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TITLE : Design of a wireless link for the telemedicine service between Huayllay and Cerro Huayllay and Cerro de Pasco using Radio Mobile software and Google Earth.

LINE OF RESEARCH : Telecommunications

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INTRODUCTION

In this research project we developed the design of a wireless link for telemedicine service between Huayllay and Cerro de Pasco using Radio Mobile software and Google Earth. First, the location of geographical points was made with the help of Google Earth where it will give us the coordinates and lines of sight of each link where it is going to get if it is necessary to use a repeater or not. Then we will use Excel to perform the necessary calculations to obtain the characteristics of the most optimal antenna to be used for the link from Cerro de Pasco to Huayllay. Finally, with the results obtained for gain, Fresnel zone, correction factor, free space loss, etc., it was introduced into the Radio Mobile software and the type of antenna to be used was also specified, to then simulate and finally test the entire procedure. With all the stages already completed, the respective conclusions will be drawn.

1. PROBLEM STATEMENT

1.1. Problem formulation and determination

In the Cerro Pasco region there are nearby rural communities that do not have telemedicine service coverage, one of which is the town of Huayllay. At present, instant communications in this district are of great need for the development of the health sector. The lack of connectivity in Huayllay means that citizens have to travel to the city of Cerro de Pasco to be attended by medical personnel specialized in each area of health.

1.1.1. General Problem:

How to design a wireless voice and data transmission link for telemedicine service between Huayllay and Cerro de Pasco, using Radio Mobile software and Google Earth?

1.1.2. Specific Problems:

- How will the geographical areas of the transmission and reception points be determined to design the wireless link for voice and data transmission between the towns of Huayllay and Cerro de Pasco?
- How will the theoretical calculations be performed to determine the characteristics of the most optimal antenna to be used in the wireless link between two geographical points of the localities Huayllay and Cerro de Pasco?
- How will the design of the wireless voice and data transmission link for the telemedicine service between the towns of Huayllay and Cerro de Pasco be verified using Radio Mobile and Google Earth software?

1.2. Importance and justification of the research work

The design of a wireless network link between Huayllay and Cerro de Pasco is important in order to provide telemedicine services to the inhabitants of this district, so that citizens can access medical care remotely and quickly with qualified medical personnel from a nearby health center, thus avoiding the need for the inhabitants to travel to the Cerro de Pasco region for a medical consultation.

1.3. Objectives

1.3.1. General Objectives:

Design a wireless voice and data transmission link for telemedicine service between Huayllay and Cerro de Pasco, using Radio Mobile software and Google Earth.

1.3.2. Specific Objectives:

- Determine the geographical areas of the transmission and reception points to design the wireless voice and data transmission link between the towns of Huayllay and Cerro de Pasco.
- Perform theoretical calculations to determine the characteristics of the most optimal antenna to be used in the wireless link between two geographical points in the towns of Huayllay and Cerro de Pasco.
- Verify the design of the wireless link for voice and data transmission for the telemedicine service between the towns of Huayllay and Cerro de Pasco, using Radio Mobile and Google Earth software.

2. THEORETICAL FRAMEWORK

2.1. Conceptual framework

Point to point radio link

The Radio Link or point to point radio link, is a system of connections between two or more antennas that use electromagnetic waves to transmit data, either to provide VoIP operator services, cell phone services for businesses, internet, etc.. One antenna will be in charge of sending information and the other will be in charge of receiving it in order to facilitate the information even in the most difficult places to access geographically. The Radios links are composed of 2 elements [1]:

Terminal Equipment: They are in charge of sending and receiving the information. It is important that they are in a high and unobstructed location for better signal quality [1]

Intermediate Repeaters: Receives and forwards the information to the terminals so as not to lose quality in order not to lose quality in the information. The greater the distance, the more terminals have to be placed. It is also used to correct the lack of visibility in locations that have obstacles, that is why they are placed in high places [1].

Radio Mobile

Radio Mobile is a freely distributed software for the calculation of long distance radio links over rough terrain. It uses geographic profiles combined with information about the equipment (power, receiver sensitivity, antenna characteristics, free space and system loss, etc.) to be simulated [2].

This program works with three-dimensional satellite maps of the areas in which the radio links will be made and operates within the range of 20MHz to 20GHz. Based on the ITS (Irregular Terrain Model) propagation model [3].

Google Earth

It is a cloud-based geomatics platform that allows users to visualize and analyze satellite images of our planet. Scientists and non-profit organizations use Google Earth to conduct remote sensing studies, linkages, predict disease outbreaks, manage natural resources, etc. Students can access this information to participate in discussions and become data scientists [4].

Line of sight

Known as LOS (line of sight), its term refers to a link that must have direct visibility between antennas, so there must be no obstacles between them. Near line-of-sight NLOS, which describes a partially obstructed path between the location of the signal transmitter and the location of the signal receiver. Obstacles that can obstruct line-of-sight include trees, buildings, mountains, and other structures. The term non-line-of-sight indicates that the entire Fresnel zone radius is blocked on a link. [5].

The Fresnel zone

The electromagnetic wave traveling from a transmitting station to a receiving station must be free of obstacles so that the signal is not significantly reduced. Thus, 60% of the first Fresnel zone that is free of obstacles is used. Therefore, Fresnel zone is defined as the volume of space between the emitter of an electromagnetic wave and the receiver, so that the phase difference of the waves in this volume does not exceed 180° (60% free of obstacles), taking the shape of an ellipsoid, this zone is called the first Fresnel zone, see figure 1. [6].



Figure 1. Fresnel zone [6].

The first Fresnel zone is where the highest power of the signal traveling from the transmitting antenna to the receiving antenna is concentrated, where at least 60% of the area must be free of obstacles. This ensures that the signal reaches the receiving station with good power to fulfill an ideal link. [6].

2.2. State of art

Nowadays WiFi wireless networks are a basic tool since it has become a necessity rather than a luxury, because it is used for communication, education and entertainment, but access to this service is limited or inefficient in some sectors of the country, due to lack of infrastructure. Devices that commonly use wireless networks include laptops, smartphones and tablets, which have become essential for businesses as a form of communication. Due to the easy access to the Internet nowadays, the new technology uses the IEEE 802.11ac standard that offers efficiency, scalability and higher transmission speed with respect to previous standards and equipment. In this article they use the 802.11ac standard because it represents the fifth generation of IEEE 802.11 standards for wireless LANs, and offers a connection with an information transfer speed of at least three times the speed of the 802.11n standard.(Cisco Solutions,2014). For the design of the WISP there is a connection model that are point-to-point links for the wireless backbone and multipoint, for the connection of subscribers used for the WISP implementation. The physical network will be divided into the following modules: access, distribution, center. As shown in figure 2. [7].

