ICT-601102 STP TUCAN3G

Wireless technologies for isolated rural communities in developing countries based on cellular 3G femtocell deployments

M61

Upgraded Networks

Abstract:

This document details the activities performed in the target networks with the aim of improving their characteristics in order to allow the implementation of the demonstration platforms conceived in the TUCAN3G project. Additionally to this description, the technical information about the configuration of the equipment and performance tests is presented, which can be compared to the initial state of these networks. This document systematizes the information regarding the technical improvements in the target transport networks and will be used as an input for the deliverable D62 and D63.

Keyword list: Target networks, transport networks, upgrade, performance.

Document Revision History

DATE	ISSUE	AUTHOR	SUMMARY OF MAIN CHANGES
20-02-2014	a	Edwin Liñan	Table of content and activities in Napo Network.
31-03-2014	b	Cesar Cordova	Activities and test in Balsapuerto Network
20-04-2014	c	Edwin Liñan	Added test diagram and first technical review
08-05-2014	d	Juan Paco	Technical and format review
15-05-2014	e	Edwin Liñan	Added references and final review
02-06-2014	f	Andrés Martinez	Technical Director Review

Executive Summary

With the aim of improving the performance of the target transport networks, a number of technical activities have been performed in order to be used for the objectives of the TUCAN3G project. For this purpose, some improvements and performance tests have been done. In the specific case of the Napo Network, it must be noted that in 2013 PUCP made changes to the transport network which allowed evaluating the subsequent performance. This was done in the framework of another project funded by international cooperation sources. With the information collected it has been concluded that the most suitable option for the purposes of the project required implementing a additional transport network which reuses the existing infrastructure (basically, telecommunications towers). This has been confirmed by new evidence and additional activities which have been carried out on this network.

This document begins by explaining the reasons for upgrading the networks. In section 3, the initial state of the target networks is presented and then, the activities performed in each of them (Napo and Balsapuerto networks), are described. Section 4 presents the activities endeavoured. Section 5 shows the comparative results of various tests. Finally, some conclusions and recommendations for the following activities in WP6 are indicated.

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List of abbreviations & symbols

D21	Report of socio-economic scenarios, technical specifications and architecture for the proof of concept
D41	UMTS/HSPA network dimensioning
D51	Technical requirements and evaluation of WiLD, WIMAX and VSAT for backhauling rural femtocells networks.
D61	Situation report of the deployment area, sensitization results and state of transport networks
DIRESA	Regional Health Department of Loreto
EHAS	Hispano American Health Link
GTR	Rural Telecommunications Group
HRL	Loreto Regional Hospital
ICT	Information and Communications Technology
IP	Internet protocol
MIMO	Multiple-input Multiple-output
PUCP	Pontifical Catholic University of Perú.
VoIP	Voice-over-Internet protocol
WILD	WiFi based long distance

1 INTRODUCTION

The geographic scenarios selected for the development of the TUCAN 3G project (WP6) are the basins of the Napo and Paranapura rivers located in Maynas and Alto Amazonas provinces respectively, both of them in the Loreto Region. From the beginning of the project, it was planned to use the existing infrastructure and equipment in both telecommunications networks.

In the case of the Napo Rural Telemedicine network, reinforcement activities in all the network were performed due the increase of data traffic, which overwhelmed the capacity of the existing network after the implementation of new telemedicine services (second opinion consultation, tele-stethoscopy, tele-microscopy and tele-echography) under the project "Improving maternal and child health in the Napo river basin through the appropriate use of ICT, Peru 2012-2013". In the deliverables D21 and D61, the initial state and the changes made in that period were reported.

In the case of the Balsapuerto Telemedicine network, in the deliverables D21 and D61, the initial state was reported and it was decided to reuse the infrastructure installed for the transport network. Additionally, preventive maintenance, improvements in the electrical power systems of the repeaters in San Juan de Armanayacu and San Gabriel de Varadero and some changes in the IP routing were made.

The current telecommunications networks in Balsapuerto and Napo are composed by the transport networks and access links. The access networks will not be used in this project and, therefore, in this document, we will focus on the backbone links (also called transport networks).

2   JUSTIFICATION

Alongside the presentation of deliverable D21, where the initial state of the networks Balsapuerto and Napo were described, the EHAS Foundation and the Rural Telecommunications Group of PUCP (GTR PUCP) had been developing the project "Improving maternal-child health in the basin of the Napo river through the appropriate use of ICT, Peru 2012-2013". The aim of this project was to implement teleservices for helping in diagnosis: second opinion consultations, tele-stethoscopy, tele-microscopy and tele-echography.

Figure 1: Services implemented in the Napo Telemedicine Network

After evaluating the capabilities of the network to support the new traffic generated by the implemented services, it was determined the need to upgrade the repeater stations and client stations of the Napo network in order to ensure the connectivity and quality of the videoconferences carried out between the 15 health posts within the network. The changes were documented in the deliverable D61.

Despite having done a description of the current state of the whole Napo network, in this document will be detailed only the changes in the four target location of the TUCAN 3G project: Tuta Pishco, Negro Urco, Tacsha Curaray and Santa Clotilde. In order to have a comprehensive view of the entire telecommunications network, the complete scheme of Napo Rural Telemedicine Network is attached (see Figure 2).

On the other hand, in the Balsapuerto network, the infrastructure installed in 2011 will be used. After 3 years of operation it was necessary to perform preventive maintenance. Additionally, improvements were made in the energy systems of San Juan del Armanayacu and San Gabriel de Varadero in order to ensure the functioning of the transport network, since some outages in the repeaters were detected at night during the rainy season. In this document, we will focus on the repeaters that will serve as part of the transport network in the TUCAN 3G project (Santa Gema Hospital, San Juan de Armanayacu and San Gabriel de Varadero).

These upgrade works in both networks have allowed validating the hypothesis presented in the deliverable D21. In that document, it was considered the need to implement a new transport network for the TUCAN 3G project in the case of the Napo network and sharing the existing transport network in the case of the Balsapuerto network. After having done the upgrade works and considering the traffic estimate in the deliverables D41 and D51 for the implementation of the demonstration platform, it will be concluded in this document that the initial hypothesis was true.

3   INITIAL STATE OF THE NETWORKS

3.1   Napo Network

The topology implemented has been designed according to the location of each point to intercommunicate inside the network. Currently, in every town, the health post is the only institution that has access to the communication system. Also, since almost all the villages are located on Napo´s riverbanks, the network is distributed following the course of the river. The topology on the transport network is point to point and point to multipoint topology on the access network.
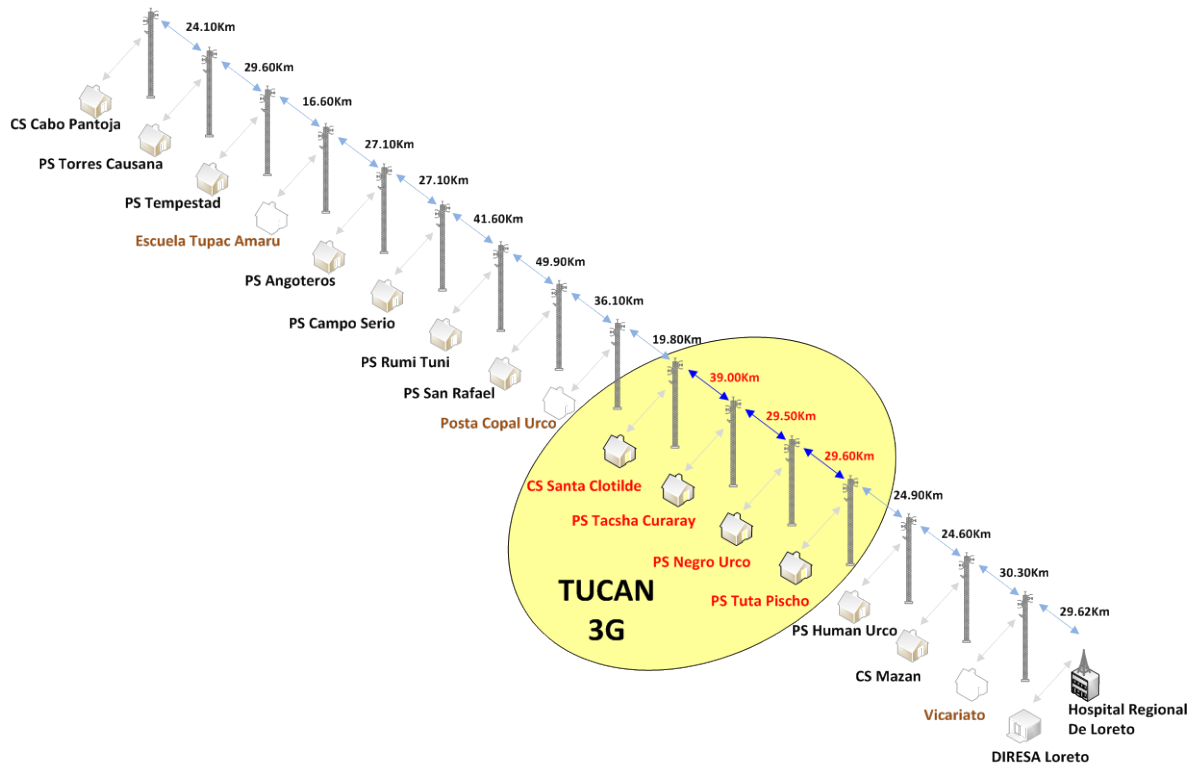
Figure 2: Topology of the Napo network

The Internet access is provided via the service contracted to Telefonica from Peru by the Regional Health Department (DIRESA) of Loreto, in Iquitos city. This service has a dedicated bandwidth of 2Mbits/s. The Voice over IP (VoIP) telephone system is implemented by configuring the Asterisk servers installed in one of the two routers located at each repeater station. In the case of the nodes located in the city of Iquitos, its extensions are recorded in the server installed in the radio transmission office at DIRESA Loreto.

The communities involved in the TUCAN 3G project are: Tuta Pishco, Negro Urco, Tacsha Curaray and Santa Clotilde, shown in Figure 3.

Figure 3: Communities along the Napo river involved in the TUCAN 3G project

The scheme of the segment of the network comprising the four nodes involved in the TUCAN 3G project is:
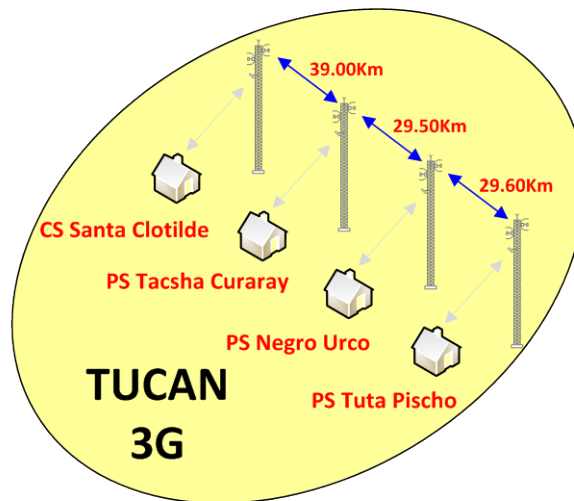
Figure 4: Topology of the segment of the Napo network used in the project

In the following subsections, it is presented a summary of the telecommunications, power and electrical protection systems of the segment showed in Figure 4, which corresponds to the area of interest of the TUCAN 3G project. The complete description has previously been detailed in the deliverable D21.

3.1.1 Equipment

In Figure 5, it is shown a schematic representation of the telecommunications system of the repeater station that used until the middle of 2013 (before the upgrade).

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Repeater Station Connection Diagram
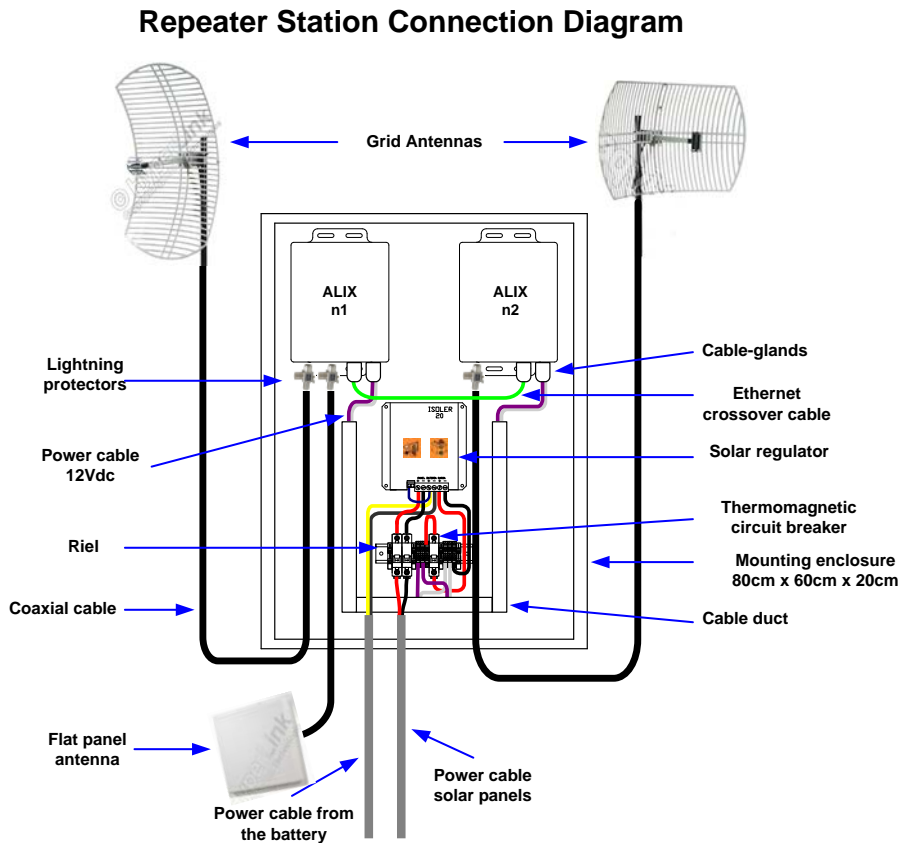
Figure 5: Distribution of the equipment in the repeater station before the upgrade

Components	Trademarks / Models	Specifications	Tuta Pishco	Negro Urco	Tacsha Curaray	Santa Clotilde
Telecommunication equipment						
System Board	PC Engines / ALIX 2C0	Embedded computers with x86 architecture, two Fast Ethernet ports, two miniPCI slots and a serial port, CompactFlash card.	2	2	2	2
Wireless Interface	Ubiquiti Networks SR2	Radio interface 2.4GHz 802.11b/g mini-PCI Chipset Atheros AR5213 MAC/BB, 24dBm	2	2	2	2
	MikroTik / R52H	Dual band radio interface 802.11a/b/g mini-PCI Maximum output power of the g standard: 25dBm	1	1	1	1
Pigtail	Hyperlink Technologies	UFL-N female	3	3	3	3
Antenna	Hyperlink Technologies HG2424G	Grid directional 24dBi 2.4GHz.	2	2	2	2
Antenna	Hyperlink Technologies HG2414P-NF	Panel directional 14 dBi 2.4 GHz	1	1	1	1

Lightning Protector	Hyperlink Technologies	Quarter wave, for 2.4GHz band.	3	3	3	3
Coaxial Cable	Andrew Heliax	3m, N female to N female connectors.	3	3	3	3
Energy equipment						
Photovoltaic Panel	Isofotón IS-75, IS-85	Monocrystalline Cell, 75Wp, 85Wp	2	2	2	2
Solar Batteries	Ritar DG12-130	Capacity: 104Ah@10hr-rate to 1.80 V per cell @ 25°C Cell per unit: 6	1	1	1	1
Solar controllers	Steca Solarix PRS 2020	20 A, Voltage 12 V (24 V) Power consumption <4 mA	1	1	1	1

Table 1: List of the equipment in each repeater

3.1.2   Configuration

Name of the link	Node	Router	Interface / Mode	Wireless card	Mode
EHAS 19	Tuta Pishco	ALIX 2C0 n1	ath0 AP	SR2	11g
	Negro Urco	ALIX 2C0 n2	ath0 ST	SR2	
EHAS 18	Negro Urco	ALIX 2C0 n1	ath0 AP	SR2	11g
	Tacsha Curaray	ALIX 2C0 n2	ath0 ST	SR2	
EHAS 17	Tacsha Curaray	ALIX 2C0 n1	ath0 AP	SR2	11g
	Santa Clotilde	ALIX 2C0 n2	ath0 ST	SR2	

Table 2: Configuration parameters of the transport network.

3.1.3   Distance, troughput and signal level

	Tuta Pishco – Negro Urco	Negro Urco – Tacsha Curaray	Tacsha Curaray – Santa Clotilde
Distance (Km)	29.60	29.50	39.00
Throughput (Mbps)	9.84	7.16	9.02
Signal level (dBm)	-68 -67	-60 -60	-66 -64

Table 3: Distance, throughput and signal level.

In this cases, the troughput was measured using the iperf tool. Iperf is a client-server program that measures the maximum speed reached by two routers or computers connected to the local network. The execution is done manually. Iperf was run from a command line terminal of the Linux operating system, which was installed on the ALIX embedded systems.

The performance tests are shown in Annex 4.

3.1.4   IP addressing scheme
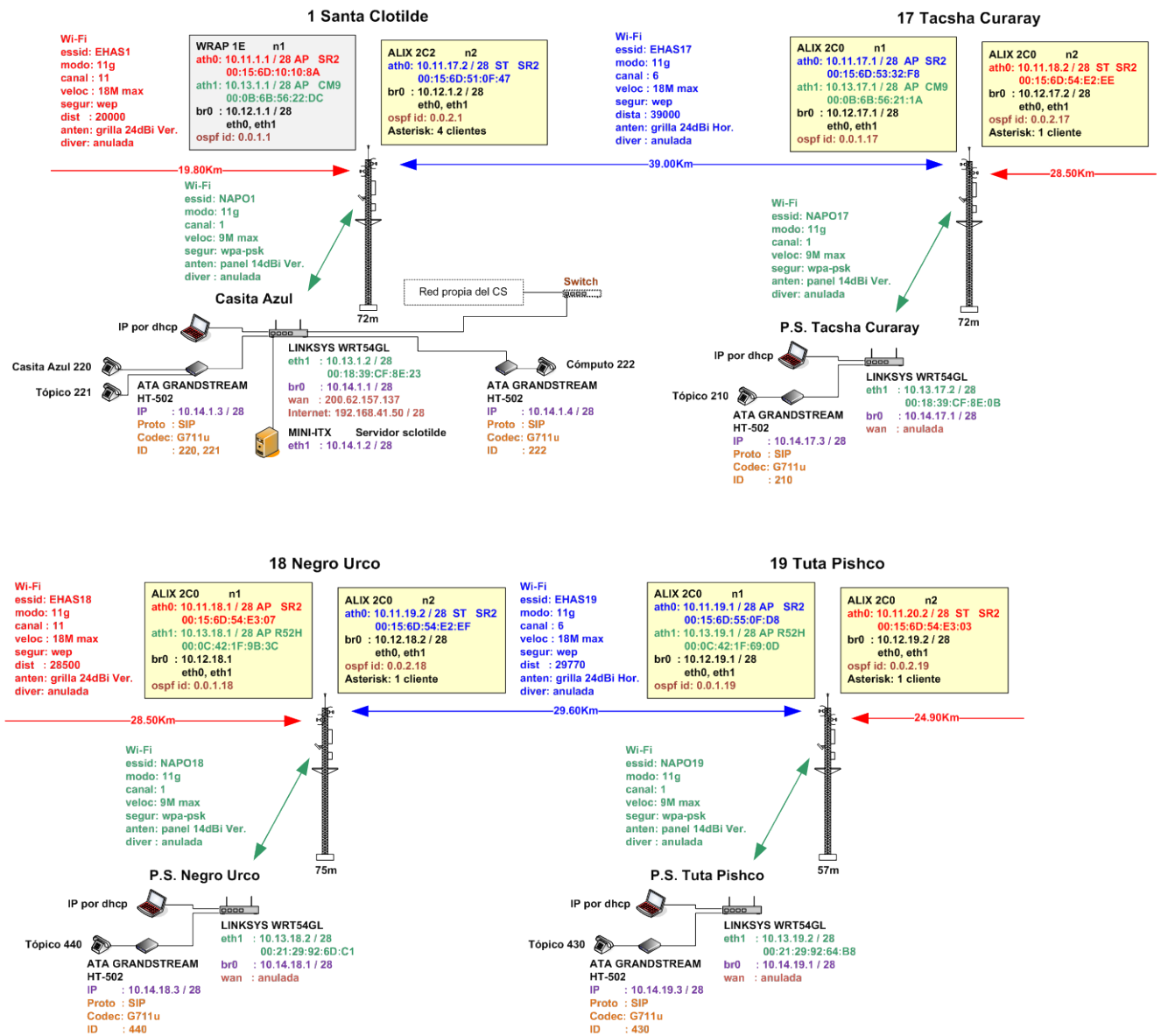
Figure 6: IP addressing scheme used in the section of the Napo network involved in the TUCAN3G project.

