = \$6,680 + \$1,216 * P_{v10} = \$16,068 \text{ for one transponder for 10 years.}$$

3.2 Fixed Link Connection

A fixed link connection from the National Park back to Puerto Natales will require a substantial amount of digging, trenching, and cabling in order to supply this location with telecommunications services. Examining the geography involved, it looks as though we need at least 150 km of cable installation and probably slightly more to deal with the terrain involved. Other costs here could include the cost of purchasing the right-of-way needed to add fixed line service to this location, which isn't considered in this cost analysis for lack of information.

The primary cost in this analysis would be the cost of connection. This connection cost includes both the laying of cable as well as the right-of-way mentioned above. With some references listing trenching costs at \$2000 USD/mile (Dr Lusignan) and others at anywhere between \$35-\$200/meter¹⁸, this cost is quite large. Using a budgetary price of \$2000 USD per mile, a distance of 120 miles (allowing for terrain problems), gives a cost of \$240,000 USD just for the cable laying. This cost could be larger depending on right-of-way costs.

Equipment costs here would be a simple cable modem or ADSL modem (depending on what type of network is being extended) at \$30 USD and whatever other equipment would be desired on the user's premises. Of course, this cost would be the same no matter how the connectivity is established.

If we assume, as above, that this connection will remain in place for 10 years (in practice, this is much longer for line operation), one can calculate the present net value for this solution. We should also assume a maintenance cost of the cabling at 10% of the

installation cost. If we assume that our business pays \$100 per month (this is probably high) for data and voice services, then the yearly payment for services is \$1200.

Present value of ten year's of operation

$$P_v = \$240,000 + \$24,000 * P_{v10} + \$1200 * P_{v10}$$

Assuming an interest rate of 5% (this is fair considering that Chile is stable politically and economically), then, the present value for 10 years of operation is:

$$P_v = \$240,000 + \$25,200 * 7.72 = \$434,588$$

4. Conclusion

Based on the above analysis, a microwave solution is far better than a fixed line solution to achieve the goals set out. However, the fixed link connection is capable of providing much higher bandwidth based on not having link limitations. A single business venture would still not be very economical based on these numbers. A possibly better solution could emerge by using microwave relays on the ground and a single hub connection back to the satellite. This could be explored in further work.

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