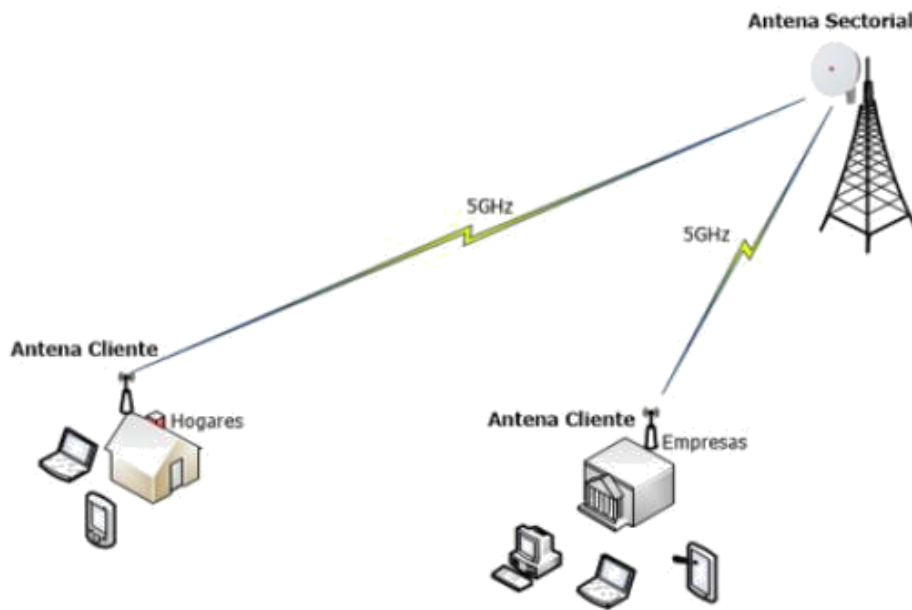


Figure 2. Network distribution (access) [7].

According to [7], the design of the Wireless Internet Service Provider network applying the IEEE 802.11ac standard presented for the urban area of Cayambe canton, will allow the universality of access to technologies and information, although it is not a new standard, it is a very proven and stable version, with significant improvements over previous versions, operating in the 5GHz band, making a flexible work, scalable network of rapid deployment and low cost compared to wired technologies. For the design of the WISP network, the IEEE 802.11ac standard was analyzed, emphasizing the quality of the radio, which depends on a correct choice of antennas according to the needs of power, gain and directivity, in addition it is necessary to support the devices in an equipment room. Also the planning process starts knowing what will be the transfer rates to be supported. The 5 GHz band was considered to be less prone to interference and above all it is a free operating band. In addition to other important factors such as the level of sensitivity of the antennas, noise ratio, transmit power and installation of the device, supporting a perfect alignment of antennas and checking that there are no obstructions within the Fresnel zone. This emission must be performed within the limits imposed by ARCOTEL.

According to [8], Maya and Antamba designed a wireless network to provide Internet access using the IEEE 802.11ac standard in the San Pablo Lake basin for the company NETSERVICE, which will allow Internet access in the area, with the aim of helping to reduce the digital divide, thereby improving the quality of both work and personal life in aspects of information and communication technologies (ICT). As days go by, both at home and in companies, they need applications with higher bandwidth, such as video conferencing, streaming movies with higher full HD definition. These applications with 802.11n will be a solution for some users, but as the use of these applications increases considerably, the bandwidth available to each of them decreases. For this reason the IEEE has launched the fifth generation of the standard for Wi-Fi networks (802.11ac), which will mitigate these situations or inconveniences for the user.

The 802.11ac standard, also known as "Gigabit Wi-Fi", is an evolutionary step from the 802.11n standard, as this standard is substantially based on the development of the 802.11n standard. The 802.11ac standard will be offered in two waves [8].

Wave 1. Covers devices that can achieve speeds up to 1.3 Gbps using wider bonded channels, increasing modulation and up to three spatial streams [8].

Wave 2. It covers devices with speeds up to 3.4 Gbps with the introduction of wide channel bonding, up to 8 spatial streams and multi-user, multi-input, multi-output (MU-MIMO) technology will be possible [8].

The authors conclude that the network design used the new IEEE 802.11ac standard operating in the free 5GHz band which is less congested than the 2.4 GHz band. In addition, they determine that the project will provide wireless internet access in the Lake San Pablo basin at an affordable price for subscribers who require the service. In addition, the authors conclude that the traffic crossing the network to meet the demand of 153 customers was set at 120 Mbps [8].

According to [9], the study of a wireless network for telemedicine applications states that: Currently, primary health care facilities in developing countries have deficiencies in providing adequate medical care to their patients. The topographic profile of the area was studied, and the different wireless technologies available were analyzed. Based on the results obtained, WiFi- RCP was chosen as the most appropriate technology for the design as it allows greater reach and coverage. The tools used for link design and network performance analysis were Radio Mobile network simulators version 7.7.1 and OPNET Modeler version 10.5.

Finally, the author concludes that the WiFi - RCP technology was chosen because it has a longer range, higher speed and is specifically designed for rural areas without Internet connection. clearance in the first Fresnel zone, power level received at the stations, delay, signal to noise ratio and communication performance [9].

According to [10], the study is to design a high speed network that allows internet access coverage in rural parishes in Latin America, it tells us about the majority of Ecuadorian citizens who have access to broadband internet which is generating a great need for service, for which there are still places where there is no internet access coverage for which a wireless network is being designed for the parishes.

The authors conducted an analysis of this area by surveying the inhabitants to verify the coverage of other providers. According to the costs, it is proposed to use Wimax technology since it has a much higher transmission speed compared to satellite because it is very expensive [10].

According to [11], the objective of this project is to design a wireless network based on the 802.11n standard, to provide Internet service to the population located in the urban sectors north of the Cayambe canton in the province of Pichincha. A review of the 802.11n standard, wireless networks, calculation of radio links and aspects related to wireless networks will be carried out. The design will take into account a hierarchical network model structured in three layers: core, distribution and access. In addition, subsystems will be designed to support the good performance of the wireless network: electrical subsystems for continuous power supply, electrical protection subsystem to ensure the safety of equipment and personnel against atmospheric discharges and irregularities in the power supply lines, and the infrastructure subsystem necessary to support the wireless equipment of the access/backhaul network on which the service coverage depends. Finally, a financial analysis will be presented to determine the economic viability of the project for investors.

Applying the 802.11n wireless standard in the project design allows implementing flexible, scalable, fast deployment and inexpensive networks compared to wired technologies. Although it is not a new standard, it is a very proven and stable version of the 802.11 standard, with significant improvements over previous versions both at the PHY and MAC layer level, achieving higher transfer rates at 2.4 and 5 GHz frequencies [11].

The project is a suitable solution that fits the current situation and topography of the coverage areas, providing a solution to the demand for Internet service at a reasonable cost for the user and economic returns for the provider, also improving the quality of life of the inhabitants through their inclusion in the use of information access technologies [11].

The channel capacity measured in [bps] for international Internet access in the backbone network is directly related to the number of subscribers in the access network. For its calculation, methods were applied that relate simultaneity and service sharing indexes. Based on the number of users projected in the market study and assuming that users will not always be using the service and that there is a probability that not all users will use the service simultaneously, an 8:1 sharing ratio was applied, which is considered very good for residential service, and 3:1 for commercial or corporate service, since these are semi-dedicated links with a simultaneity index of 20%, a value applied to semi-urban environments. Thus, it is necessary to contract a bandwidth of 48 [Mbps] in the fifth year of operation, a capacity that the network design must be able to support without affecting the quality of service to the end user. [11].