3.2   Balsapuerto Network

The sites involved in the TUCAN3G project are: San Gabriel de Varadero, San Juan de Armanayacu and Santa Gema Hospital. In these nodes, showed in Figure 7, the existing infrastructure will be reused (part of the transport network), but separating the data traffic of the telemedicine network and cellular network access (TUCAN3G project).
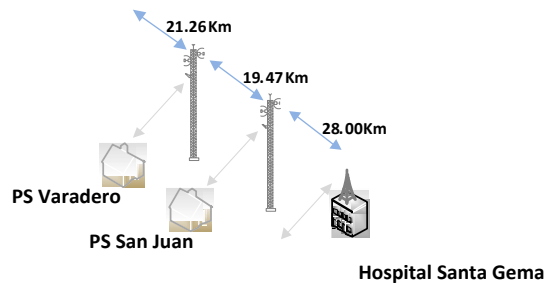
Figure 7: Part of Balsapuerto wireless network involved on Tucan3G project.

3.2.1.1 Equipment

The network consists of long distance point to point links with MIMO configuration and it is basically composed for Mikrotik equipment and dual polarity antennas. The schemes of the equipment installed at the repeaters stations are shown in Figure 8, Figure 9 and Figure 10. Additionally, the list of the equipment is presented in Table 4.
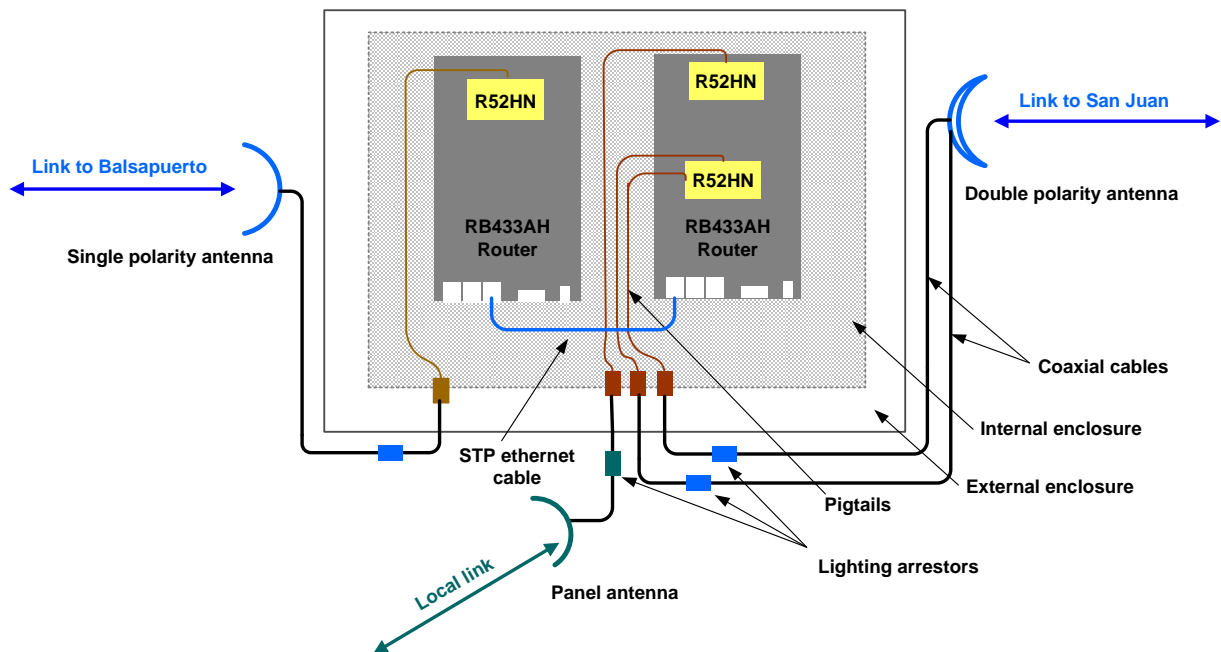
Figure 8: Diagram of the equipment in the Varadero node.
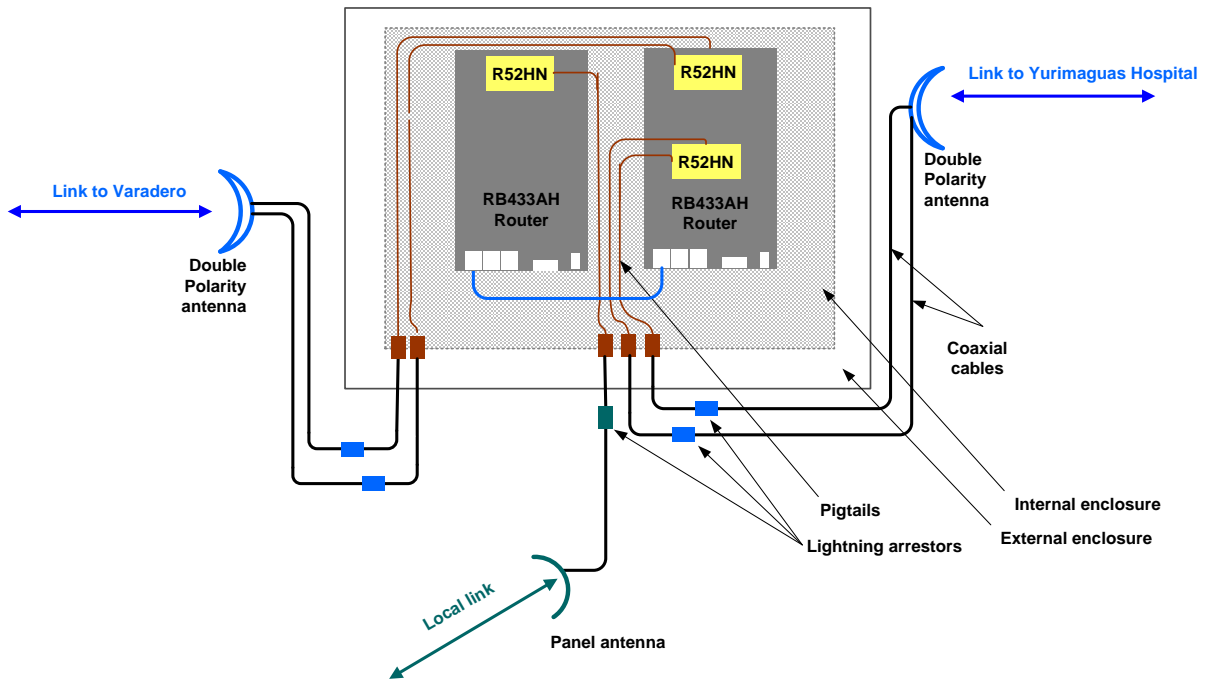
Figure 9: Diagram of the equipment in the San Juan node.
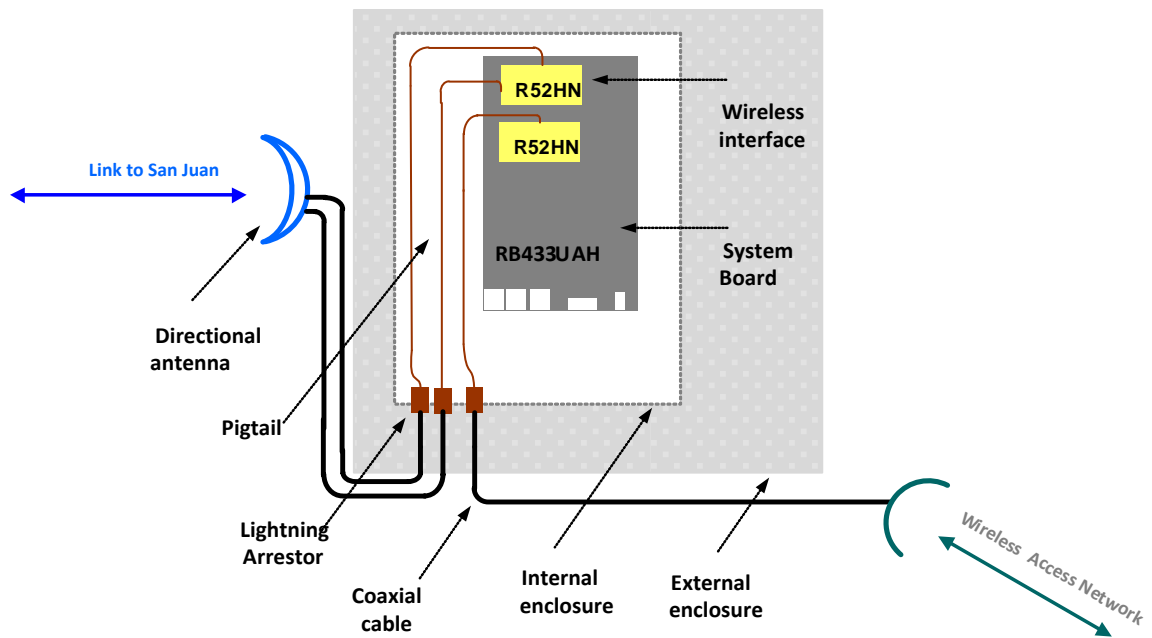
Figure 10: Diagram of the equipment in the Santa Gema Hospital node.

Components	Trademarks / Models	Specifications	Varadero	San Juan	Santa Gema Hospital
System Board	Mikrotik / RouterBoard 433AH	3 ethernet ports, 128 MB RAM, 3 MiniPC slots. Embedded RouterOS operating system.	2	2	1
Wireless Interface	Mikrotik / RouterBoard /R52Hn	Radio interface 802.11a/b/g/n dual band miniPCI card, 25dBm	3	3	2
Pigtail	Hyperlink	MMCX-N female	4	5	3
Antenna	Hyperlink	Grid directional 27dBi 5.8GHz.	1	0	0
Antenna	Hyperlink	Parabolic directional 29dBi 5.8GHz dual polarity.	1	2	1
Antenna	Hyperlink	Panel directional 14dBi 5.8GHz.	1	1	0
Antenna	Hyperlink	Omnidirectional 11dBi 5.8GHz	0	0	1
Lightning Protector	Hyperlink	Quarter wave, for 5GHz band.	4	5	3
Coaxial cable	Andrew / Heliax	3meters, N male to N male connectors	4	5	3
Photovoltaic Panel	Solar World	Monocrystalline Cell, 85Wp	2	2	0
Solar Batteries	Ritar/ RA12-100	12VDC, 100Ah, free maintenance	1	1	0
Solar controllers	Steca/ Solarix PRS 2020	20A, Voltage 12 V (24 V), Power consumption <4 mA.	1	1	0

Table 4: Equipment located in the current Balsapuerto nodes

3.2.1.2   Configuration.

The following tables show the configuration for each wireless link.

Name of the link	Node	Router	Interface / Mode	Wireless card	Mode
BALSA5	Santa Gema	Mikrotik b1	wlan1 ST	R52Hn	11n
	San Juan	Mikrotik b1	wlan3 AP	R52Hn	
BALSA7	San Juan	Mikrotik b1	wlan1 ST	R52Hn	11n
	Varadero	Mikrotik b1	wlan3 AP	R52Hn	

Table 5: Configuration parameters in the transport network

	Varadero - San Juan	**San Juan - Hospital Santa Gema**
SSID	BALSA7	BALSA5
Wireless technology	802.11n 2x2	802.11n 2x2
Band / Frequency	5.8GHz / 5825GHz	5.8GHz / 5765GHz
Security	None	None
Max. Rate	Mcs-8 Mcs-15	Mcs-15
Channel Width	20MHz	20MHz

Table 6: Configuration parameters in the transport network

3.2.1.3   Distance, throughput and signal level

The following table shows the distance, throughput and signal level.

	Varadero – San Juan	**San Juan – Hospital Santa Gema**
Distance (Km)	19.47	28.0
Throughput (Mbps)	36.5	34
Signal level (dBm)	-72 -74	-62 -65

Table 7: Distance, throughput and signal level in the wireless backhaul network

In this case, considering that all installed routers are of the brand Mikrotik,the throughput was measured by using the Mikrotik bandwidth-test tool. The measurement is carried out manually, indicating the duration. The measurements were performed considering a duration of 20 seconds.

3.2.1.4   IP addressing scheme

It is displayed in figure 11.
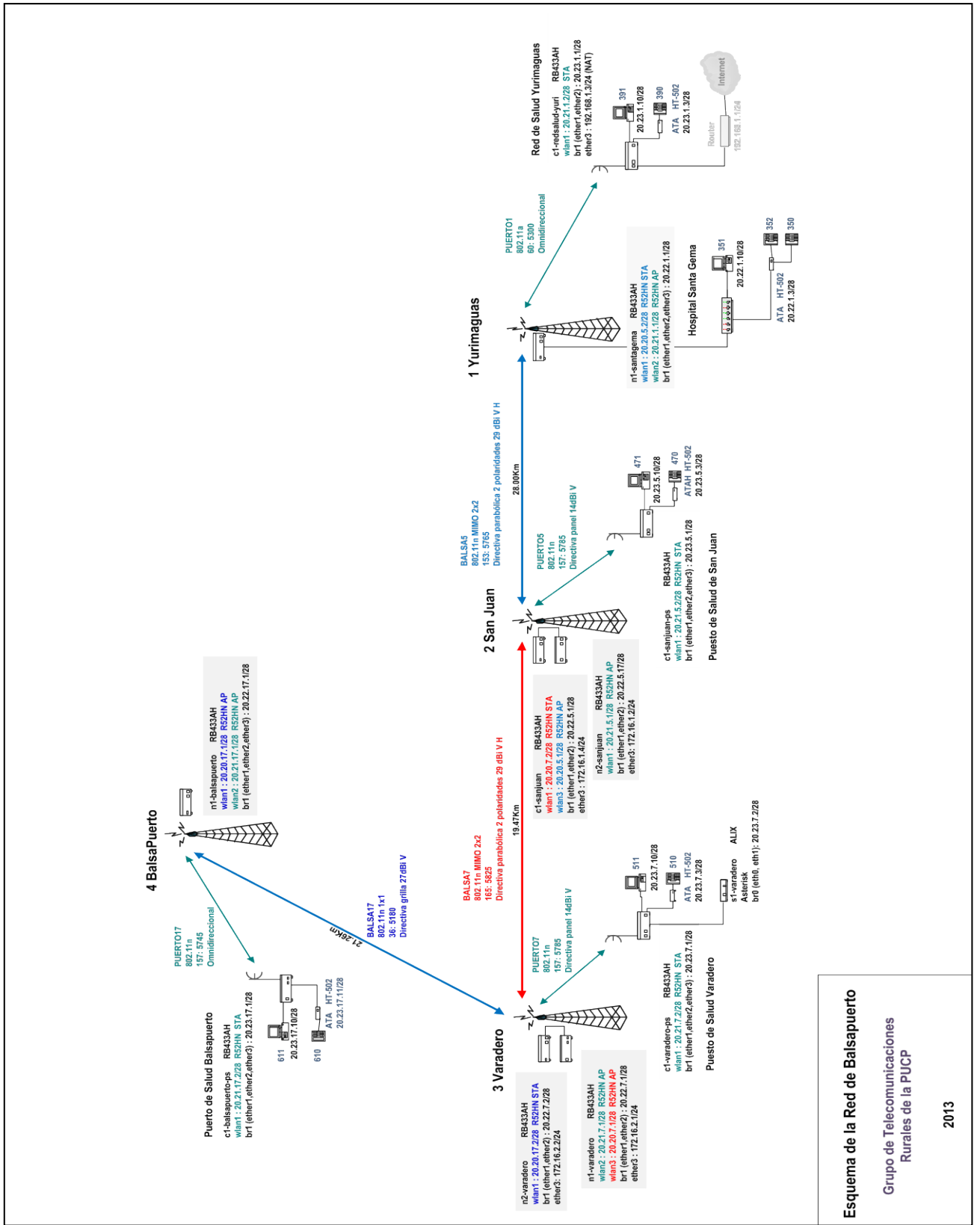
Figure 11: IP address diagram of Balsapuerto network

4   PERFORMED ACTIVITIES

4.1   Napo Network

The works for upgrading the Napo Network were planned in three phases. In the first one, we worked on the nodes located in the city of Iquitos (DIRESA Loreto, Regional Hospital of Loreto, PetroPerú and the Apostolic Vicariate of San José del Amazonas). The second phase involved the nodes located in the Lower Napo (Mazan - Santa Clotilde). And the third phase was concluded with the remaining nodes located in the Upper Napo (Copal Urco - Cabo Pantoja). The original work plan was fulfilled by 95%. Only was necessary to reschedule the upgrade of the node located at the plant of sales of PetroPerú to the third phase, because of it was necessary to apply and obtain a formal permission from Petro Peru to enter their facilities.

Phase I: Iquitos (20/08/2013 – 23/08/2013)
In this phase, the work was performed at the stations located in the city of Iquitos.
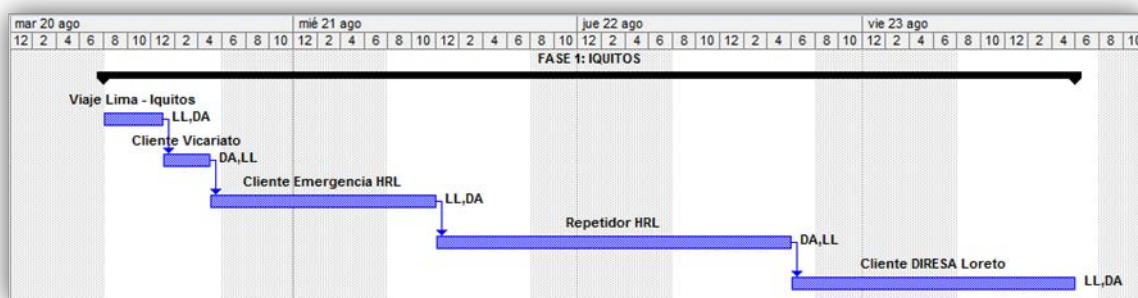
Figure 12: Phase I

Phase II: Lower Napo (24/08/2013 – 30/08/2013)
It consisted on visiting the communities of Mazan, Huaman Urco, Tuta Pishco, Negro Urco, Tacsha Curaray and Santa Clotilde. In these communities, the work was performed at both stations (client and repeater).
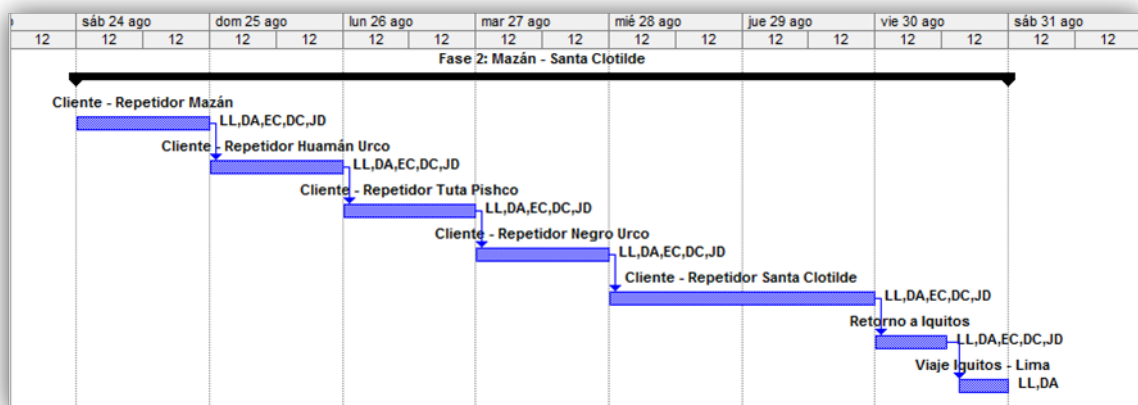
Figure 13: Phase II

Phase III: Upper Napo (20/09/2013 – 27/10/2013)
It included visiting the communities of Copal Urco, San Rafael, Rumi Tuni, Campo Serio, Angoteros, Tupac Amaru, Tempestad, Torres Causana and Cabo Pantoja. In these communities, the work was also performed at both stations (client and repeater).
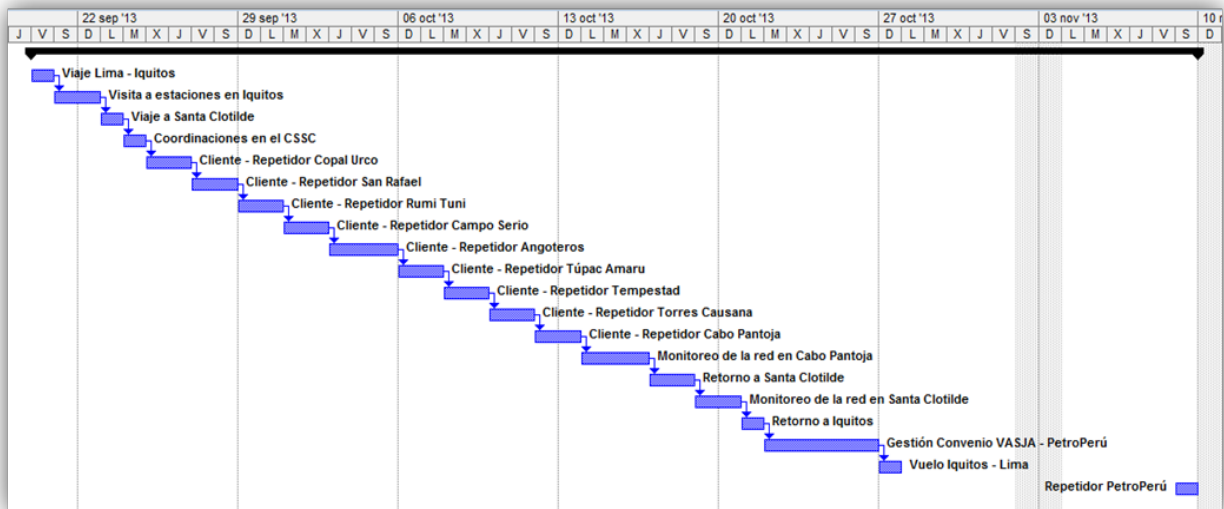
Figure 14: Phase III

4.1.1 Network improvements

In the following subsections will be presented a summary of the main changes and activities performed in the nodes of interest for the TUCAN 3G project.