The quality of a radio link depends on the correct choice of the device or antenna according to the needs in terms of power, gain, directivity, etc. The planning process starts by knowing what the transfer rate to be supported will be. The 5 GHz band has been used because it is considered less prone to interference and above all it is a band of free operation. At the physical layer level, the 802.11n standard defines modulation and coding schemes that determine the transmission rate, so the higher the transfer rate, the more appropriate the modulation type will be applied. The radio link also depends on other factors such as antenna sensitivity level, signal to noise ratio, transmission power and the installation of the device, maintaining a perfect antenna alignment and verifying that there are no obstructions within the Fresnel zone. These emissions must be carried out under the limits imposed by Arcotel. By using the Xirio simulation tool, the feasibility of the backhaul links and access network was verified with propagation diagrams and reports of the results, showing the behavior of the transmitted signals and supporting the planning of wireless communication systems, prior to their installation [11].

The design of the power backup, electrical protection and infrastructure subsystems are an important part of the performance of the wireless network providing the service, applying standards that guarantee the continuous availability of the service for users and the protection of equipment and work personnel against possible alterations in the power supply or atmospheric disturbances [11].

According to [12], his thesis project consists of the design of a telemedicine network in the Huayrul Village Center of the district of Incahuasi, belonging to the province of Ferreñafe, Lambayeque region. The network will basically consist of remotely linking the Huayrul health center with the Lambayeque Regional Hospital so that the people of Huayrul can receive better medical care. better medical attention. The first chapter is focused on analyzing the problems that have been encountered in the Centro Poblado de Huayrul from both the technological and social points of view; it will also evaluate the problems in order to propose the objectives to be met by the telemedicine network and finally define the information to be transmitted. The

second chapter seeks to present the different network technologies used for telemedicine and to choose one of them, as well as the various telemedicine devices used in our country. The third chapter presents the bandwidth analysis for the telemedicine network, i.e., it defines the data and equipment that will transmit information between one node and another and defines the bandwidth capacity that the network will have to support. The fourth chapter describes the design of the telemedicine network, both the IP link to be made, as well as the designs and equipment of the VoIP network, IP videoconferencing, telemedicine devices, Internet access and the local LAN network of the Huayrul health center. The fifth chapter focuses on the costs of installing the telemedicine network, as well as the operation and maintenance of the network. Finally, the conclusions and recommendations of the present work are presented, in addition to proposing some future work to implement the design carried out in Huayrul as well as in other populated centers. At the end of this project, the following conclusions can be drawn:

The telemedicine network system presented is a project that will not involve too high a cost in comparison with other telemedicine network alternatives applied in other countries and this allows providing a quality service at low cost, which is what is sought in projects focused on the social rather than business-oriented side [12].

Studies of the population of Huayrul and their social and technological needs were carried out to determine the telemedicine equipment that we would use in the network to benefit the population and thus provide them with better health care [12].

VoIP, videoconferencing, telemedicine equipment and LAN networks will be designed within the facility, all these networks are easy to implement and our IP radio link system covers all the necessary bandwidth for these networks to work properly with high efficiency as has been demonstrated in other projects [12].

The most suitable alternative was chosen to perform the IP radio link given the parameters with which this system worked, its low cost and its implementation in our country by an operator of this system [12].

The free bands will be used correctly, especially in the case of the 5.8 GHz band, which is not very used and is not too congested, as opposed to the 2.4 GHz band, which is widely used by companies for various purposes and according to the law, these free bands can be applied for medical uses and in this case would be used efficiently [12].

According to [13], in this thesis a wireless network was designed to provide broadband Internet access to the rural town of San José de Paucar. The TOP-DOWN approach was used for information processing, analyzing the system in a general way and then detailing each part of it, also developed a working model for the design of the system. The requirements and constraints

of the project were identified, such as the evaluation of the geographical characteristics of the area (climate and terrain), existing networks, information on policies and regulations on the use of wireless technology in rural areas. Then, the logical part of the network was designed, based on the star type topology, which was best adapted according to the design requirements. Subsequently, the physical design of the network was developed using the GOOGLE EARTH tool for the antenna location criteria, the equipment was selected considering the necessary technical aspects and requirements, choosing equipment of the AIRMAX line of the Ubiquiti brand that will fulfill its functions working in a free frequency of 5.8 GHz and in 20 MHz channels. The power supply and support infrastructure of this equipment was also evaluated. All these technical aspects are entered into the Radio Mobile simulation program for processing. The latter produced data on the behavior of the radio links and their connectivity, and the AIRLINK web application was also used for comparison and corroboration of these data. The final product of this research is the proposal of the wireless network design for its future implementation. Key words: Wireless network, Broadband, Google Earth, Radio Mobile.

Finally, he concludes that the network design complies with the rules and regulations for the placement of antennas for rural areas and thus we can obtain a high-performance service without entering into violations. The system can support an average total transmission capacity of 70 Mbps on a 20 MHz channel. The network is designed to be implemented based on AIRMAX equipment in a free frequency of 5.8 GHz that allows broadband Internet access with less interference [13].

3. SOLUTION APPROACH

3.1. Description and characteristics of the solution or product to be obtained

The type of research is applied and technological. As for the research method, it is empirical and experimental.

The solution is represented in Figure 3, which is a pictographic diagram, where we first have the location of geographical points with the help of Google Earth, which will give us the coordinates and lines of sight of each link where we will find out if it is necessary to use a repeater or not. Then we will make use of Excel to perform the necessary calculations to obtain the characteristics of the most optimal antenna to be used for the link from Cerro de Pasco to Huayllay. Finally, with the results obtained for gain, Fresnel zone, correction factor, free space loss, etc., we will introduce it into the Radio Mobile software and also specify what type of antenna will be used, then simulate and finally we can check the whole procedure. With all the stages already completed, we will end up giving conclusions and general and specific observations.

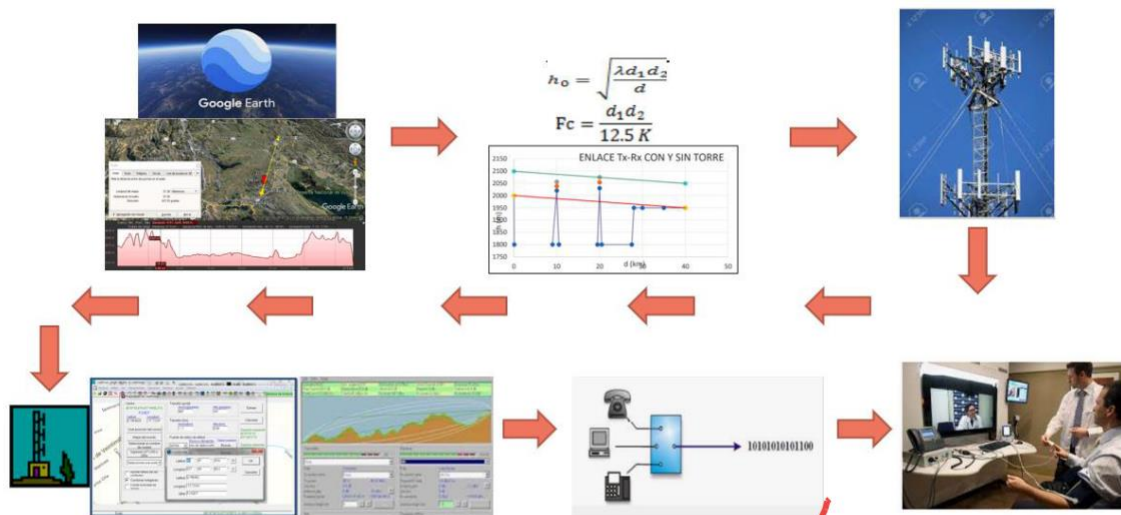


Figure 3. Pictographic diagram of the solution.

3.2. Solution Methodology

In the methodology of the solution of the first specific objective, Google Earth was used to choose our geographical points of the link between Cerro de Pasco and Huayllay. Where the locations were strategically chosen, considering mainly that they have power supplies, in addition to being in an area of easy access. With the points obtained, it was observed that a repeater was needed, for which a homogeneous procedure was developed for the transmission and reception points chosen.

Figure 4 shows the line of sight of the link from Cerro de Pasco to Huayllay, where at a distance of approximately 37.5 km there is a height that hinders the direct link between the two points, so it is necessary to use the repeater.

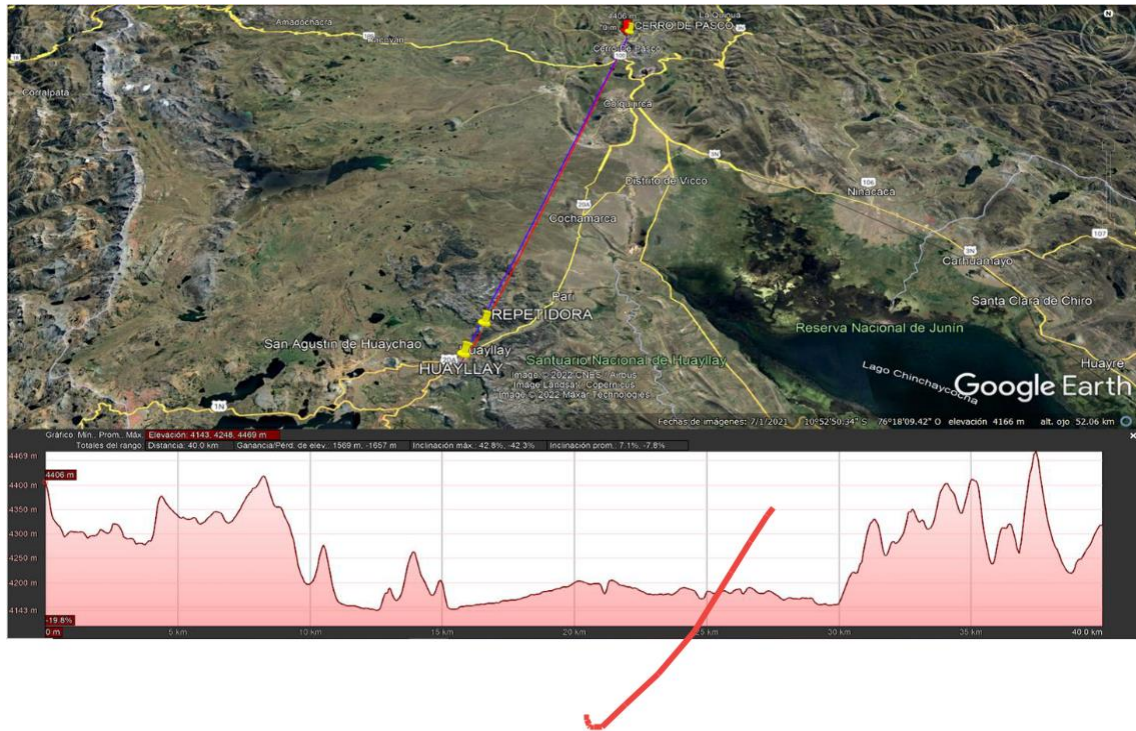


Figure 4. Elevation profile Cerro de Pasco-Huayllay.

Ciudad	Estación A	Estación B	Coordenadas estación A	Coordenadas estación B	Objetivo	Distancia Tx-Rx (Km)
CERRO DE PASCO	CERRO DE PASCO	REPETIDORA	10°39'47.40"S 76°15'37.94"O	10°58'56.09"S 76°21'14.99"O	TRANSMISIÓN	36.8
REPETIDORA	REPETIDORA	HUAYLLAY	10°58'56.09"S 76°21'14.99"O	11°0'15.92"S 76°21'50.29"O	REPETIDORA	2.66
HUAYLLAY	HUAYLLAY	REPETIDORA	11°0'15.92"S 76°21'50.29"O	10°58'56.09"S 76°21'14.99"O	RECEPCIÓN	2.66

Table 1. Table of coordinates of the selected points.

Finally, Google Earth was used to note the coordinates and distances of the selected points, which can be seen in Figures 5, 6 and 7. Table 1 shows a summary table detailing the coordinates, distance and function of each station mentioned above.



Figure 5. Point chosen for Cerro de Pasco.

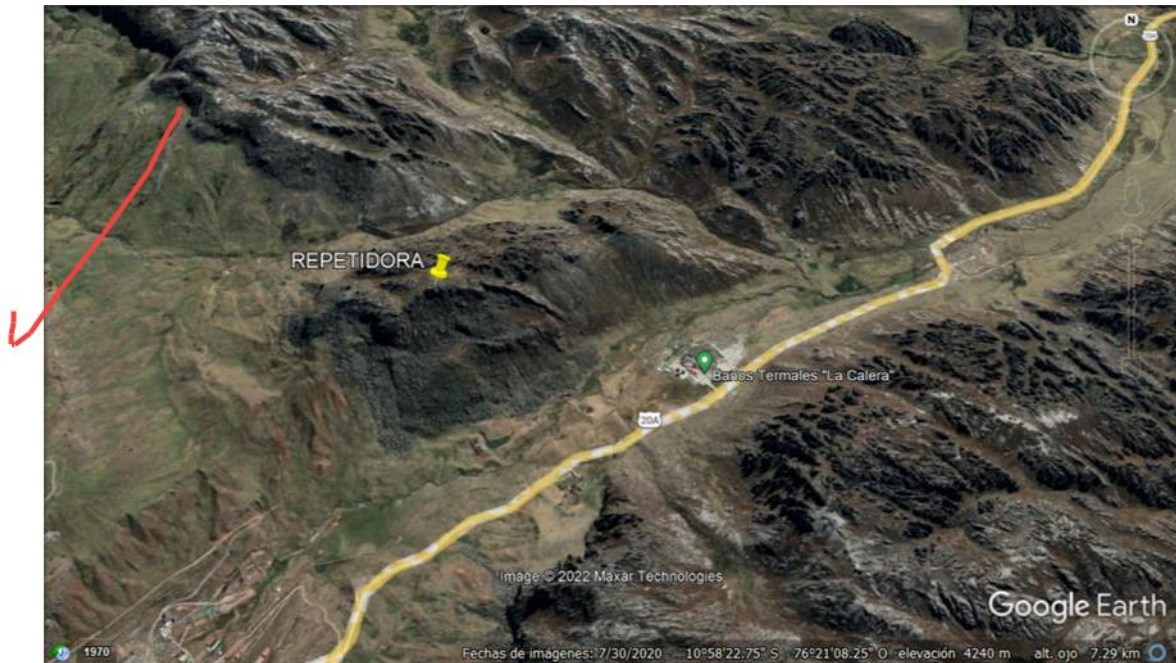


Figure 6. Point chosen for the Repeater.



Figure 7. Point chosen for Huayllay.