The distribution network works on 5.8GHz frecuency band for the link: Regional Hospital of Loreto (HRL) to Mazan and 2.4GHz frecuency band for the links: Mazan to Cabo Pantoja. The main change was the use of equipment of the MikroTik brand instead of Alix routerboard.

The MikroTik equipment installed was the following:
- MikroTik RB 493G + R52nM: DIRESA Loreto, Emergency room in HRL
- MikroTik RB 433UAH + (2) R52nM + R52Hn: HRL
- MikroTik RB 433UAH + (2) R52Hn: Backbone network (from PetroPerú to Cabo Pantoja)
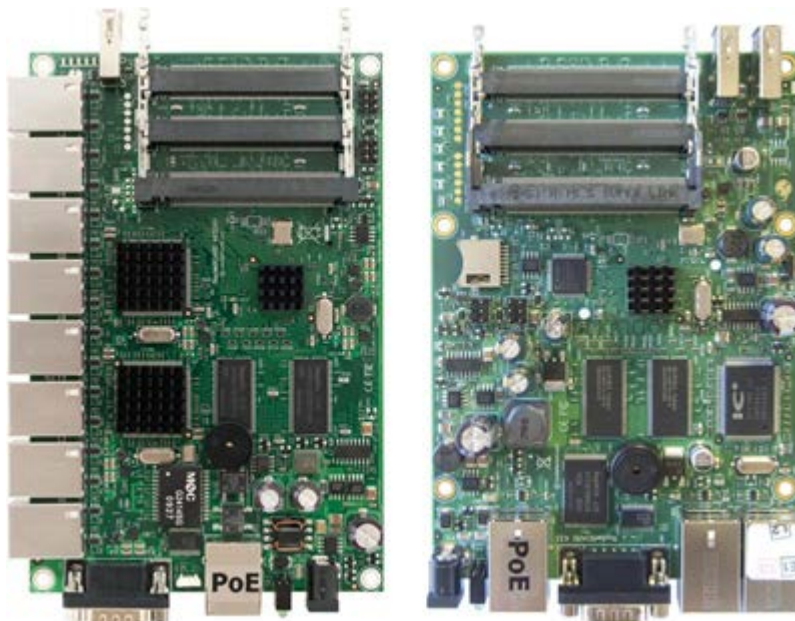
Figure 15: Routers Mikrotik, models 493G and 433UAH

Figure 16: MiniPCI cards, models R52n-M and R52Hn

In the case of the links to the client stations, the Alix/Wrap boards and the SR2 radios were used, which initially met the requirement of establishing the distribution links. The first board remained installed in the tower and the second one was relocated in the health establishment. Also, in the board located in the tower, the local Asterisk server was kept.

The routers installed in the local links are the following:

- Alix 2C0 + SR2: From Mazan to Santa Clotilde, and PetroPerú - Vicariato
- Wrap + SR2: From Copal Urco to Cabo Pantoja
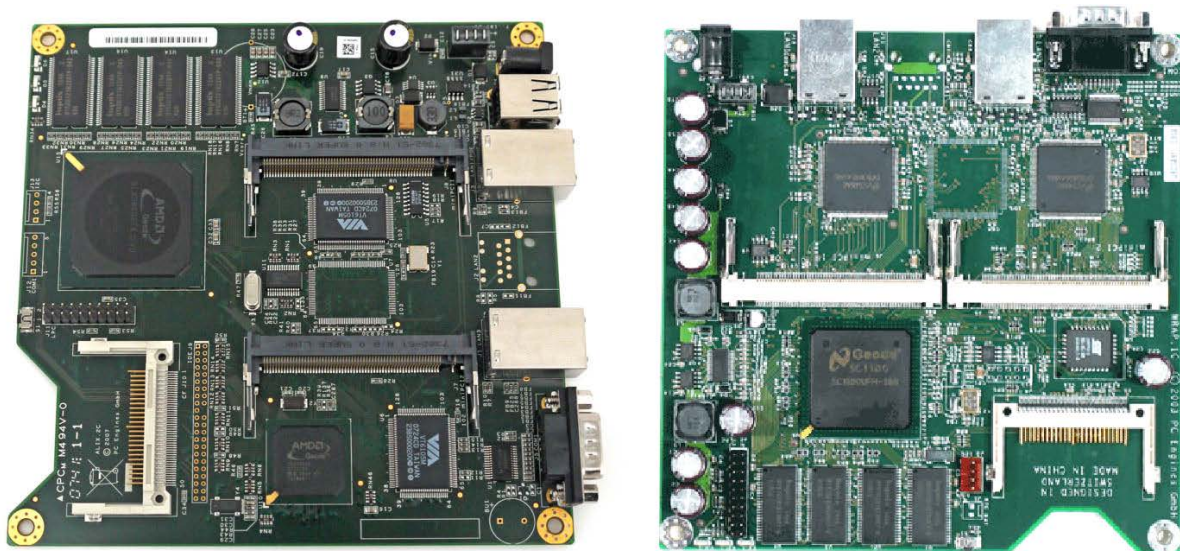
Figure 17: Boards used as routers, models Alix2C0 and Wrap

Figure 18: MiniPCI card, model SR2

The schemes of the distribution of the telecommunications equipment are shown in Figure 19, Figure 20, Figure 21 and Figure 22.
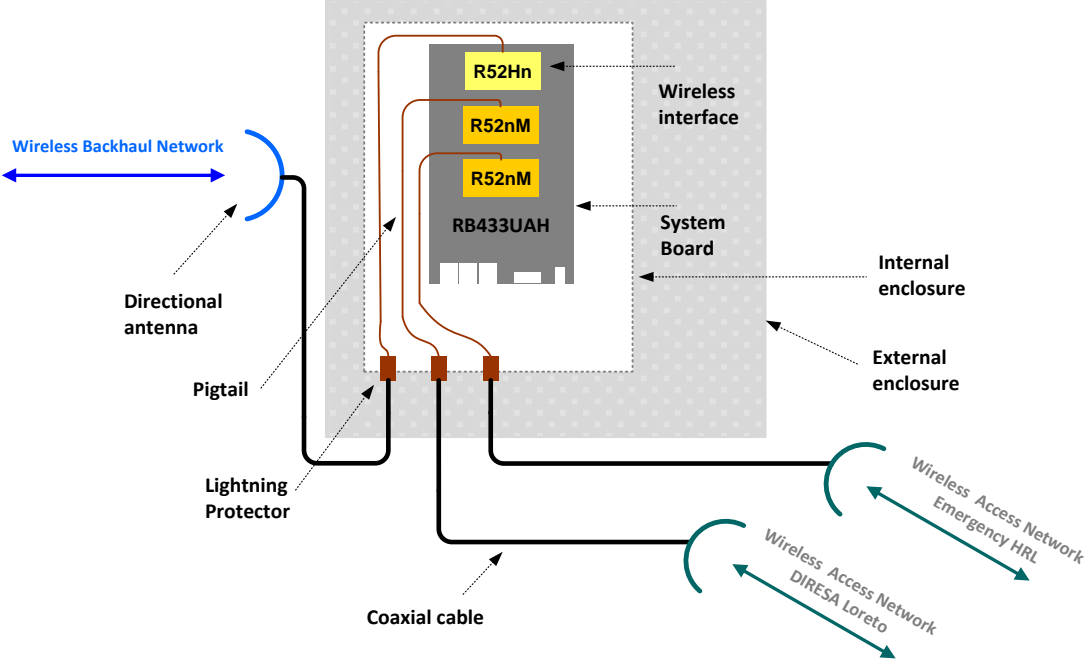
Figure 19: Diagram of the repeater's equipment installed in HRL after de upgrade.
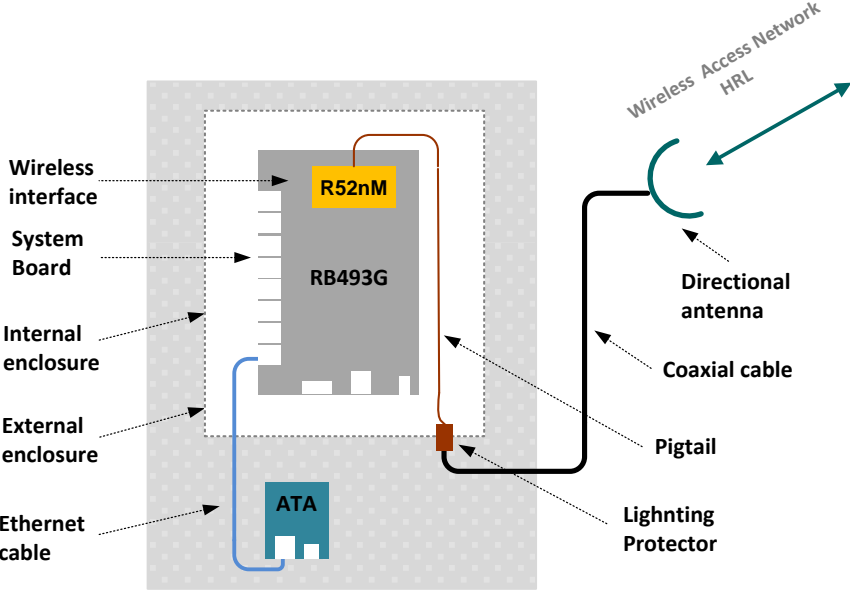
Figure 20: Diagram of the equipment installed in DIRESA Loreto and in the Emergency room of HRL after de upgrade.
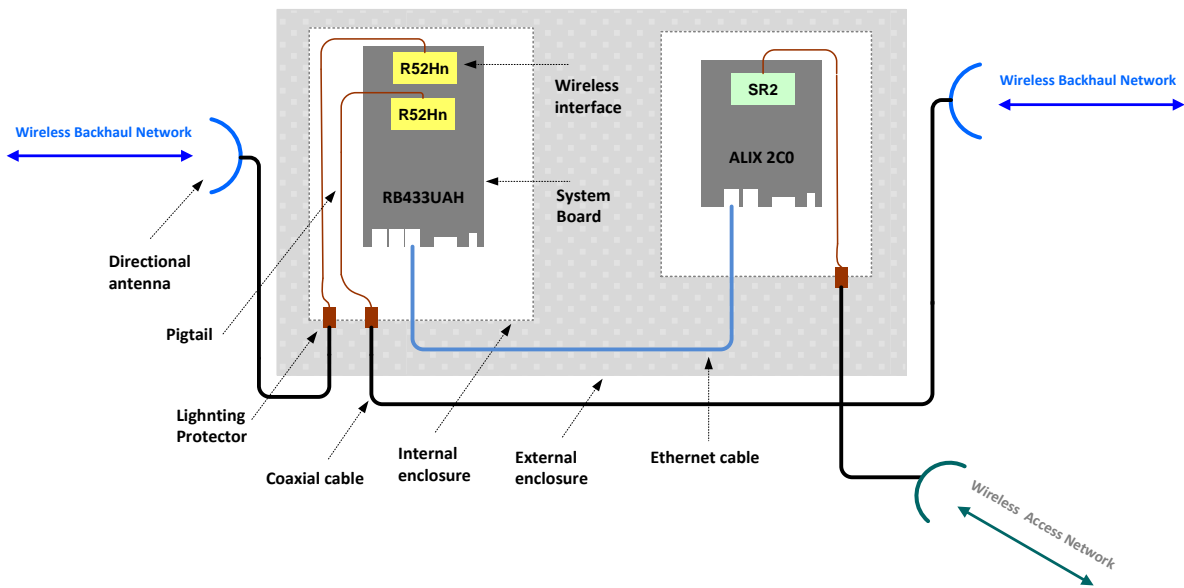
Figure 21: Diagram of the equipment installed in Tuta Pischco, Negro Urco, Tacsha Curaray and Santa Clotilde repeaters after de upgrade.
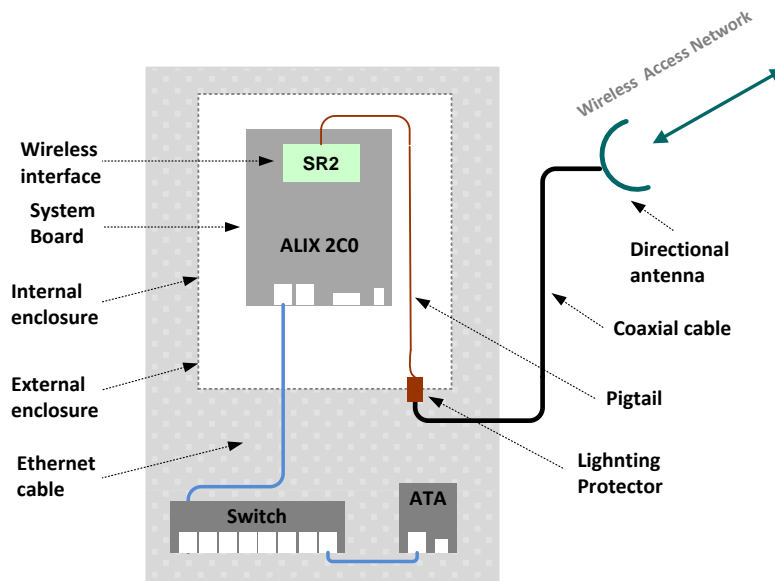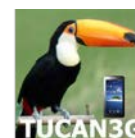
Figure 22: Diagram of the equipment installed in Tuta Pischco, Negro Urco, Tacsha Curaray and Santa Clotilde client stations

Components	Trademarks / Models	Specifications	Tuta Pishco	Negro Urco	Tacsha Curaray	Santa Clotilde
Telecommunication equipment						
System Board	MikroTik / RB433UAH	3 ethernet ports, 128 MB RAM, 3 MiniPC slots, 2 USB. Embedded RouterOS operating system	1	1	1	1
System Board	PC Engines / ALIX 2C0	Embedded computers with x86 architecture, two Fast Ethernet ports, two miniPCI slots and a serial port, CompactFlash card.	1	1	1	1
Wireless Interface	MikroTik / R52Hn	Radio interface 802.11a/b/g/n dual band miniPCI card, 25dBm	2	2	2	2
	Ubiquiti Networks SR2	Radio interface 2.4GHz 802.11b/g mini-PCI; Chipset Atheros AR5213 MAC/BB, 24dBm	2	2	2	2
Pigtail	Hyperlink Technologies	MMCX – N Female	2	2	2	2
	Hyperlink Technologies	UFL – N Female	1	1	1	1
Antenna	Hyperlink Technologies HG2424G	Grid directional 24dBi 2.4GHz.	2	2	2	2
Antenna	Hyperlink Technologies HG2414P-NF	Panel directional 14 dBi 2.4 GHz	1	1	1	1
Lightning Protector	Hyperlink Technologies	Quarter wave, 2.4GHz band	3	3	3	3
Coaxial Cable	Andrew Heliax	3meters, N male to N male connectors	3	3	3	3
Energy equipment						
Photovoltaic Panel	Isofotón IS-75, IS-85	Monocrystalline Cell, 75Wp, 85Wp	2	2	2	2
Solar Batteries	Ritar DG12-130	Capacity: 104Ah@10hr-rate to 1.80 V per cell @ 25°C Cell per unit: 6. Free maintenance.	1	1	1	1
Solar controllers	Steca Solarix PRS 2020	Voltage 12 V (24 V) Power consumption <4 mA Open circuit voltage for solar module: < 47 V	1	1	1	1

Table 8: List of the equipment installed in the repeaters after the upgrade

Components	Trademarks / Models	Specifications	Tuta Pishco	Negro Urco	Tacsha Curaray	Santa Clotilde
Telecommunication equipment						
System Board	PC Engines / ALIX 2C0	Embedded computers with x86 architecture, two Fast Ethernet ports, two miniPCI slots and a serial port, CompactFlash card.	1	1	1	1
Pigtail	Hyperlink Technologies	UFL – N Female	1	1	1	1
Antenna	Hyperlink Technologies HG2414P-NF	Panel directional 14 dBi 2.4 GHz	1	1	1	1
Lightning Protector	Hyperlink Technologies	Quarter wave, 2.4GHz band	1	1	1	1
Coaxial Cable	Andrew Heliax	3meters, N male to N male connectors	1	1	1	1
Energy equipments						
Photovoltaic Panel	Isofotón IS-75, IS-85	Monocrystalline Cell, 75Wp, 85Wp	3	3	3	3
Solar Batteries	Ritar DG12-130	Capacity: 104Ah@10hr-rate to 1.80 V per cell @ 25°C Cell per unit: 6	2	2	2	2
Solar controllers	Steca Solarix PRS 3030	Voltage 12 V (24 V) Power consumption <4 mA Open circuit voltage for solar module: < 47 V	1	1	1	1

Table 9: List of the equipment installed in the client stations after the upgrade.

	Tuta Pishco – Negro Urco	Negro Urco – Tacsha Curaray	Tacsha Curaray – Santa Clotilde
SSID	EHAS19	EHAS18	EHAS17
Wireless technology	802.11n	802.11n	802.11n
Band Frequency	2.4GHz / 2.437GHz	2.4GHz / 2.462GHz	2.4GHz / 2.437GHz
Security	WPA-PSK	WPA-PSK	WPA-PSK
Max Rate	MCS-3	MCS-3	MCS-3
Channel Width	20MHz	20MHz	20MHz

Table 10: Configuration parameters of the radio links in the transport network

	Tuta Pishco	Negro Urco	Tacsha Curaray	Santa Clotilde
SSID	NAPO19	NAPO18	NAPO17	NAPO1
Wireless technology	802.11g	802.11g	802.11g	802.11g
Band Frequency	2.4GHz / 2.12GHz	2.4GHz / 2.12GHz	2.4GHz / 2.12GHz	2.4GHz / 2.12GHz
Security	WPA-PSK	WPA-PSK	WPA-PSK	WPA-PSK
Max Rate	18Mbps	18Mbps	18Mbps	18Mbps
Channel Width	20MHz	20MHz	20MHz	20MHz

Table 11: Configuration parameters of the radio links in the distribution network

4.1.1.1   Distance, throughput and signal level

The distances between the braced towers for the point-to-point links of interest are shown in Table 12.