Subsequently, with the help of Google Earth we were able to obtain the elevation profile between Cerro de Pasco and the Repeater. This shows some high-altitude peaks in the line of sight without considering the height of the antennas. The same was done for the link from the repeater to Huayllay, but in this case there were no obstacles as shown in Figure 8, 9.

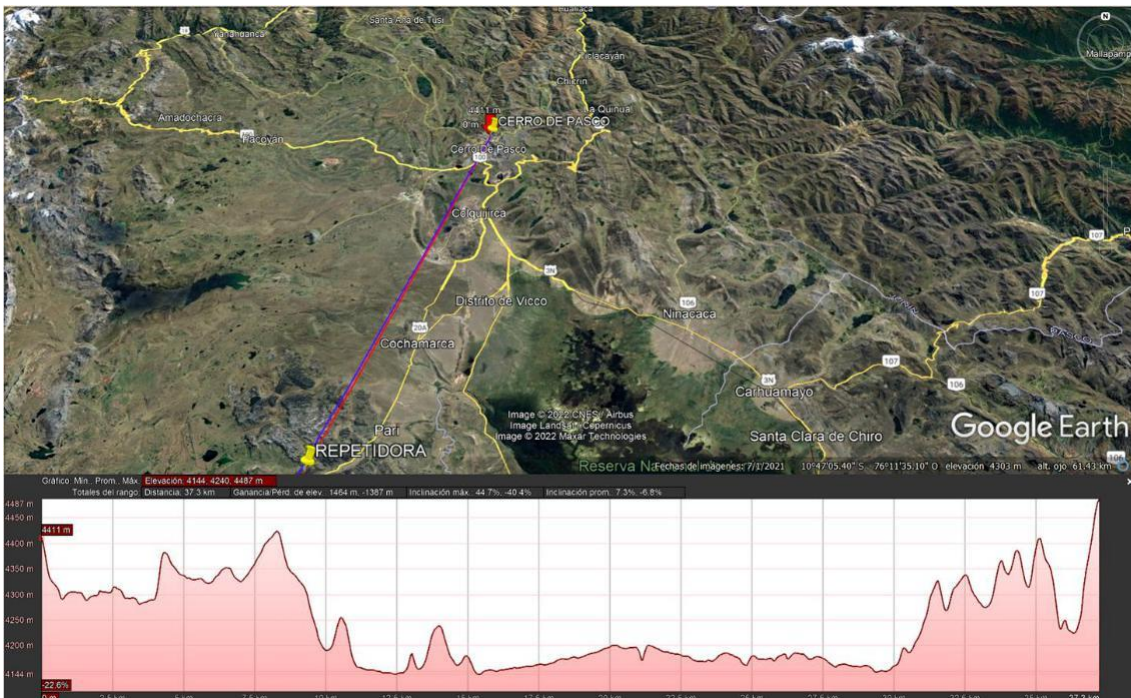


Figure 8. Cerro de Pasco-Repetidor elevation profile.

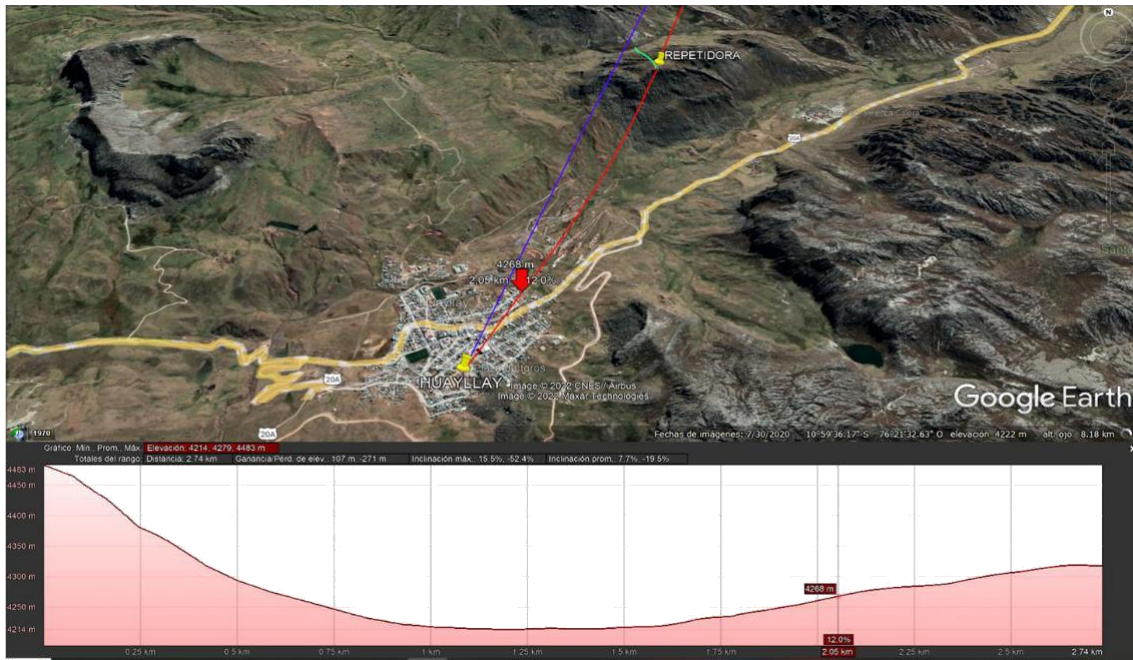


Figure 9. Repetidor-Huayllay elevation profile.

Next, the second specific objective will be discussed in the solution methodology. In the development, first a table in Excel was elaborated from the data obtained by Google Earth in function of the distances and heights obtaining a topographic profile from Cerro de Pasco to Huayllay, as shown in table 2 and figure 10 respectively.

d(Kms)	h(m)
0	4406
2.5	4315
5	4336
8.2	4417
10	4200
12.5	4144
15	4206
17.5	4164
20	4200
22.5	4183
25	4179
27.5	4178
30	4161
31.3	4331
35	4411
37.54469	
39.94319	

Table 2. Table of data taken as a function of distance and heights.

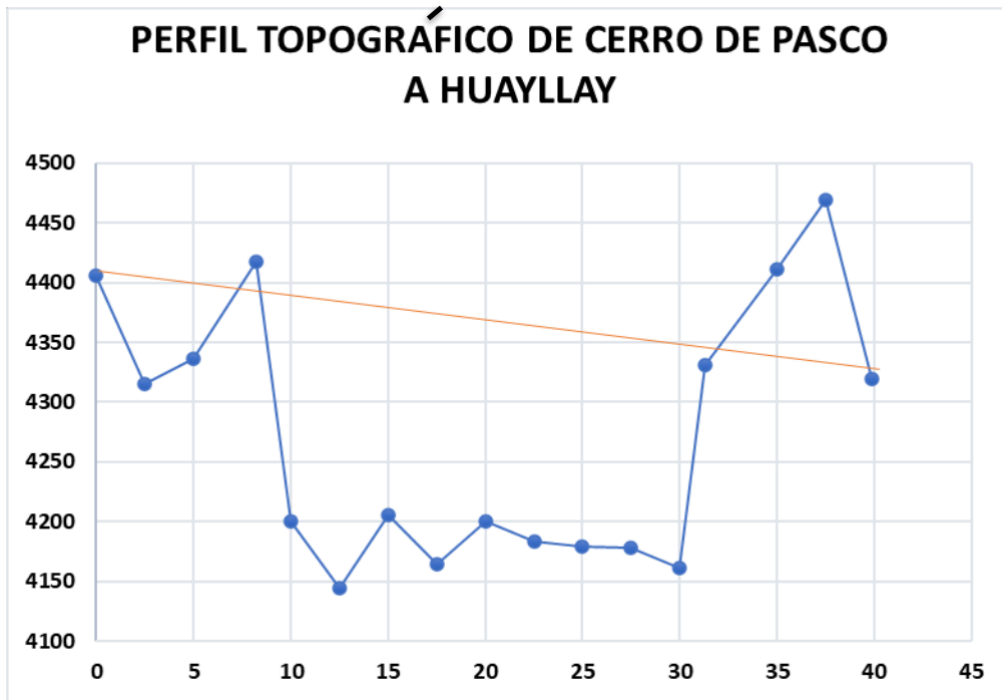


Figure 10. Topographic Profile from Cerro de Pasco to Huayllay.