	Tuta Pishco – Negro Urco	Negro Urco – Tacsha Curaray	Tacsha Curaray – Santa Clotilde
Distance (Km)	29.60	29.50	39.00

Table 12: Distance between repeaters

According Mikrotik, the" p-throughput is the estimated approximate throughput that is expected to the given peer, taking into account the effective transmit rate and hardware retries. Calculated once in 5 seconds" For the analysis of p-throughput, the network behavior was monitored. The p-throughput of each radio link of interest for the TUCAN 3G project was recorded for 3 days, which allowed obtaining the following graphs:

Tuta Pishco (interface wlan1) – Negro Urco (interface wlan2) radio link:

The radio link is stable and has an average p-throughput of 17.8Mbps. Recording was done for 24 hours per day.
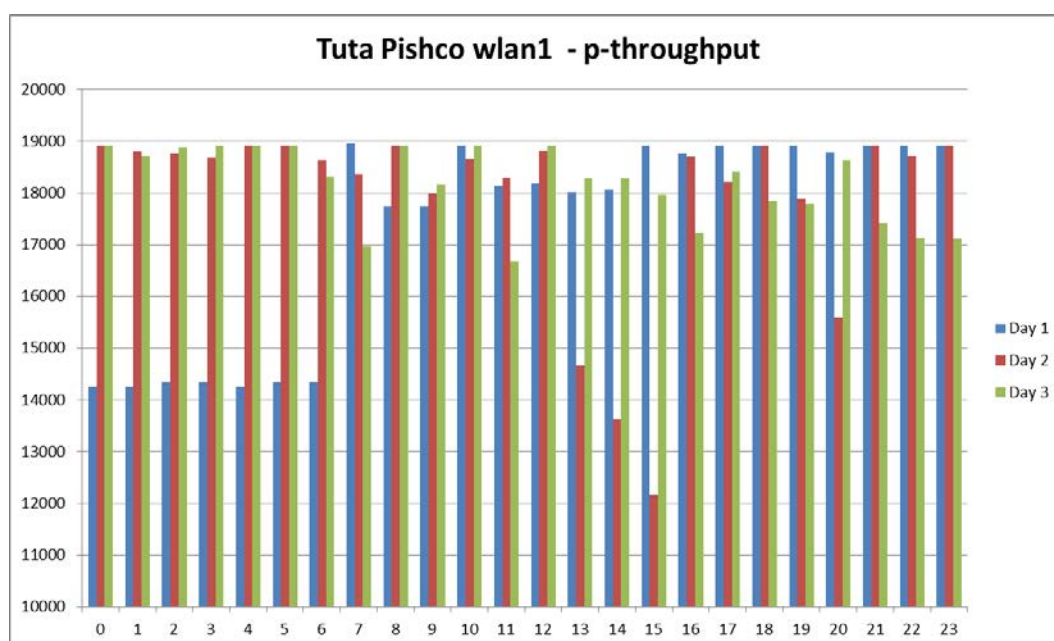
Figure 23: Tuta Pishco – Negro Urco link

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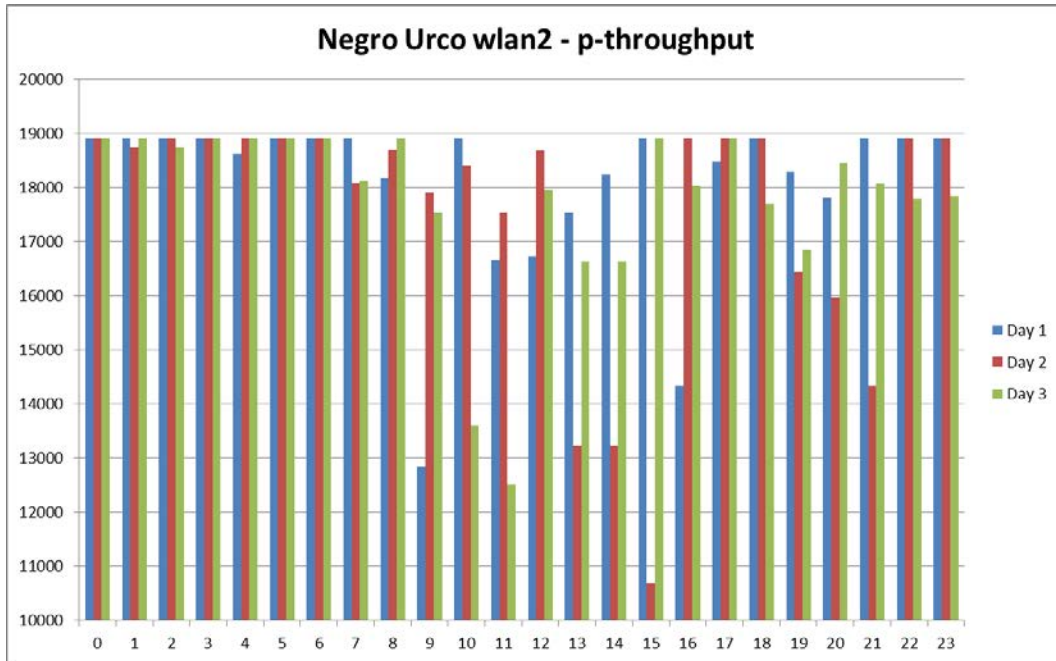
Figure 24: Negro Urco – Tuta Pishco link

Negro Urco (interface wlan1) – Tacsha Curaray (interface wlan2) radio link:

The radio link is stable and has an average p-throughput of 18.6Mbps. Recording was done for 24 hours per day.
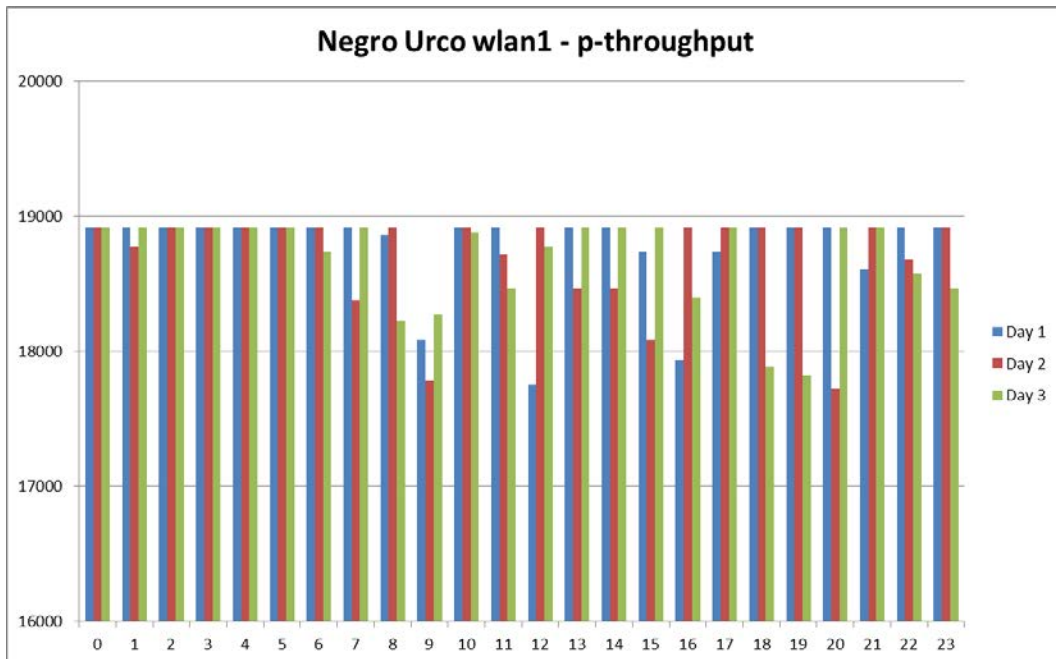
Figure 25: Negro Urco – Tacsha Curaray link
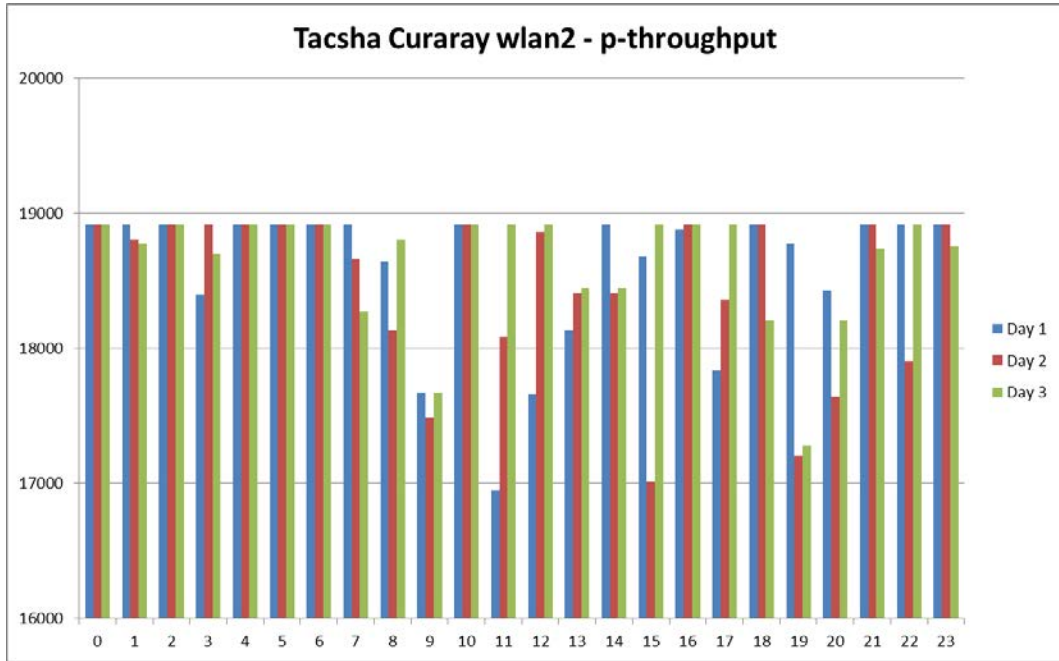
Figure 26: Tacsha Curaray – Negro Urco link

Tacsha Curaray (interfaz wlan1) – Santa Clotilde (interfaz wlan2) radio link:

The radio link is stable and has an average p-throughput of 17.4Mbps. Recording was performed for 24 hours per day.
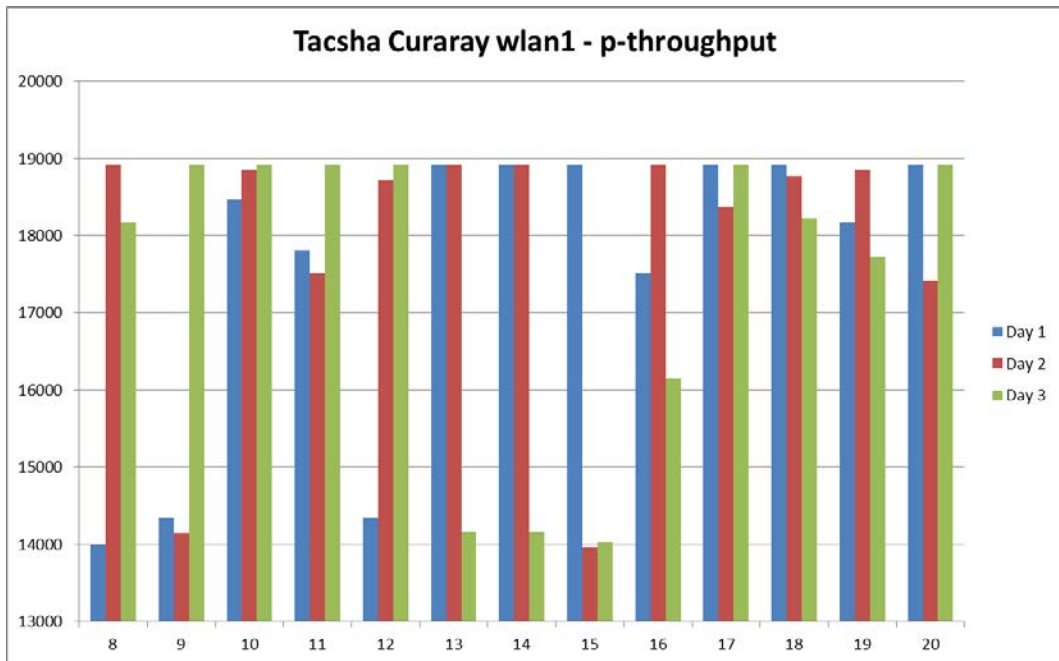
Figure 27: Tacsha Curaray – Santa Clotilde link

29
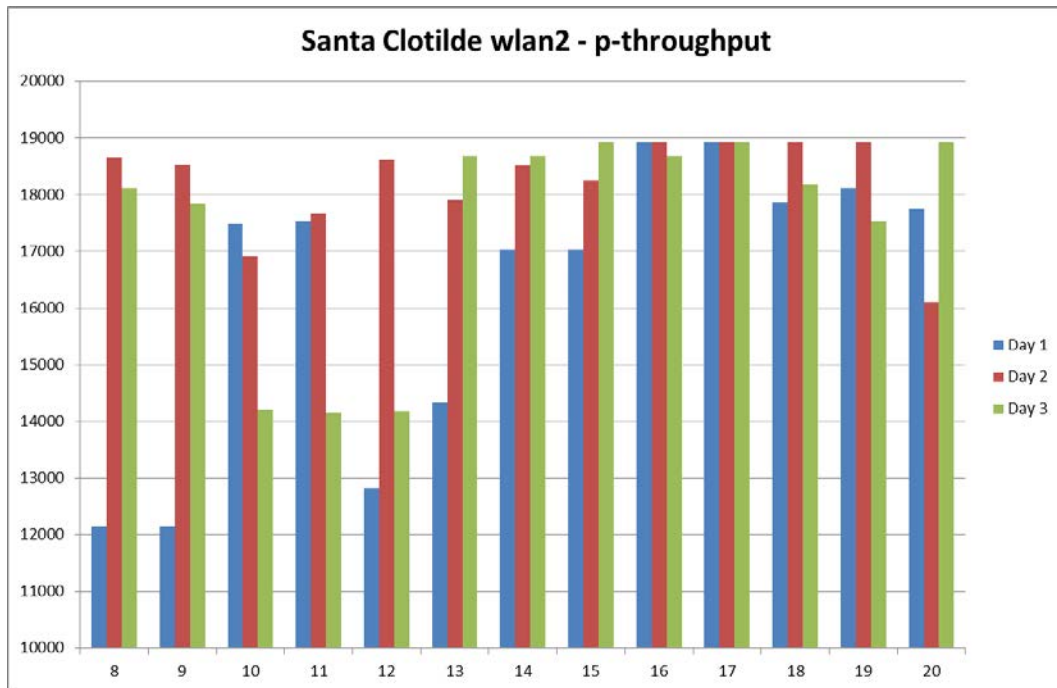
Figure 28: Santa Clotilde – Tacsha Curaray link

Regarding the signal level at each radio, the following information was recorded:

Tuta Pishco – Negro Urco radiolink
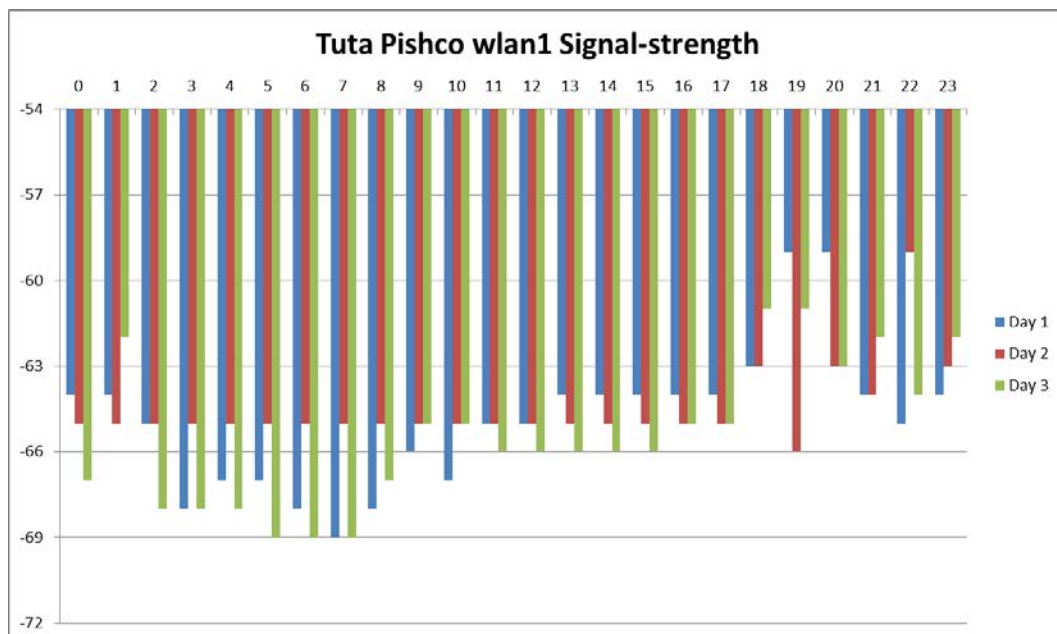
Figure 29: Signal level at the Tuta Pishco radio
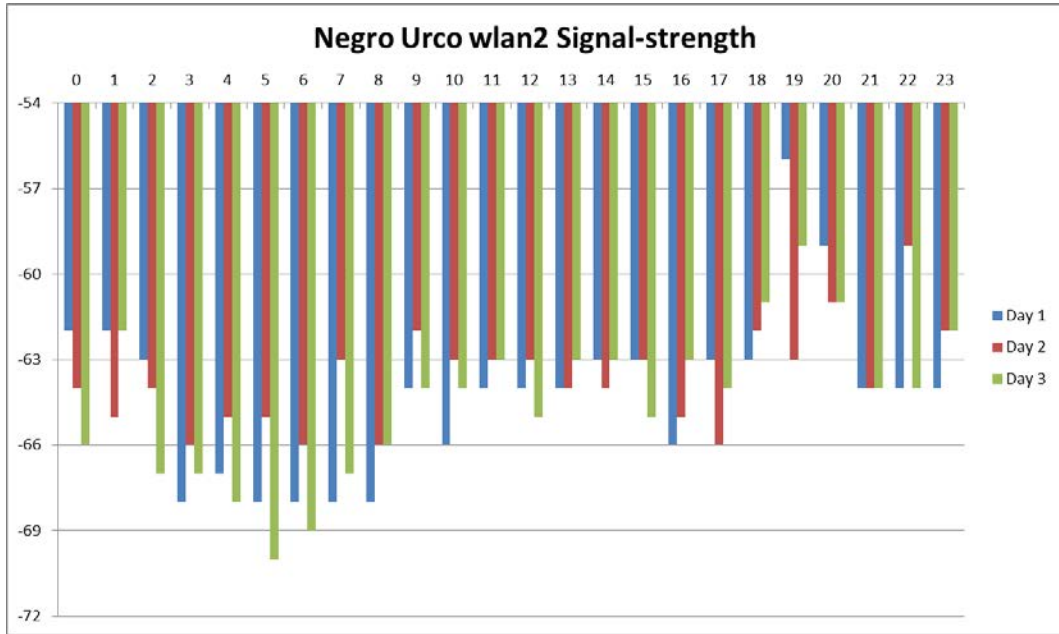
Figure 30: Signal level at the Negro Urco radio

We can see in the graphs that the signal levels in the Tuta Pishco – Negro Urco link are in the range of -59dBm to -69dBm. Therefore, the radio link is stable. Also, similarly to the previous cases, the signal levels were recorded for 24 hours per day.

Negro Urco – Tacsha Curaray radio link
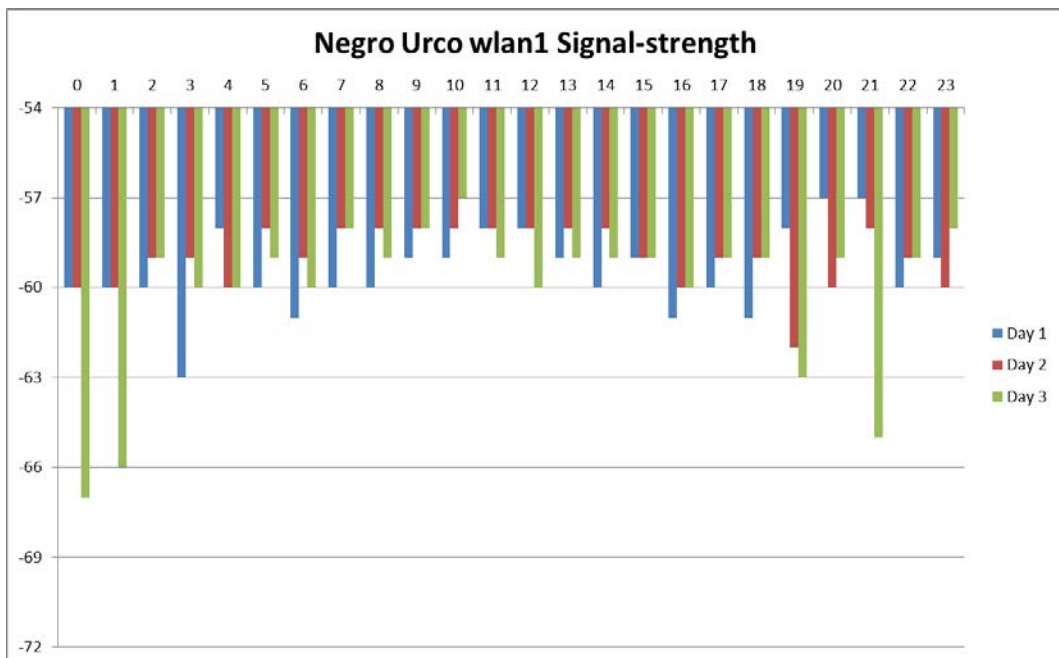
Figure 31: Signal level at the Negro Urco radio
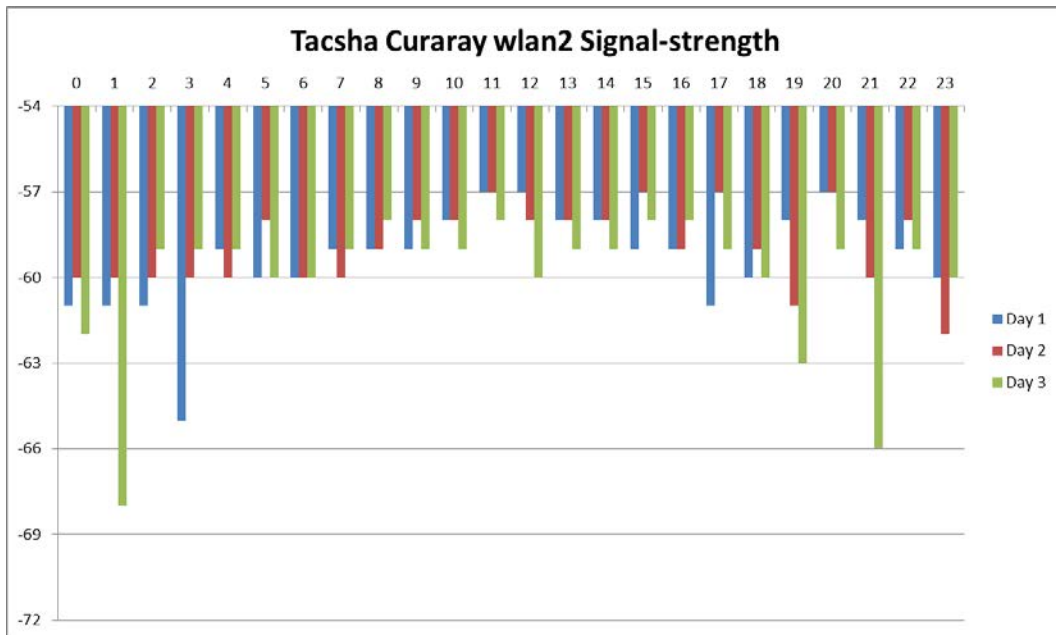
Figure 32: Signal level at the Tacsha Curaray radio

We can see in the graphs that the signal levels in the Negro Urco – Tacsha Curaray link are in the range of -57dBm to -68dBm. Therefore, the radio link is stable. Again, signal levels were recorded for 24 hours a day.

Tacsha Curaray – Santa Clotilde radio link
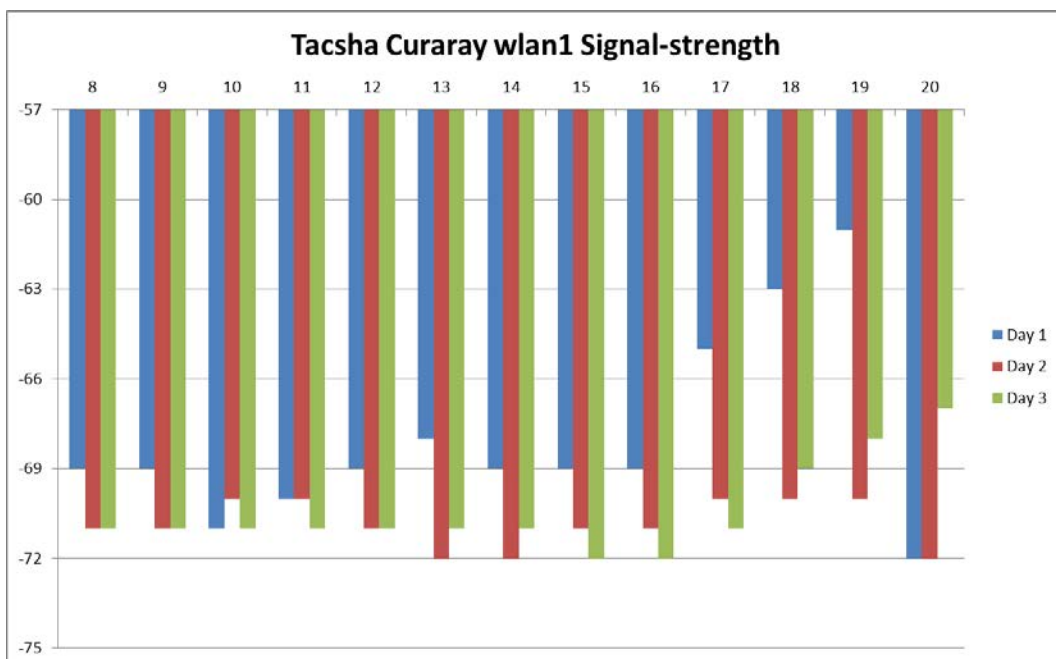
Figure 33: Signal level at the Tacsha Curaray radio
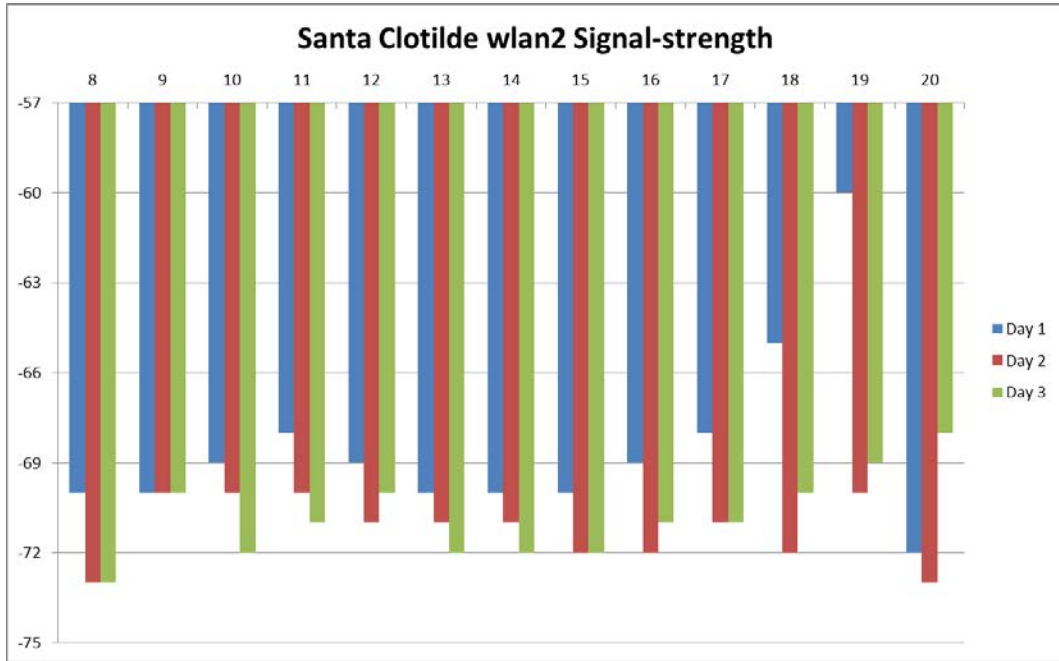
Figure 34: Signal level at the Santa Clotilde radio

We can see in the graphs that the signal levels of the Tacsha Curaray - Santa Clotilde radio link are in the range of -60dBm to -73dBm. Therefore, the radio link is stable. The signal levels were recorded for 12 hours a day.

Additionally, it was monitored the battery voltage levels registered in the four stations of interest for the TUCAN3G project.
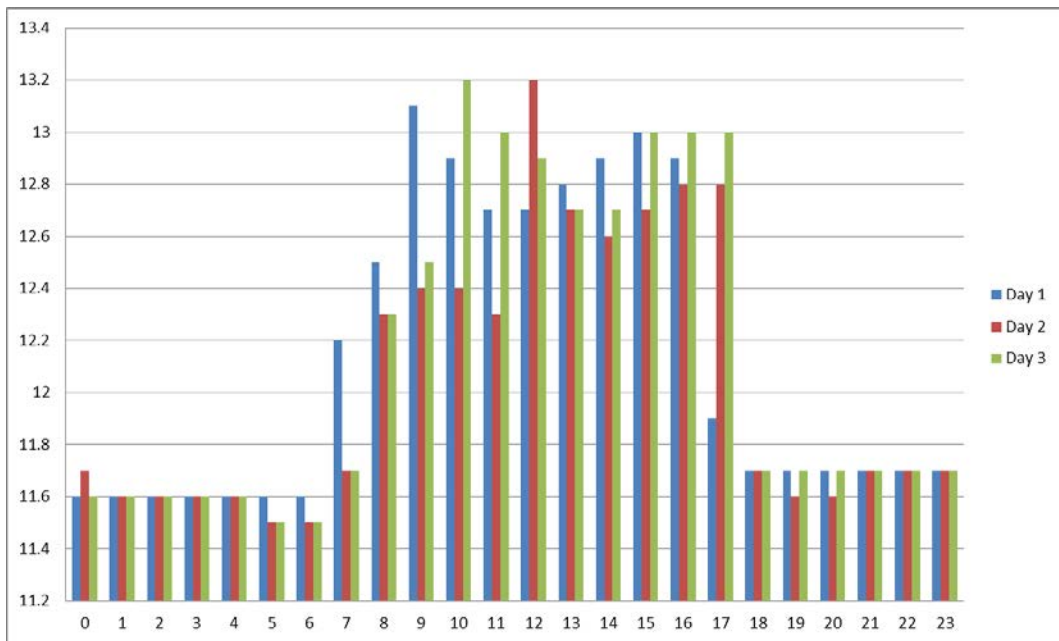
Figure 35: Tuta Pishco –Battery voltage level

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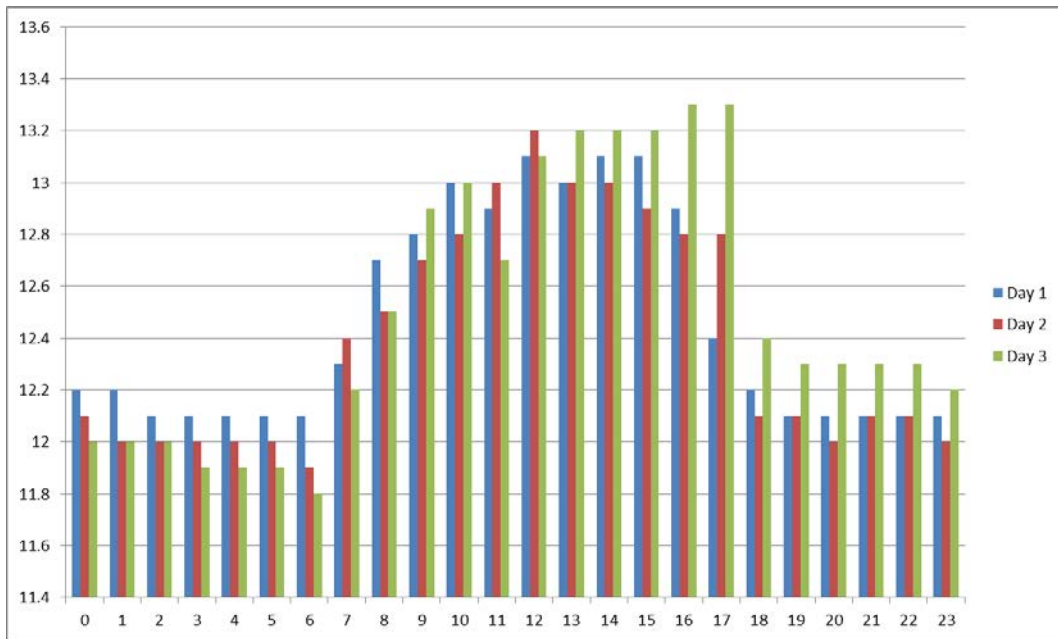
Figure 36: Negro Urco – Battery voltage level
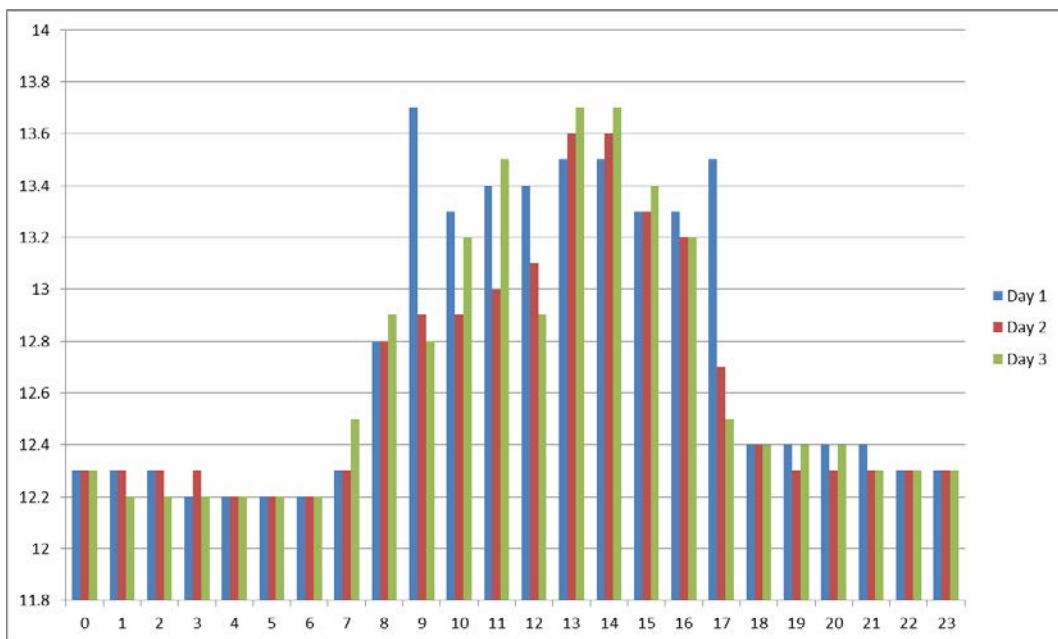
Figure 37: Tacsha Curaray – Battery voltage level
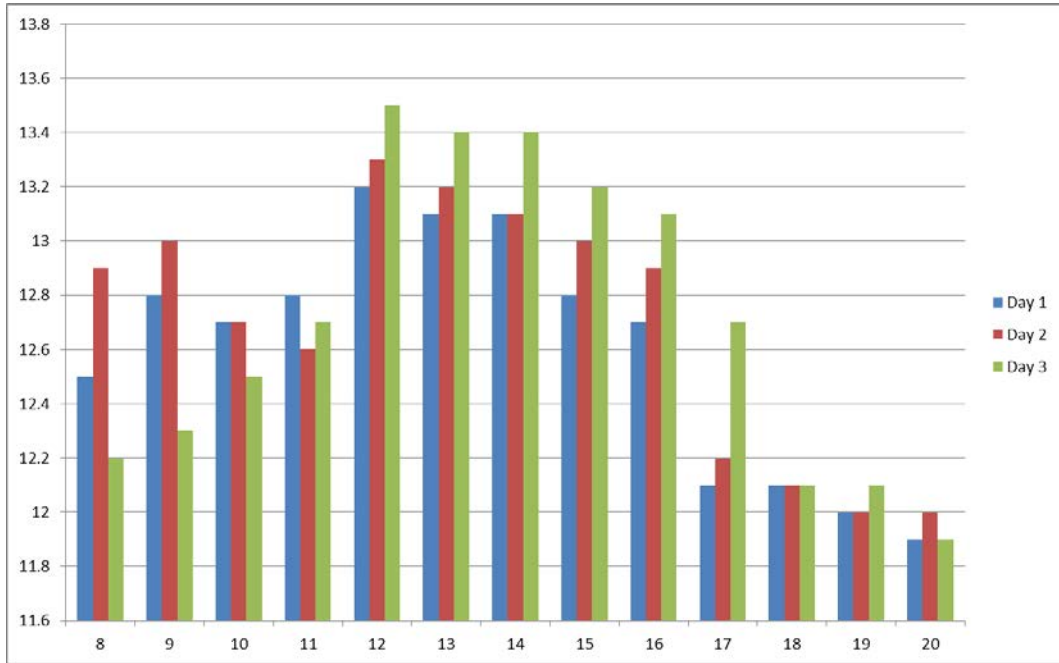
Figure 38: Santa Clotilde – Battery voltage level

The graphs show a normal charging and discharging behavior of the batteries. The minimum voltage registered is 11.4Vdc and the maximum is 13.5Vdc.