Then, with this data, the Fresnel zone (h_0) and the correction factor (F_c) were calculated, taking 7 GHz as the frequency for our link. Where we will obtain the correct calculations of the tower heights as shown in table 3 and visualized in figure 11. Where the height of the antenna at the second point we get 163.7961 meters which is an unfeasible value for the elevation of the tower, therefore, the decision was made to place a repeater at kilometer 37.7 and then make a link from the repeater to Huayllay.

f	7	GHz
λ	0.0428571	m
d	39.9	Km
h1	4406	m
h2	4319	m
K	1.333	
a	6370	Km
PRIMER PUNTO CRÍTICO		
d1	8.2	Km
d2	31.7	Km
hs	4417	m
h0	16.709433	m
Fc	15.6003	m
ha1	20	m
ha2	218.99176	m
SEGUNDO PUNTO CRÍTICO		
d1	37.5	Km
d2	2.4	Km
hs	4469	m
h0	9.8321029	m
Fc	5.4013503	m
ha1	20	m
ha2	163.79613	m
ALTURAS DE TORRES		
ha1	20	m
ha2	163.79613	m

Table 3. Calculations of Fresnel zone and correction factor and tower heights.

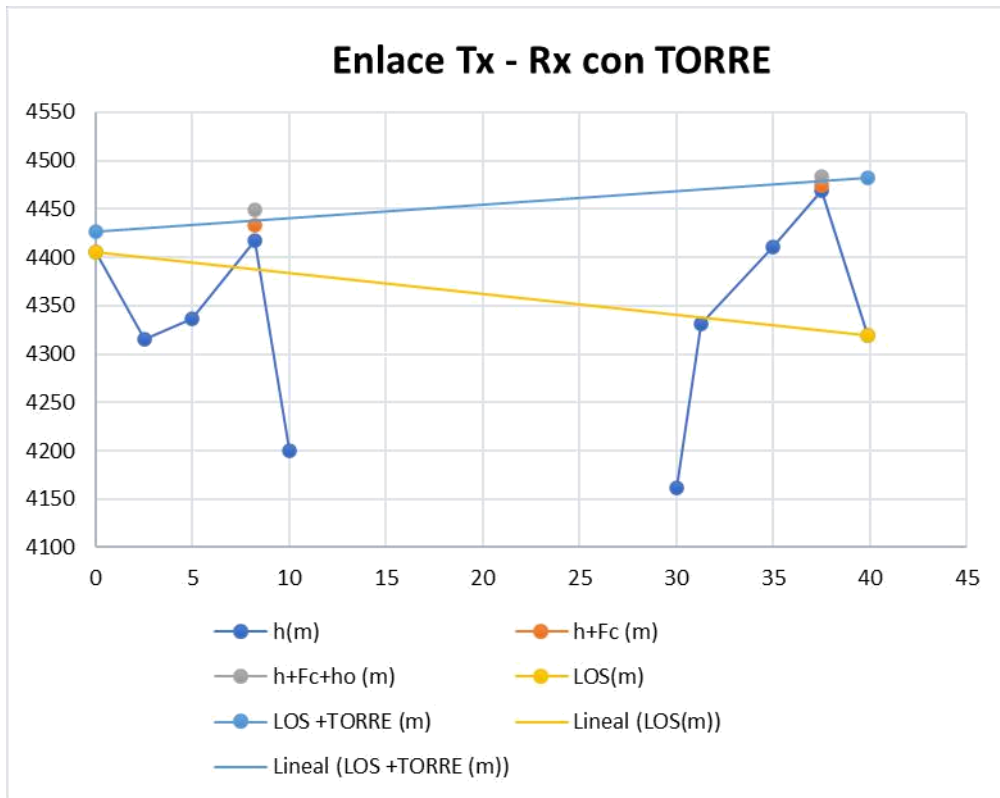


Figure 11. Transmission and reception link with tower.

Finally, the respective calculations were made for the link from Cerro de Pasco to the Repeater where the free space loss that in the Excel table we call A_0 , the result for the mentioned link was 140.83dB, also the transmission gain was calculated which is the same as the reception gain with this data we could obtain the beam width and the diameter of the antennas that in each case are 2.25°s and 1.54 m respectively. Finally, the signal to noise ratio (C/N) was calculated using the temperature of the reception area, Boltzmann's constant, noise bandwidth and noise figure with which the noise power was obtained and the signal power was calculated with the data obtained previously. This process was carried out similarly for the link from repeater to Huayllay where we got different results from the Cerro de Pasco to repeater link. Next, the calculations will be shown in the following tables 4, 5, 6 and 7.

CÁLCULO DE ALTURA DE ANTENA ENLACE- Cerro de Pasco - Repetidor		
f		7 GHz
d		37.5 km
Ptx		27 dBm
Aten.Unit.Tx		2 dB/100m
Long. Alim.Tx		40 m
Aten. Alim. Tx		0.8 dB
Ao		140.83 dB
Abranching		3 dB
Aten.Unit. Rx		2 dB/100m
Long. Alim.Rx		25 m
Aten. Alim. Rx		0.5 dB
Prx		-67 dBm
Margen		25 dB
Gtx	$(Prx - Ptx + Atx + Ao + M + P_{circ} + Arx) / 2$	38.07 dBi
Grx		38.07 dBi
η		0.50
λ		0.043 m
Diametro de las antenas		1.54 m
Ancho de haz		2.25 ° S

Table 4. Calculation of antenna diameter and losses between Cerro de Pasco and Repetidor.

CÁLCULO C/N DE ENLACE- Cerro de Pasco - Repetidor				
f			7	GHz
d			37.5	km
Tasa de bitios			460	Mbit/s
r			0.4	
n (tipo de modulación)			11	
B	$B_T = 2B_N = \frac{r_{BB}(1+r)}{n}$		58.55	MHz
Tamb.			6	°C
Ptx			27	dBm
Aten.Unit. Tx			2	dB/100m
Long. Alim.Tx			40	m
Perd. Alim. Tx			0.80	dB
Gtx			38.07	dB
Ao			-140.83	dB
Margen			25	dB
Grx			38.07	dB
Pcirc.			3	dB
Aten.Unit. Rx			2	dB/100m
Long. Alim.Rx			25	m
Perd. Alim. Rx			0.5	dB
Prx (1+1)			-67	dBm
C		Ptx-Atx+Gtx-Ao-M+Grx-Pcirc-Arx	-67	dBm
C			-97	dBW
K			-228.60	dBW/ °K- Hz
Tabs.	279	° K	24.46	dB-°K
B	58.55	MHz	77.67	dB- Hz
F			5	dB
N		N=K+T+B+F	121.47	dBW
C/N		C - N	24.47	dB

Table 5. C/N calculation between Cerro de Pasco and Repetidor.