4.1.1.2   IP addressing scheme
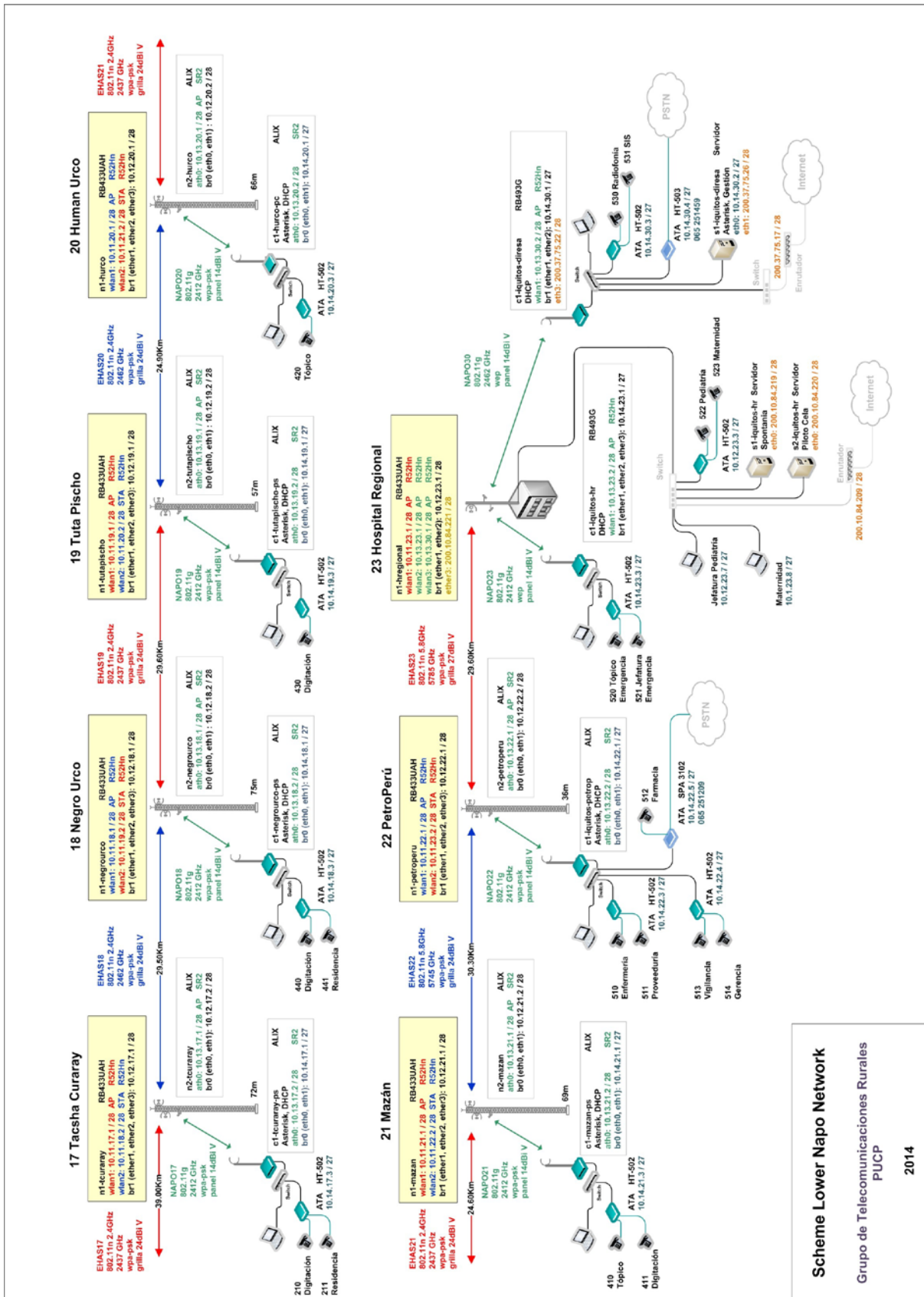
Figure 39: IP addressing scheme – Lower Napo

Figure 40: IP addressing scheme – Upper Napo

4.1.2   Field activities

The activities in the four nodes of interest for the TUCAN3G project have been performed in August of 2013 (see Figure 13) and the results were published in the deliverable D61. Among the main activities in Tuta Pishco, Negro Urco, Tacsha Curaray and Santa Clotilde we can mention the following:

- Client station:
  - Installation of the ALIX board
  - Configuration of the client station
  - Redistribution of the equipment in a containing box
  - Installation of a 8-ports switch
  - Maintenance of the computer system
  - Maintenance of the electrical protection system
  - Maintenance of the photovoltaic power system
  - Tidying up of the existing cabling
  - Testing of voice and data

- Repeater station:
  - Retired one ALIX router and replaced by MikroTik RB433UAH routerReconfiguration of the Asterisk server
  - Tidying up of the existing cabling
  - Fine tuning alignment of the antennas of the distribution links
  - Maintenance of the electrical protection system
  - Maintenance of the photovoltaic power system
  - Connectivity test

Details of these activities are shown in Annex 3.

Figure 41: Client station (upper-left corner); repeater station (upper-right corner); Grounding system maintenance at the repeater station (lower-left corner); Grounding system maintenance at the client station (lower-right corner)

Figure 42: Torres Causana and Tempestad client stations (upper pictures); Napo Rural Telemedicine Network users (lower pictures)

4.2 Balsapuerto Network

Before the activities, coordinations were made with officials from the Alto Amazonas Health Network to make some changes and preventive maintenance on the Balsapuerto Telemedicine Network. The arrangements were made with representatives of the health network, Santa Gema Yurimaguas hospital, San Gabriel de Varadero health post and Balsapuerto health center.

4.2.1 Network improvements

In the San Juan and Varadero repeaters, power outages in the tower were detected at night, especially during the rainy season. The energy calculations were revised for the equipment in the tower and it

was found that the system was designed for autonomy of 1.5 days. Since the network is expected to increase its data traffic when femtocells are deployed, the system was re-dimensioned for autonomy of 3 days. For this purpose, two batteries of 100 ampere-hour were installed in the San Juan and Varadero repeaters and, additionally, the wireless card for the local link (R52Hn, with maximum consumption of 7Watts) was replaced with a lower power one (R52M-n, with maximum consumption of 3Watts), since the links are short distance (less than 200 meters) and do not require too much transmit power. The diagrams of the equipment are shown in Figure 43, Figure 44 and Figure 45. The list of the equipment is shown in Table 13.

On the other hand, since the IP addressing included public addresses in the range 20.X.X.X for the internal networks, they were replaced with private addresses in the range 10.X.X.X.
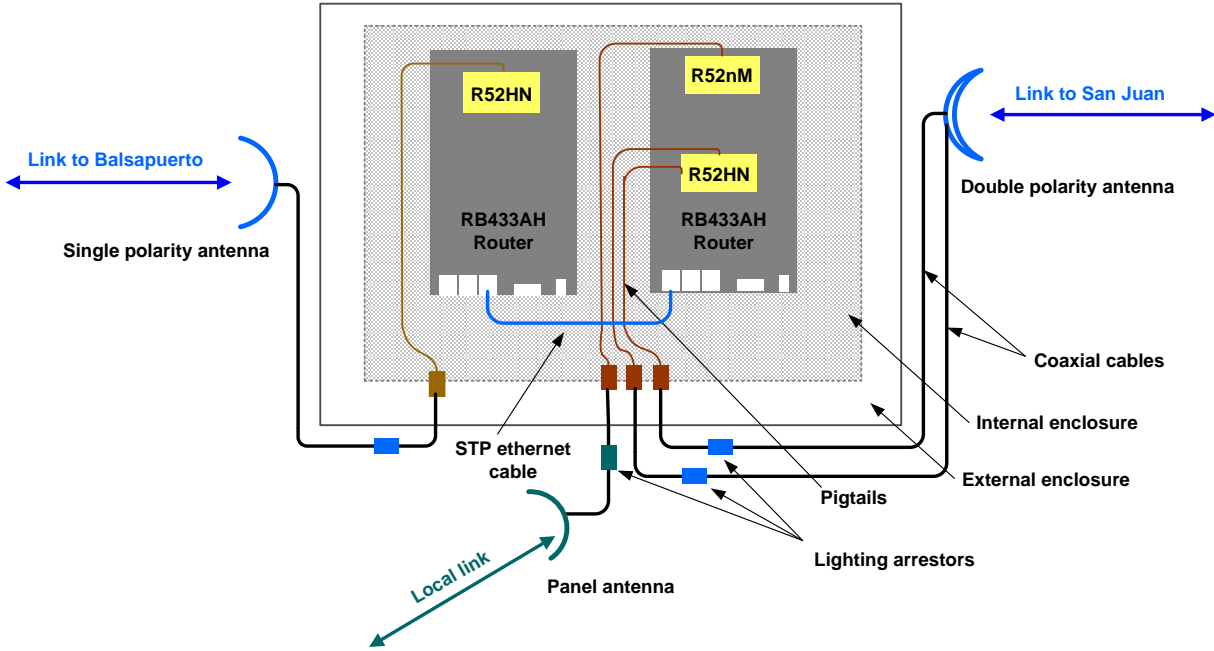
Figure 43: Diagram of equipment in the Varadero repeater
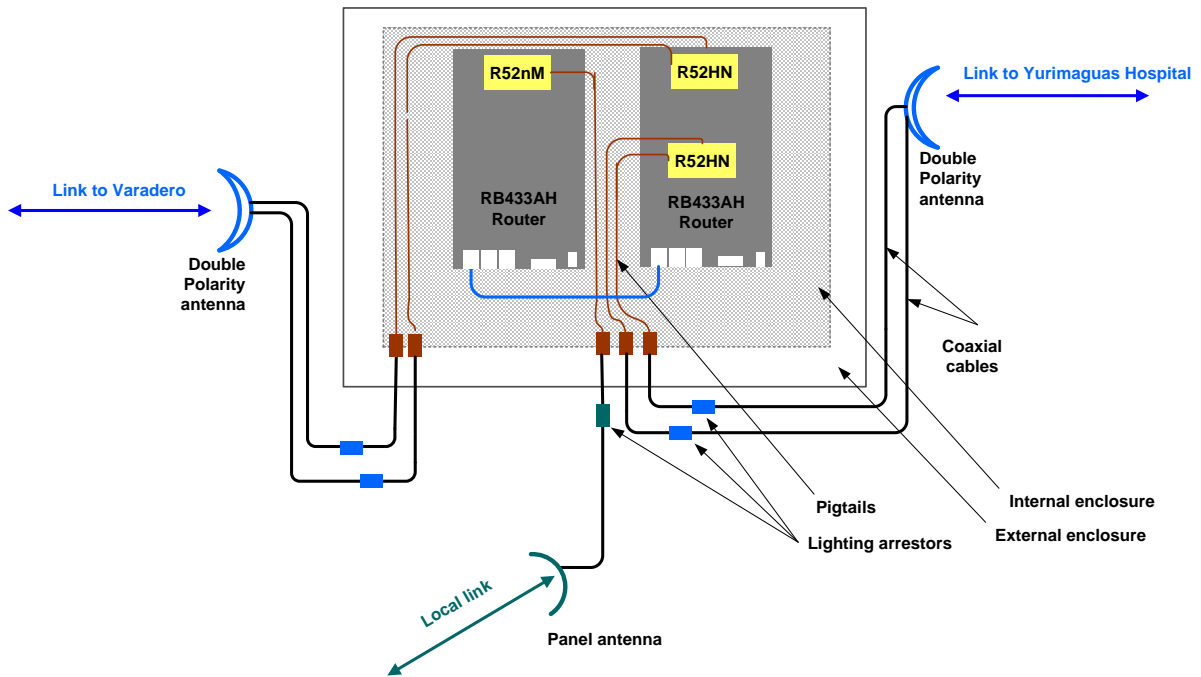
Figure 44: Diagram of the equipment in the San Juan repeater
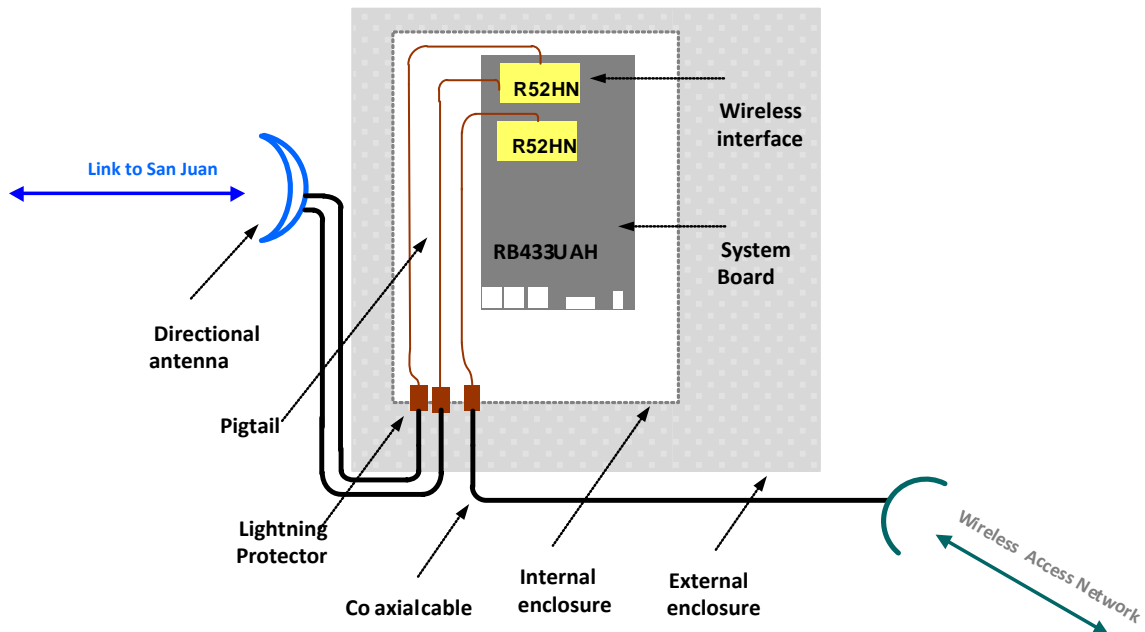
Figure 45: Diagram of the equipment in the Santa Gema Hospital repeater

Components	Trademarks / Models	Specifications	Varadero	San Juan	Santa Gema Hospital
System Board	Mikrotik / RouterBoard 433AH	3 ethernet ports, 128 MB RAM, 3 MiniPC slots. Embedded RouterOS operating system	2	2	1
Wireless Interface	Mikrotik / RouterBoard /R52Hn	Radio interface 802.11a/b/g/n dual band miniPCI card, 25dBm	2	2	2
Wireless Interface	Mikrotik / RouterBoard /R52n-M	Radio interface 802.11a/b/g/n dual band miniPCI card, 23dBm	1	1	2
Pigtail	Hyperlink	MMCX - N female	4	5	3
Antenna	Hyperlink	Grid directional 27dBi 5.8GHz	1	0	1
Antenna	Hyperlink	Parabolic directional 29dBi 5.8GHz dual polarity	1	2	1
Antenna	Hyperlink	Panel directional 14dBi 5.8GHz	1	1	0
Lightning Protector	Hyperlink	Quarter wave , for 5GHz band.	4	5	3
Coaxial cable	Andrew / Heliax	3meters, N male to N male connectors	4	5	3
Photovoltaic Panel	Solar World	Monocrystalline Cell, 85Wp	2	2	0
Solar Batteries	Ritar/ RA12-100	12VDC, 100Ah, free maintenance	2	2	0
Solar controllers	Steca/ Solarix PRS 2020	20A, Voltage 12 V (24 V), Power consumption <4 mA.	1	1	0

Table 13: Equipment located in the Backhaul repeaters.

4.2.1.1 Distance, throughput and signal level

The distances between the braced towers used for the point-to-point links of interest for the project are shown in Table 14.

	Varadero – San Juan	San Juan – Hospital Santa Gema
Distance (Km)	19.47	28.00

Table 14: Distances between the repeaters

For the throughput analysis, the network behavior was monitored and the p-throughput of each radio link of interest was recorded for 6 days (3 days before the changes and 3 days after making the changes). This is a reference value.

Figure 46 , Figure 47, Figure 48, Figure 49, Figure 50 and Figure 51 show that, before the work performed, there were interruptions in the communications at night, which were restored within the first hours of the day. After performing the maintenance activities and improving the energy storage

capacity in San Juan and Varadero repeaters, it is possible to see that there were no more communication interruptions during the 24 hours per day.

Santa Gema – San Juan radio link:
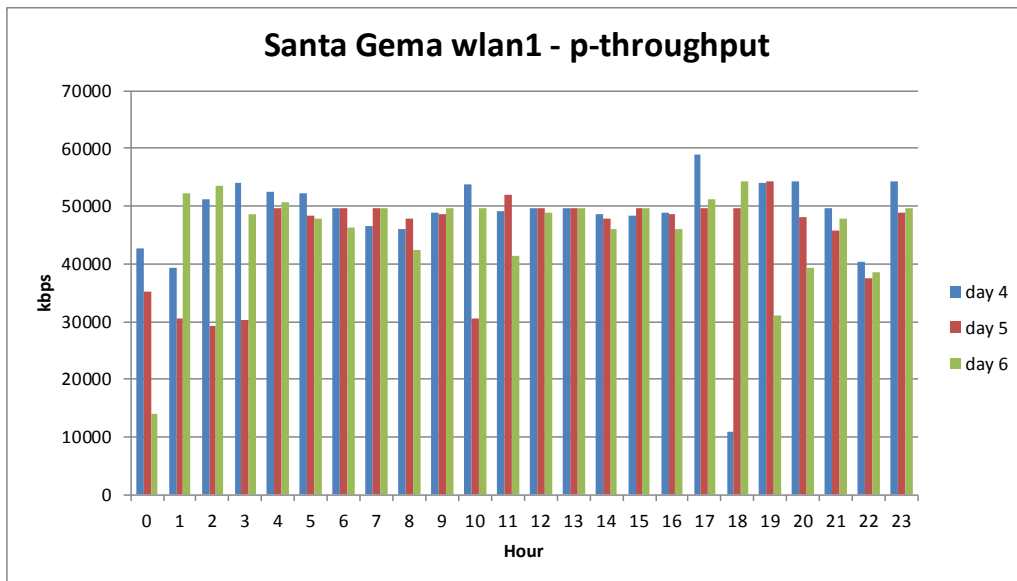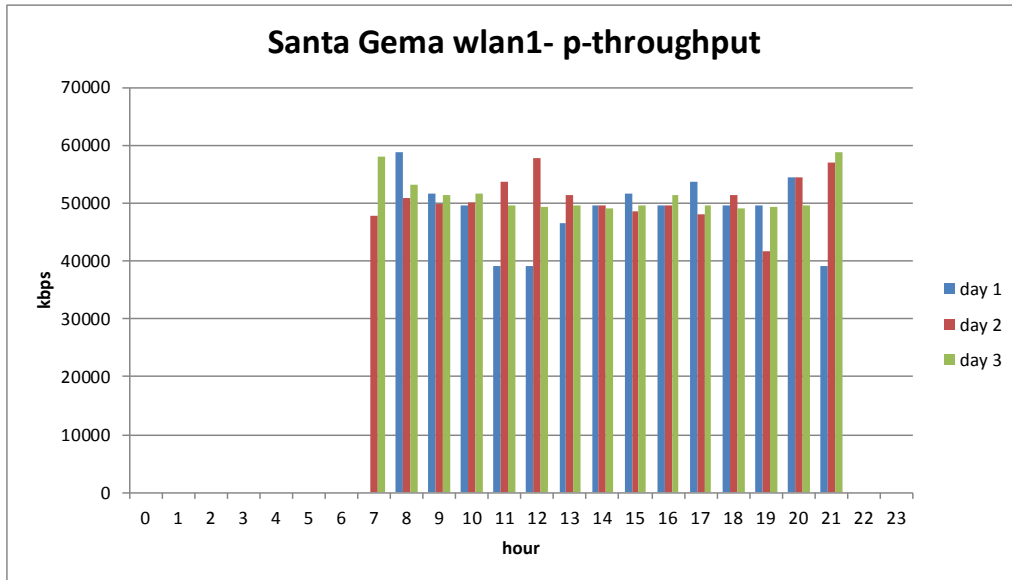
Figure 46: p-throughput measured 3 days before the maintenance and 3 days after the maintenance at the Santa Gema repeater
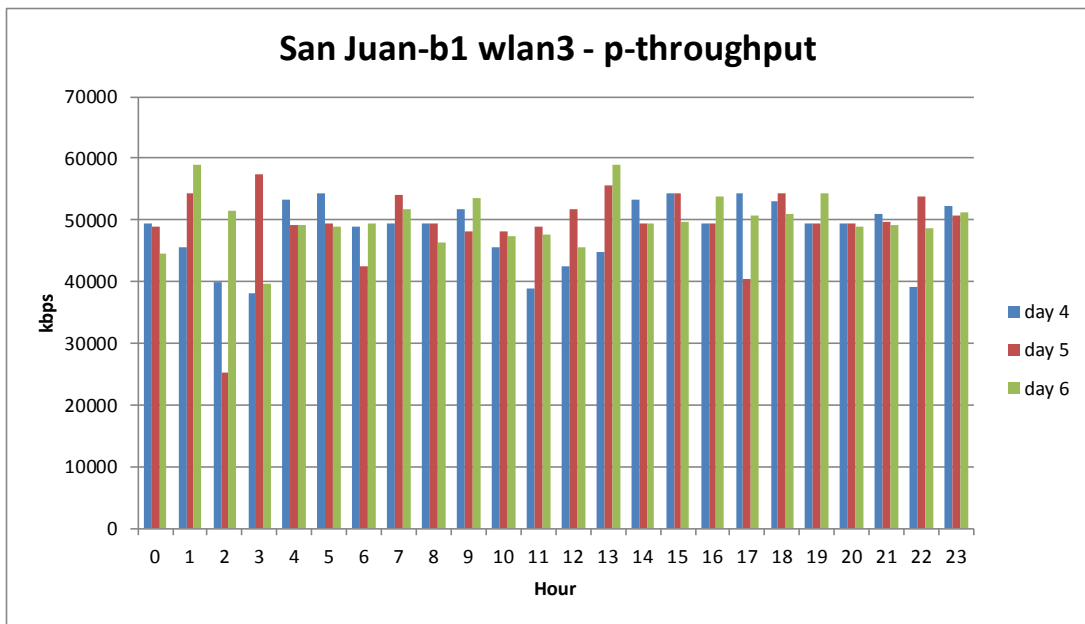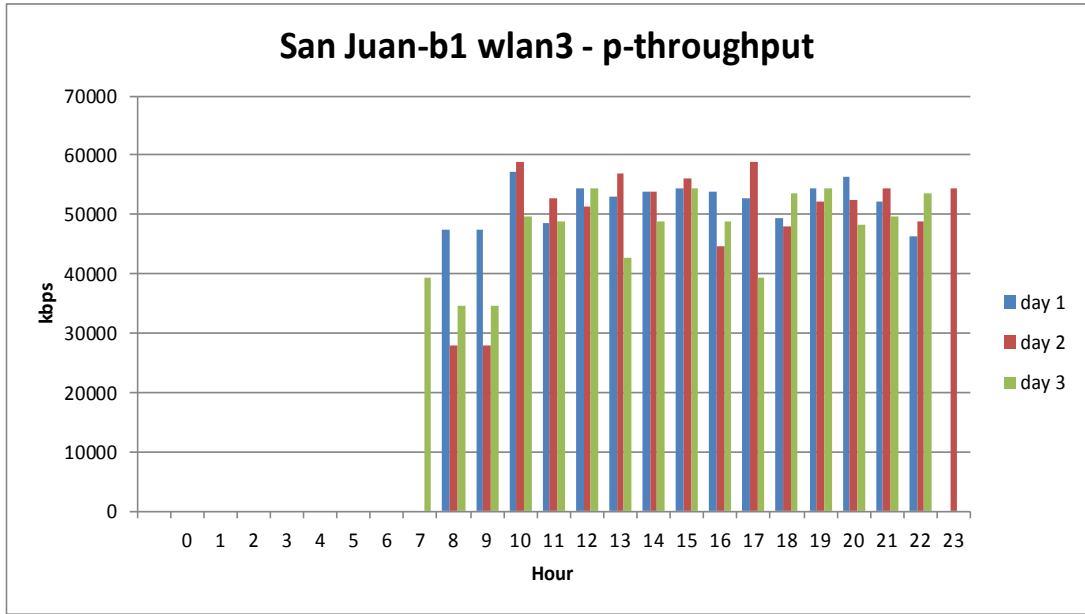
Figure 47: p-throughput measured 3 days before the maintenance and 3 days after the maintenance at the San Juan repeater

Figure 48 shows that the received signal level in the link between the repeaters located at Santa Gema and San Juan is almost stable and has a value of around -65dBm during the hours of operation of the network.
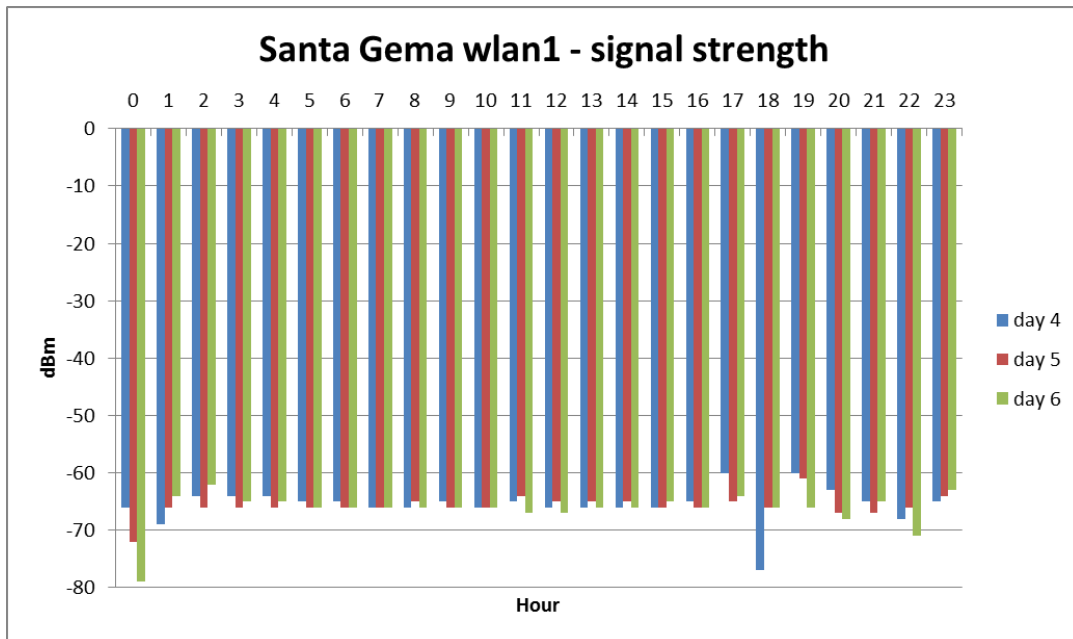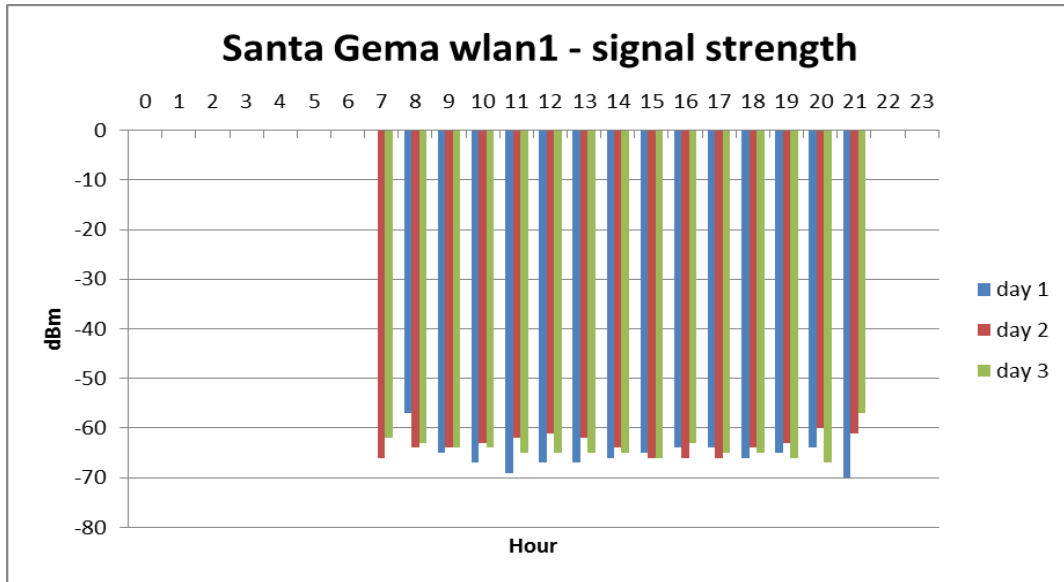
Figure 48: Signal-strength measured 3 days before the maintenance and 3 days after the maintenance at the San Gema repeater
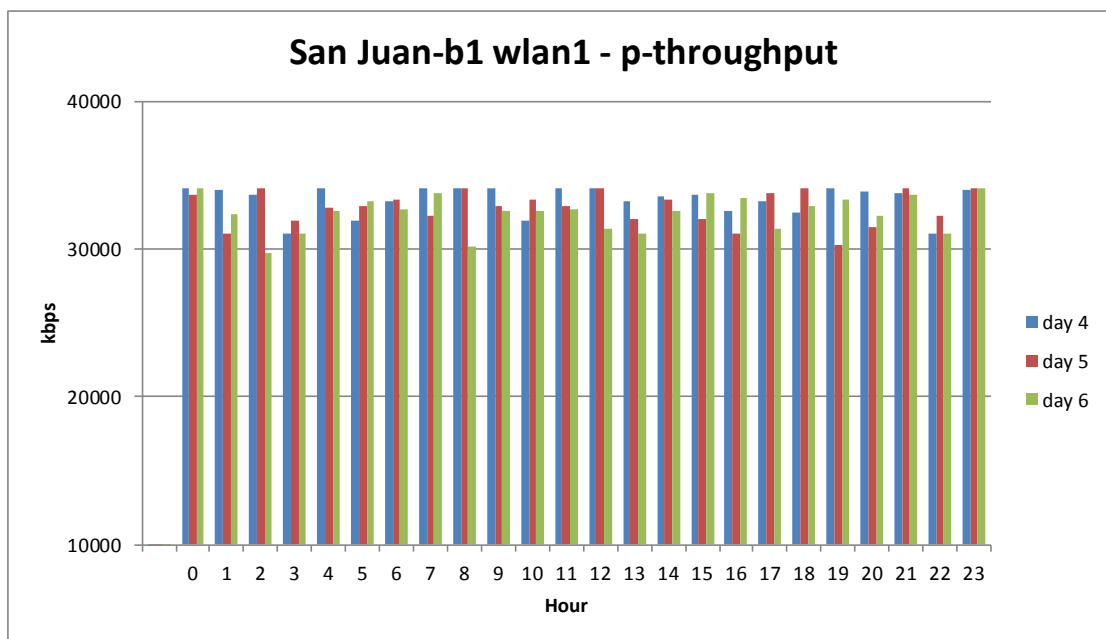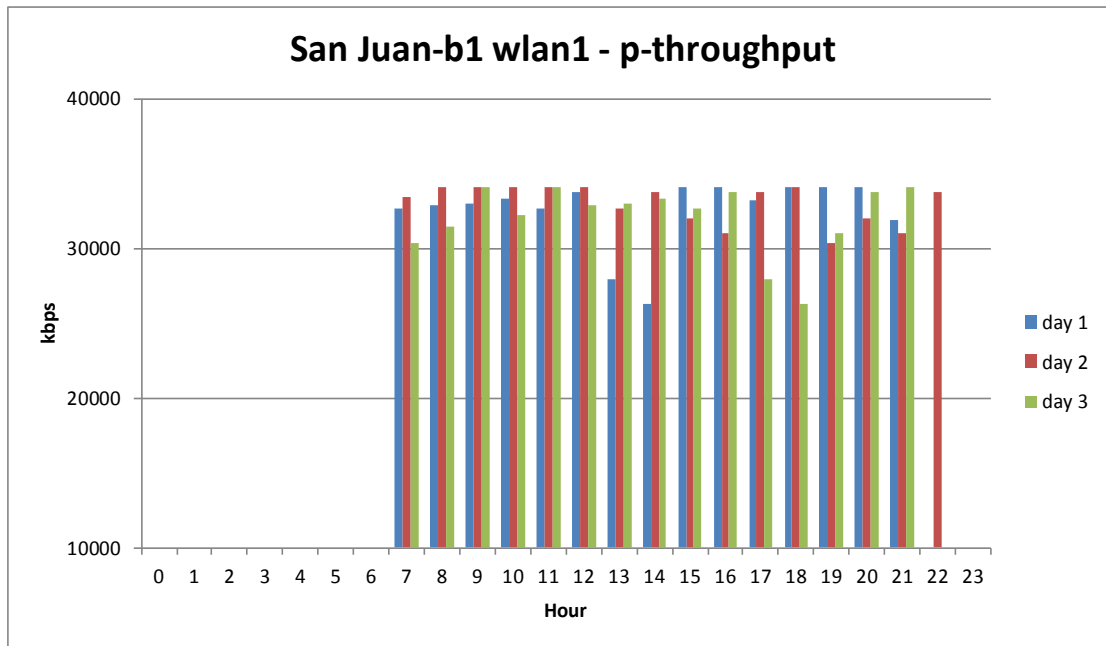
Figure 49: p-throughput measured 3 days before the maintenance and 3 days after the maintenance at the San Juan repeater
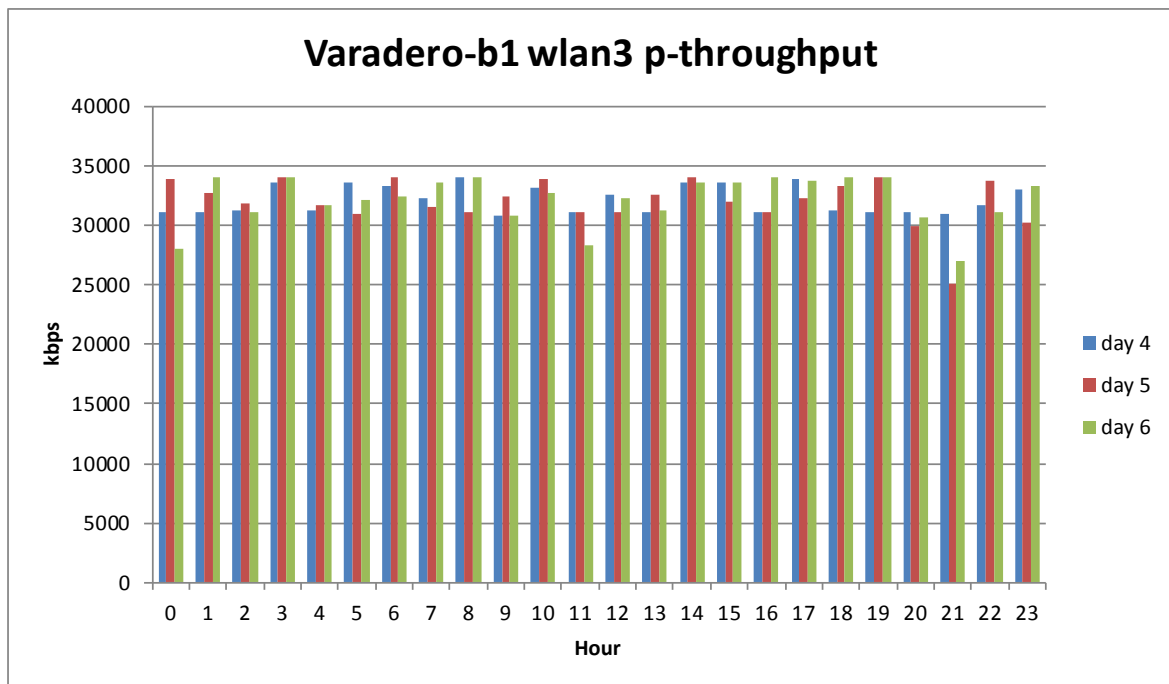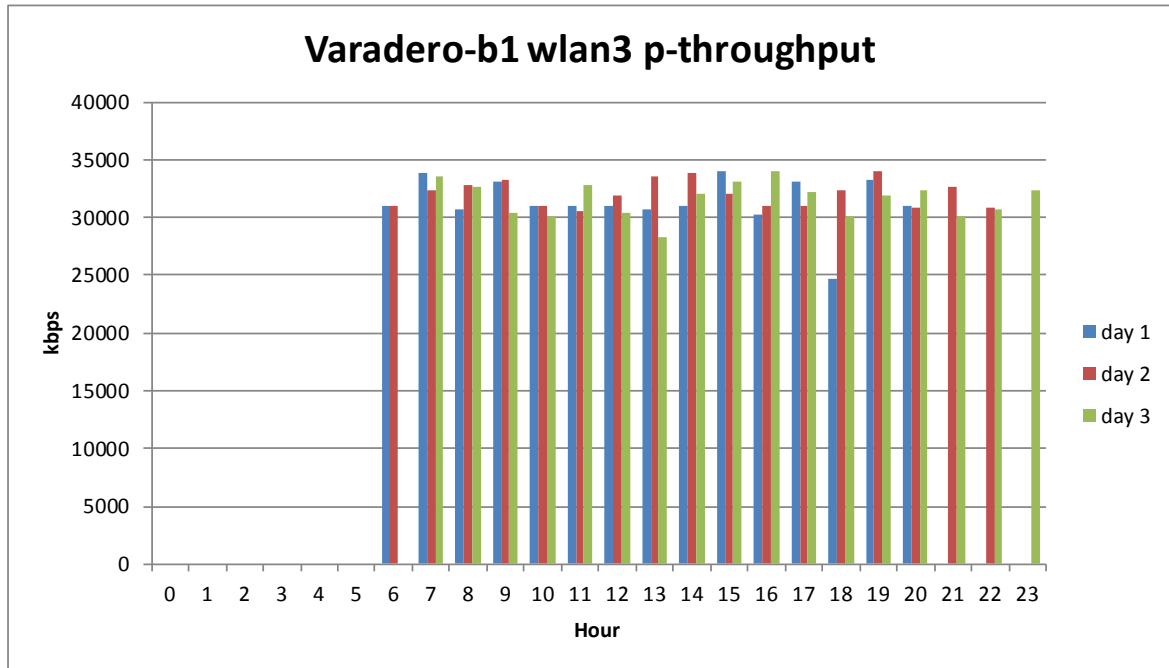
Figure 50: p-throughput measured 3 days before the maintenance and 3 days after the maintenance at the Varadero repeater

In Figure 51 it is shown that the received signal level in the link between the repeaters located at San Juan and Varadero is almost stable during the hours of operation of the network and has a value of around -65dBm.
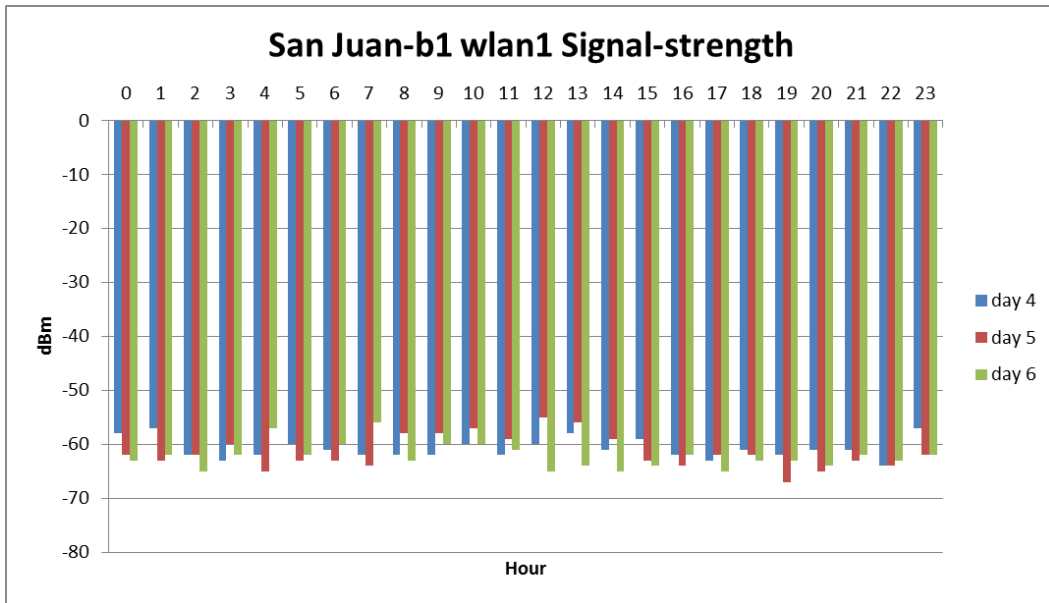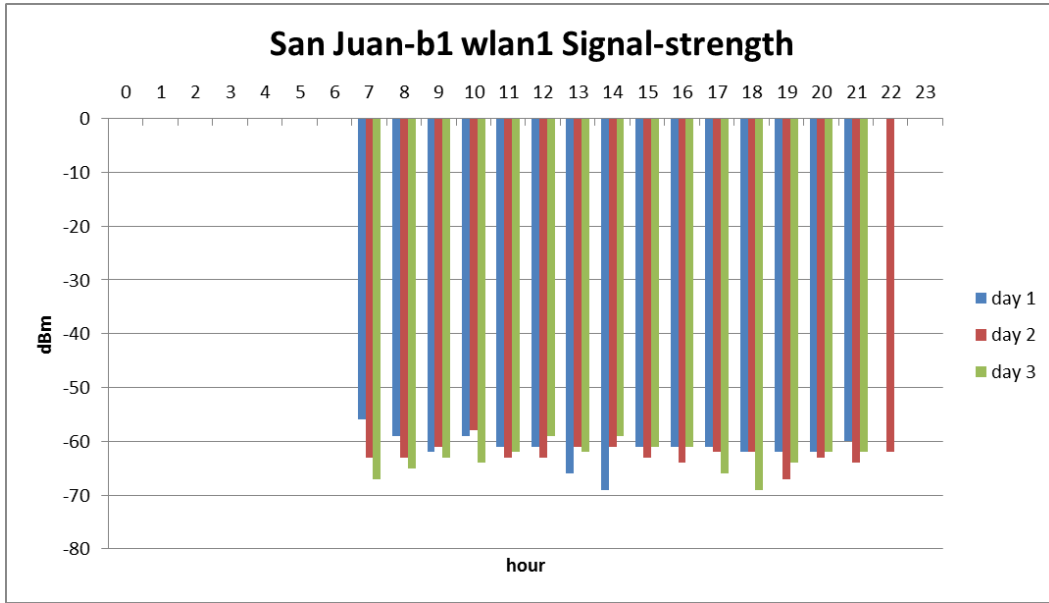
Figure 51: Signal-strength measured 3 days before the maintenance and 3 days after the maintenance at the San Juan repeater