CÁLCULO DE ALTURA DE ANTENA ENLACE- Repetidor - Huayllay			
f		7	GHz
d		2.4	km
Ptx		27	dBm
Aten.Unit.Tx		2	dB/100m
Long. Alim.Tx		25	m
Aten. Alim. Tx		0.5	dB
Ao		116.96	dB
Abranching		3	dB
Aten.Unit. Rx		2	dB/100m
Long. Alim.Rx		30	m
Aten. Alim. Rx		0.6	dB
Prx		-67	dBm
Margen		25	dB
Gtx	$(Prx - Ptx + Atx + Ao + M + Pcirc + Arx) / 2$	26.03	dBi
Grx		26.03	dBi
η		0.5	
λ		0.043	m
Diametro de las antenas		0.39	m
Ancho de haz		8.99	° S

Table 6. Calculation of antenna diameter and losses between the repeater and Huayllay.

CÁLCULO C/N DE ENLACE- Repetidor - Huayllay				
f			7	GHz
d			2.4	km
Tasa de bits			460	Mbit/s
r			0.4	
n (tipo de modulación)			11	
B	$B_T = 2B_N = \frac{r_{BB}(1+r)}{n}$		58.55	MHz
Tamb.			6	°C
Ptx			27	dBm
Aten.Unit. Tx			2	dB/100m
Long. Alim.Tx			25	m
Perd. Alim. Tx			0.5	dB
Gtx			26.03	dB
Ao			-116.96	dB
Margen			25	dB
Grx			26.03	dB
Pcirc.			3	dB
Aten.Unit. Rx			2	dB/100m
Long. Alim.Rx			30	m
Perd. Alim. Rx			0.6	dB
Prx (1+1)			-67	dBm
C		Ptx-Atx+Gtx-Ao-M+Grx-Pcirc-Arx	-67	dBm
C			-97	dBW
K			-228.6	dBW/ °K- Hz
Tabs.	279	° K	24.46	dB-°K
B	58.55	MHz	77.67	dB- Hz
F			5	dB
N		N=K+T+B+F	-121.47	dBW
C/N		C - N	24.47	dB

Table 7. C/N calculation between Repetidor and Huayllay.

To conclude with the development of the research project, we have the fulfillment of our third specific objective which is to verify the design of the wireless link for voice and data transmission for the telemedicine service between the towns of Huayllay and Cerro de Pasco, using the Radio Mobile software and Google Earth. First, we corroborated the link from Cerro de Pasco to the Repeater with the corresponding simulation. Finally, we checked the last link from the Repeater to Huayllay. This corroboration procedure for the first link is shown in Figure 12 and 13, and for the last link we can see it in Figure 14 and 15.

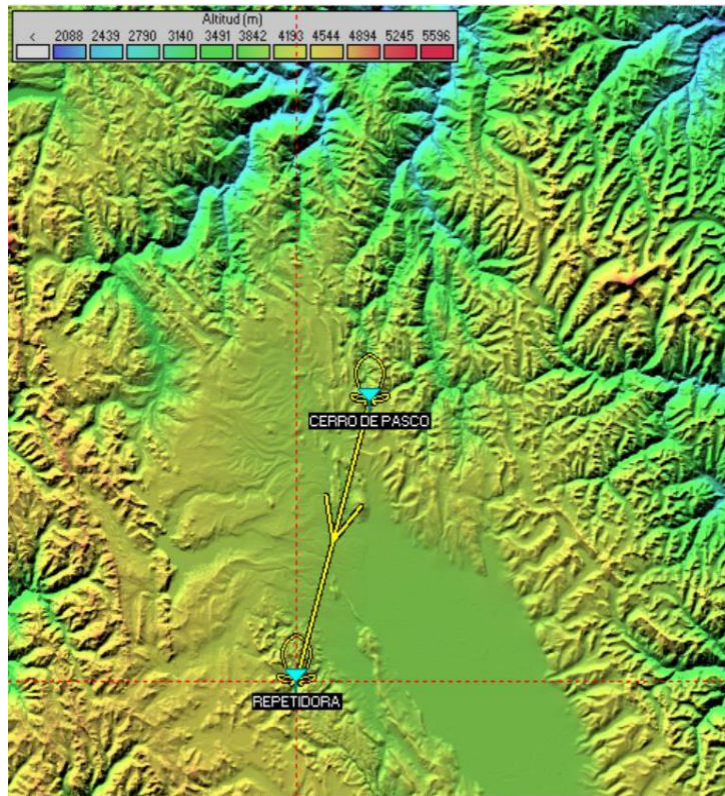


Figure 12. Sketch between Cerro de Pasco and the Repeater using Radio Mobile software.

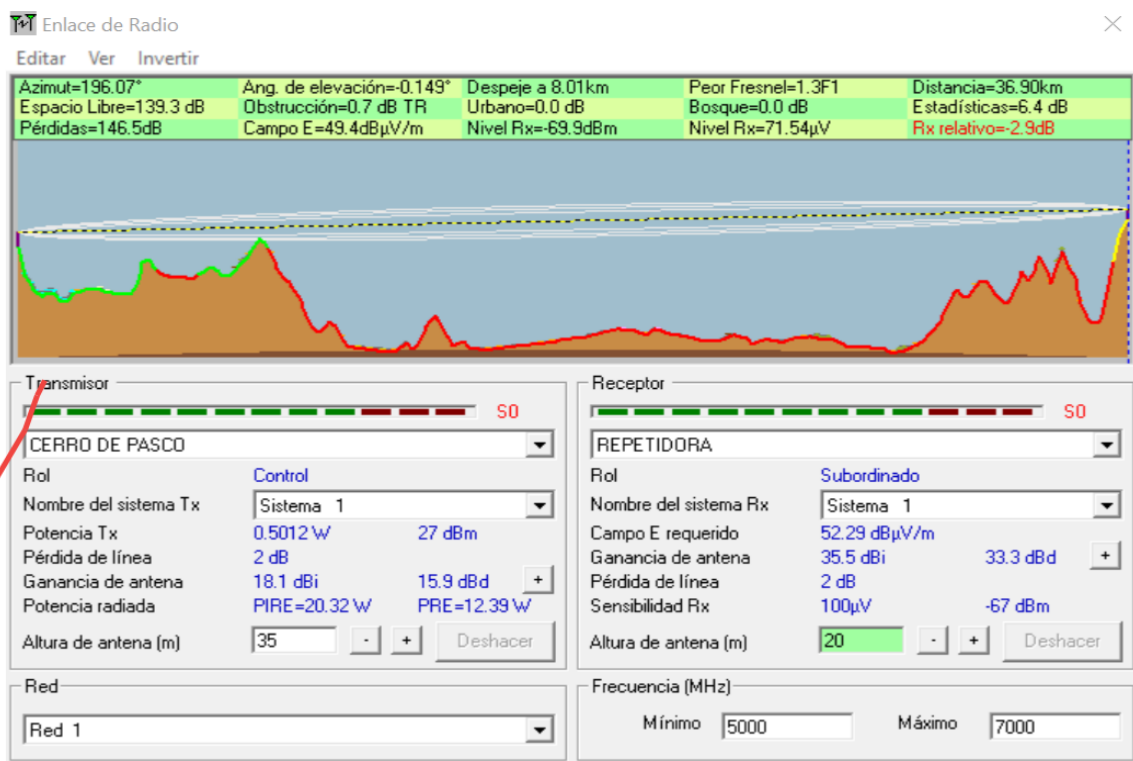


Figure 13. Link between Cerro de Pasco and the Repeater using Radio Mobile software.

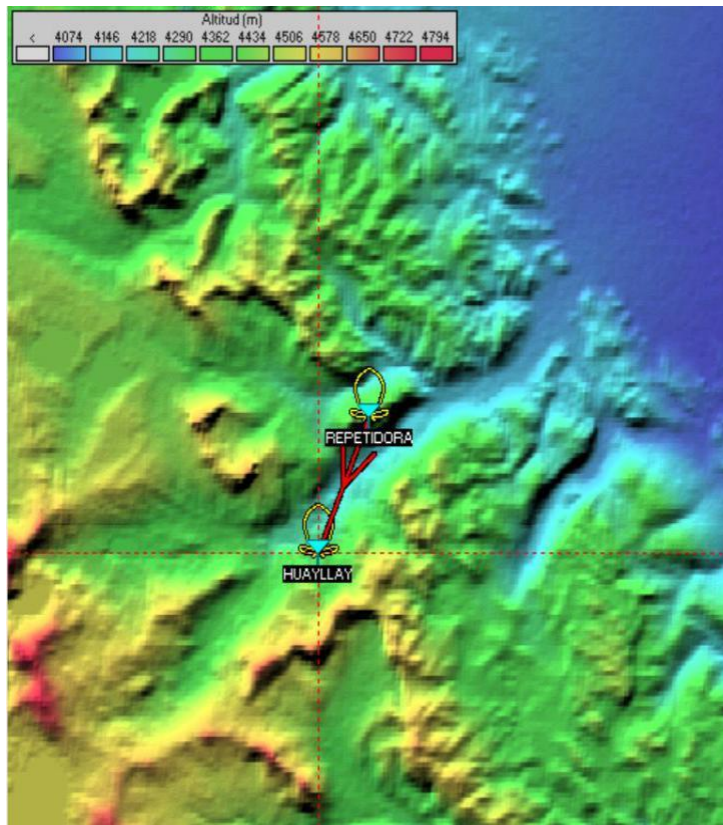


Figure 14. Sketch between Repeater and Huayllay using Radio Mobile software.

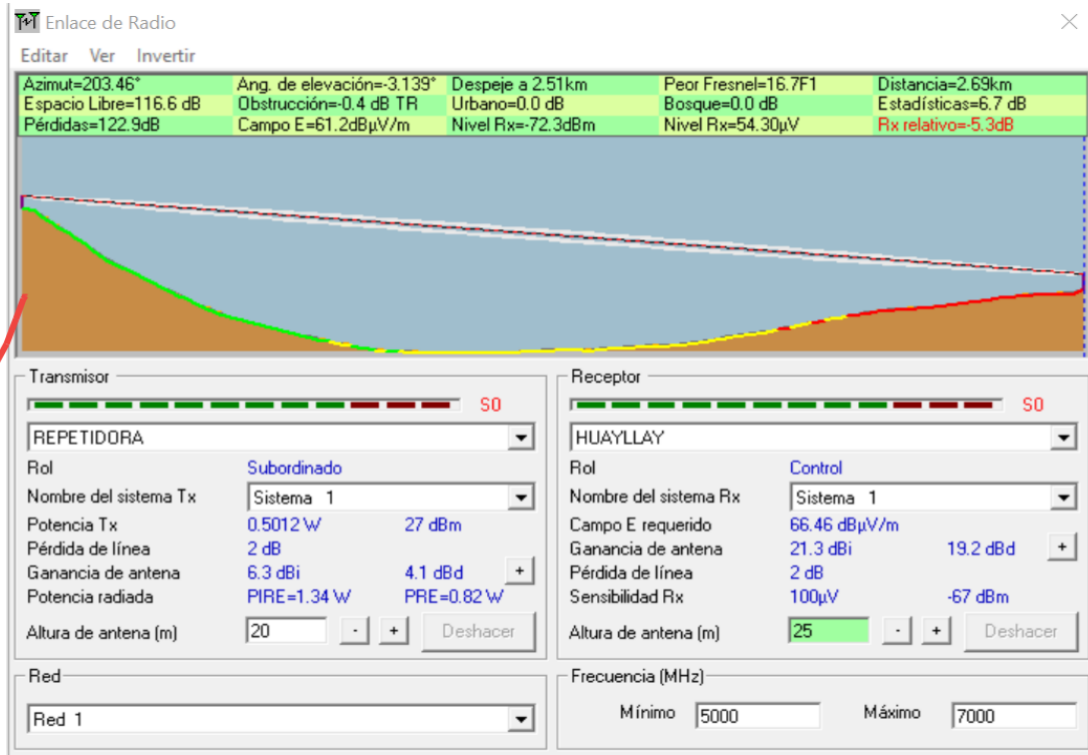


Figure 15. Link between Repeater and Huayllay by means of the Radio Mobile software.

3.3. Design of the solution or product

Fulfilling the three specific objectives, we can say that we have a solution to the research work proposed. Figure 16 shows a sketch of the link made between Cerro de Pasco and Huayllay where only one repeater was used, considering the considerations in the location of the points for transmission, reception and the repeater.



Figure 16. Outline of the link between Cerro de Pasco to Huayllay.

4. TESTS AND RESULTS

The data obtained from the simulation between the Cerro de Pasco links to the repeater using the 5 and 7 GHz frequencies, as was also done for the other link from the repeater to Huayllay, can be seen in Table 8.

Distancia (Km)	5GHz	7GHz
36.90	-267.2dBm	-69.9dBm
2.69	-199.4dBm	-72.3dBm

Table 8. 5 GHz and 7GHz tests to check reception levels

Table 8 shows that the reception levels are better using the 7 GHz frequency, which is why this frequency was used in this research work. With this data it is observed that an effective reception was obtained between the links for Cerro de Pasco-Repeater and Repeater-Huayllay.

5. CONCLUSIONS



It was possible to determine the geographical areas of the transmission and reception points to design the wireless voice and data transmission link between the towns of Huayllay and Cerro de Pasco, using the Google Earth tool. For this link it was necessary to place a point between the 2 localities which function is the repeater and thus achieve the link without problems of obstacles.



Theoretical calculations were made to determine the characteristics of the most optimal antenna to be used in the wireless link between two geographical points in the towns of Huayllay and Cerro de Pasco, for the respective values we used the frequency of 7GHz, since it was considered that the distances are regularly long and also have better reception levels is therefore the most appropriate frequency is mentioned.



The design of the wireless voice and data transmission link for the telemedicine service between the towns of Huayllay and Cerro de Pasco was verified using the Radio Mobile software and Google Earth, where similarities were found in results such as the loss in the free space that is the A_0 in the Excel tables, also the verification of the lines of sight, and finally the reception power.

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