4.2.1.2   IP addressing scheme
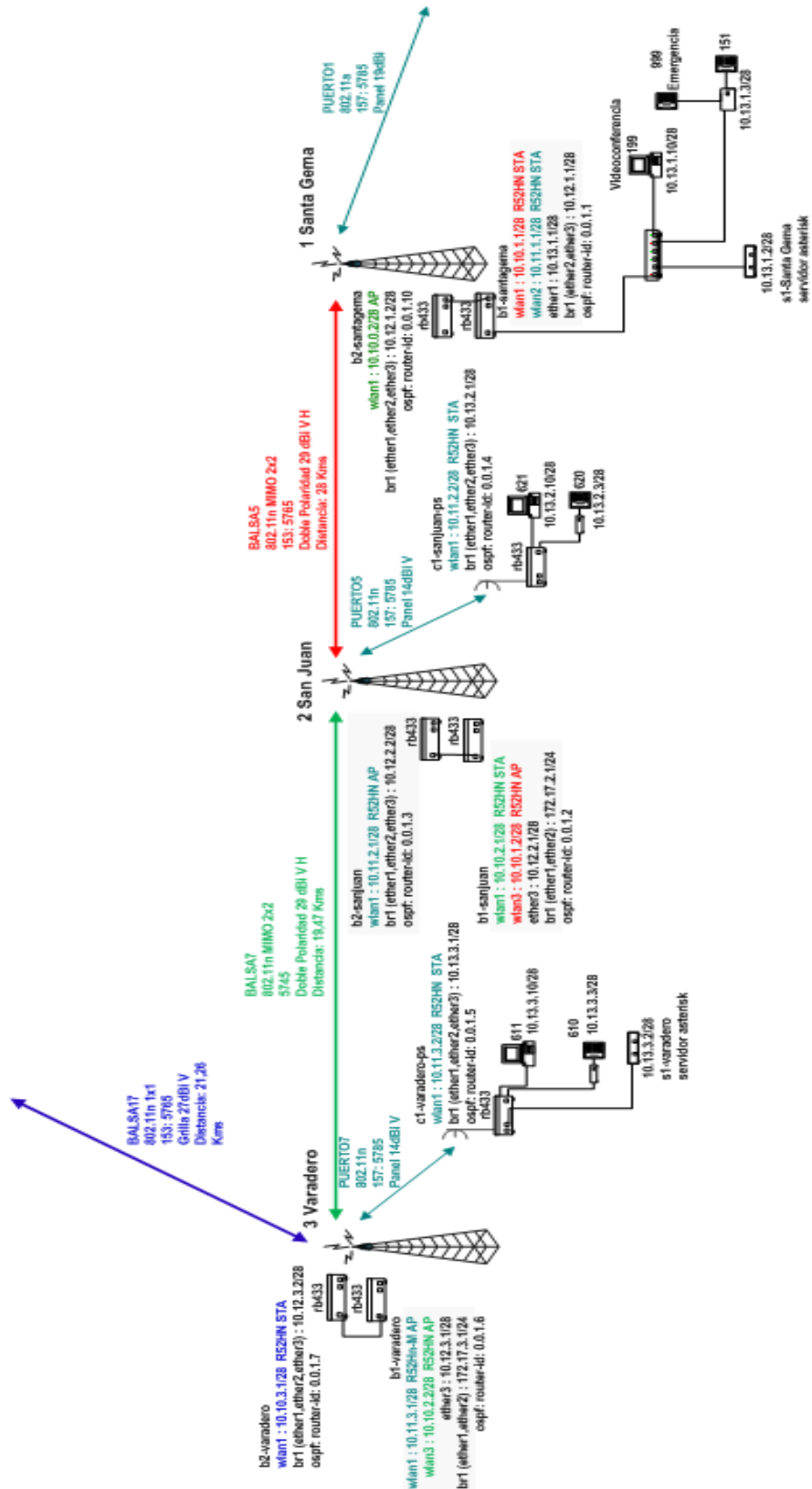
Figure 52: Scheme of the new IP addressing in Balsapuerto network

4.2.2 Field activities

The field activities had the participation of the manager of the telecommunications area of the Alto Amazonas Health Network, the participation of a tower technician and locally hired staff for support work.

4.2.2.1 *Yurimaguas*

The following activities were developed on Yurimaguas city, in Santa Gema Hospital.

- Preventive maintenance of the equipment used in the repeater located in the Santa Gema Yurimaguas Hospital (performance verification of the equipment, checking of the connections, checking of possible water leakages, voltage levels and cleaning).
- Configuration of the equipment according to the new IP addressing scheme
- Maintenance of the grounding system. The resistance of the grounding system was measured and the system was improved by lowering the resistance and adding a product called REDUGEL, which helps to obtain lower the resistance.
  - Initial resistance: 15 ohms.
  - Resistance after maintenance: 7.5 ohms.
- Testing of radio links. The tests consisted of verifying the new configuration (parameters of the radio link, IP addressing, routing tables) and measuring the signal level and bandwidth between the point-to-point links.

Figure 53: Upgrade of the grounding system and maintenance of the equipment used in the repeater located in Santa Gema Hospital

4.2.2.2 *San Juan de Armanayacu*

The following activities were developed on San Juan de Armanayacu community, travelling 1.5 hours by motocar from Yurimaguas.

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- Preventive maintenance of the equipment used in the repeater (performance verification of the equipment, checking of the connections, checking of possible water leakages, voltage levels and cleaning).
- Installation of a new bank of 2 batteries in the tower in order to increase the capacity and autonomy days of the power system
- Replacement of the R52Hn wireless card with the R52M-n card, which requires lower energy consumption for the communication with the client station.
- Configuration of the equipment according to the new IP addressing scheme
- Maintenance of the grounding system. The resistance of the grounding system was measured and the system was improved by lowering the resistance and adding a product called REDUGEL, which helps to obtain lower the resistance.
  - Initial resistance: 14 ohms.
  - Resistance after maintenance: 4.1 ohms.
- Testing of radio links. The tests consisted of verifying the new configuration (parameters of the radio link, IP addressing, routing tables) and measuring the signal level and bandwidth between the point-to-point links.

Figure 54: Upgrade of the grounding system and maintenance of the equipment used in the repeater located in Varadero

Figure 55: Maintenance of the equipment used in the repeater located in San Juan.

4.2.2.3   *San Gabriel de Varadero*

The following activities were developed on San Gabriel de Varadero community, travelling 1 hour by motocar and 3 hours by boat, from Yurimaguas:

- Preventive maintenance of the equipment used in the repeater (performance verification of the equipment, checking of the connections, checking of possible water leakages, voltage levels and cleaning).
- Correction of the tilt of the braced tower
- Installation of a new bank of 2 batteries in the tower in order to increase the capacity and autonomy days of the power system
- Replacement of the R52Hn wireless card with the R52M-n card, which requires lower energy consumption for the communication with the client station
- Configuration of the equipment according to the new IP addressing scheme
- Maintenance of the grounding system. The resistance of the grounding system was measured and the system was improved by lowering the resistance and adding a product called REDUGEL, which helps to obtain lower the resistance.
  - Initial resistance: 6 ohms.
  - Resistance after maintenance: 0.64 ohms.
- Testing of radio links. The tests consisted of verifying the new configuration (parameters of the radio link, IP addressing, routing tables) and measuring the signal level and bandwidth between the point-to-point links.

Figure 56: Upgrade of the grounding system and maintenance of the equipment used in the repeater located in San Gabriel de Varadero

4.2.2.4 *Balsapuerto*

This node is not part of the transmission system of the TUCAN3G project, but is part of the Telemedicine network and, since it was necessary to do changes in the IP addressing of the entire network, we proceeded to perform preventive and corrective maintenance.

The following activities were developed on Balsapuerto community, travelling 3 hours by boat, from San Gabrielde Varadero:

- Preventive maintenance of the equipment used in the repeater (performance verification of the equipment, checking of the connections, checking of possible water leakages, voltage levels and cleaning).
- Configuration of the equipment according to the new IP addressing scheme
- Maintenance of the grounding system. The resistance of the grounding system was measured and the system was improved by lowering the resistance and adding a product called REDUGEL, which helps to obtain lower the resistance. The soil is sandy and there is little moisture retention, which causes the resistance to be high. For this reason, it has been recommended to add water and salt periodically in order to keep the grounding system wet and lower the electrical resistance.
  - Initial resistance: 30 ohms.
  - Resistance after maintenance: 20 ohms.
- Testing of radio links. The tests consisted of verifying the new configuration (parameters of the radio link, IP addressing, routing tables) and measuring the signal level and bandwidth between the point-to-point links.

Figure 57: Maintenance of the equipment used in the repeater located in Balsapuerto.

5 NETWORK PERFORMANCE TESTS

Some tests were performed in order to measure the throughput between the trunk links.

As shown in Part 4, it was monitored the p-throughput parameter. This parameter is calculated by the Mikrotik router and, for that purpose, the Mikrotik routers were configured to send these values every hour.

On the other hand, a more realistic way of measuring the throughput available was performed using the Mikrotik bandwidth-test tool, which injects data traffic and indicates the available bandwidth. Since the networks were in operation, the result was the value of the bandwidth available at the time the measurements were made. The measurements using the bandwidth-test tool were performed manually and each measurement had a duration of 20 seconds.

The performance tests are shown in Annex 5: Performance tests after making changes in the Napo network.

5.1 Napo Network

The averages of the registered p-throughput values are shown in the following table:

	Tuta Pishco – Negro Urco	Negro Urco – Tacsha Curaray	Tacsha Curaray – Santa Clotilde
Distance (Km)	29.60	29.50	39.00
p-throughput (Mbps)	17.8	18.6	17.4

Table 15: Distance and p-throughput in the Napo wireless backhaul network

According to the deliverable D41, the bandwidth capacities required on the backhaul of the Napo network are:

Node	Uplink (kbps)	Downlink (kbps)	Total Uplink + Downlink (kbps)	Comments
Santa Clotilde	1144	2288	**3432**	Year 5, only data traffic
Negro Urco	685	1206	**1891**	Year 5
Tuta Pishco	698	1321	**2019**	Year 5
Total	2527	4815		

Table 16: Bandwidth capacities required for data traffic on the backhaul of the Napo network according to the deliverable D41

In order to validate whether the upgraded Napo network can handle the extra traffic required by the TUCAN 3G project, the throughput at full load (with proper network traffic) was measured on each of the nodes involved (Tuta Pishco, Negro Urco, Tacsha Curaray and Santa Clotilde). The throughput measurement was manually performed every hour, using the bandwidth-test tool, and the following results were obtained:

Figure 58: Measurement of the bandwidth available from Santa Clotilde using the bandwidth-test tool
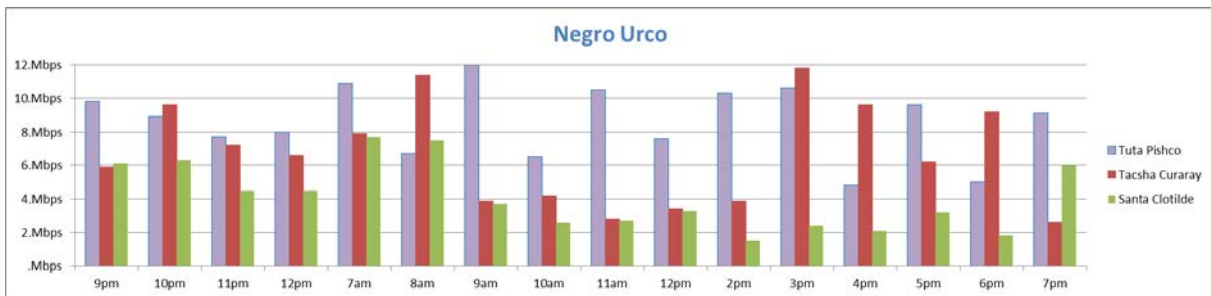
Figure 59: Measurement of the bandwidth available from Negro Urco using the bandwidth-test tool
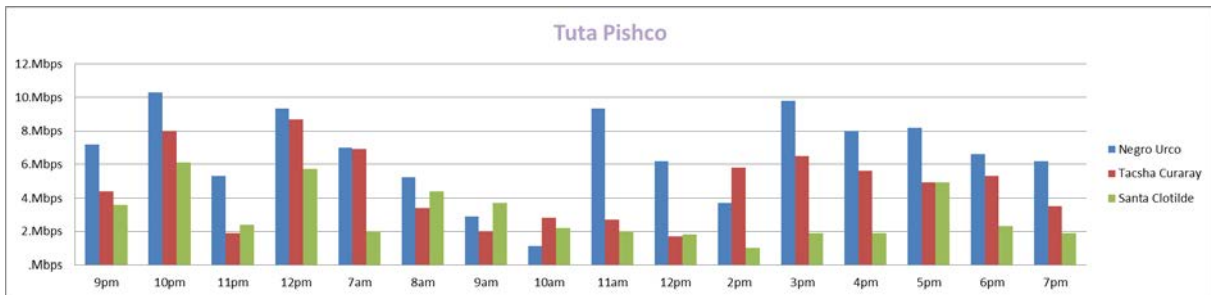
Figure 60: Measurement of the bandwidth available from Tuta Pishco using the bandwidth-test tool

According to the deliverable D41, a satellite access will be installed in Negro Urco, which will be shared among the femtocells that will be installed in Santa Clotilde, Negro Urco and Tuta Pischo. For that reason, it was necessary to know the available bandwidth between Negro Urco - Santa Clotilde and Negro Urco - Tuta Pischo. According to the results shown in the precedent graphics, we can note that the required bandwidths are not guaranteed for some cases and in others, there is a very small margin to ensure the availability of services to be implemented over broader time periods. Then it can be concluded that the upgraded Napo network would not cover the additional traffic demand required by the Tucan 3G project. Therefore, the initial hypothesis stated in the deliverable D21, regarding the need to implement a transport network parallel to the existing one, can be validated.

5.2   *Balsapuerto Network*

The performance tests were made on the transport network, in the following nodes of interest: Santa Gema Hospital, San Juan and San Gabriel de Varadero.

The average p-throughput values registered are shown in the following table:

57

	Varadero – San Juan	San Juan – Hospital Santa Gema
Distance (Km)	19.47	28.00
Throughput (Mbps)	32	48

Table 17: Distance and p-throughput in Balsapuerto wireless backhaul network

According to the deliverable D41, the bandwidth capacities required on the backhaul of the Balsapuerto network are:

Node	Uplink (kbps)	Downlink (kbps)	Total Uplink + Downlink (kbps)	Comments
Varadero	1049	2268.6	**3317.6**	Year 5
San Juan	427	775	**1202**	Year 5
Total	1476	3043.6	4519.6	

Table 18: Bandwidth capacities required for data traffic on the backhaul of the Balsapuerto network according to the deliverable D41 (for the TUCAN 3G project)

According to previous table, the total data traffic that would be generated in the nodes San Juan and Balsapuerto is 4519.6Kbps.

	Varadero – San Juan	San Juan - Santa Gema Hospital	Varadero - Santa Gema Hospital
Distance (Km)	19.47	28.00	
Throughput (Mbps)	30	45	27.9

Table 19: Bandwidth available on the Balsapuerto network measured with the bandwidth-test tool

According to Table 19, the available bandwidth from the node located in Santa Gema Hospital to the node in Varadero is 27.9Mbps, which satisfies the data traffic requirement for the TUCAN 3G project (4519.6 Kbps), as shown in Table 18. Therefore, there is bandwidth available in this network, which will be used on a shared basis, separating the data traffic from the telemedicine network and the traffic generated by the 3G femtocells that will be installed in Varadero and San Juan.

6 CONCLUSIONS AND RECOMENDATIONS

- The users of the services of the Napo Network have expressed their satisfaction with the improved quality of service in the teleservices.

- The new MikroTik equipment installed in the stations is allowing the researchers of the TUCAN 3G Project to have a real idea of the capabilities of this technology.

- After evaluating the new traffic that is being generated in the Napo Rural Telemedicine Network, the conclusion is that it is required to install a wireless network parallel to the existing one.

- With the increase in the power capacity in the repeaters at San Juan and San Gabriel de Varadero and the reduction in the power consumption because of the change of the wireless interfaces in the local links, it was possible to increase the autonomous time for running the equipment up to 3 days.

- The telecommunications network in Balsapuerto is operational and ready for the implementation of the TUCAN 3G project.

- For the connection of the Balsapuerto network to Telefonica's core network, it is recommended to connect its central station in Yurimaguas, located at 210 meters from the Santa Gema Yurimaguas Hospital, via a wireless link.

- It is recommended to evaluate the implementation of the radio links with the NV2 system and perform tests on the radio links. According to laboratory tests carried out in WP51, better results would be achieved this way.

- During the radio links tests, in the Santa Gema Hospital node it was detected another network operating in the same frequency band used for the link with San Juan. This could be a source of interference and, in order to minimize the risks, it is recommended to use another frequency band that has a lower risk of interference.

7 ANNEXES

Annex 1: Configuration of the equipment in the Balsapuerto network.

Annex 2: Performance tests in Balsapuerto network

Annex 3: Maintenance forms of the Napo network

Annex 4: Performance tests before making changes in the Napo network

Annex 5: Performance tests after making changes in the Napo network

Annex 6: Data sheets of the telecommunications equipment

Annex 1: Configuration of the equipment in the Balsapuerto network.

Annex 1 index:

1. YURIMAGUAS

1.1. Santa Gema repeater (tower)

Mikrotik Routerboard 433AH – Board 1 (Tower)

```
****************
* RouterOS 4.5 *
****************

Password
********
[admin@MikroTik] > password
*******


Board name
******************
[admin@MikroTik] > system identity set name=b1-santagema


Wireless interface
******************
[admin@b1-santagema] > interface wireless security-profiles add name=psk2-ieee

[admin@b1-santagema] > interface wireless security-profiles set psk2-ieee
authentication-types=wpa2-psk group-ciphers=aes-ccm unicast-ciphers=aes-ccm wpa2-
pre-shared-key=******* mode=dynamic-keys
[admin@b1-santagema] > interface wireless set wlan1 security-profile=psk2-ieee
[admin@b1-santagema] > interface wireless set wlan2 security-profile=psk2-ieee

[admin@b1-santagema] > interface wireless set wlan1 ack-timeout=dynamic band=5ghz-
onlyn frequency=5765 mode=station ssid=BALSA5 disable-running-check=yes rate-
set=configured tx-power=24 tx-power-mode=card-rates disabled=no ht-extension-
channel=disabled ht-guard-interval=any ht-basic-mcs=mcs-15 ht-supported-mcs=mcs-
0,mcs-1,mcs-2,mcs-3, mcs-4,mcs-5,mcs-6,mcs-7,mcs-8,mcs-9,mcs-10,mcs-11,mcs-12,mcs-
13,mcs-14,mcs-15 ht-txchains=0,1 ht-rxchains=0,1

[admin@b1-santagema] > interface wireless set wlan2 ack-timeout=dynamic antenna-
mode=ant-a band=5ghz frequency=5785 mode=ap-bridge ssid=PUERTO1 disable-running-
check=yes basic-rates-a/g=6Mbps supported-rates-a/g=6Mbps,9Mbps,12Mbps,18Mbps rate-
set=configured tx-power=25 tx-power-mode=card-rates disabled=no


IP addresses
**************
[admin@b1-santagema] > interface bridge add name=br1
[admin@b1-santagema] > interface bridge port add interface=ether2 bridge=br1
[admin@b1-santagema] > interface bridge port add interface=ether3 bridge=br1


[admin@b1-santagema] > ip address add address=10.10.1.1/28 interface=wlan1
[admin@b1-santagema] > ip address add address=10.11.1.1/28 interface=wlan2
[admin@b1-santagema] > ip address add address=10.13.1.1/28 interface=ether1
[admin@b1-santagema] > ip address add address=10.12.1.1/28 interface=br1


OSPF
****

[admin@b1-santagema] >routing ospf area set backbone area-id=0.0.0.0

[admin@b1-santagema] > routing ospf instance set router-id=0.0.1.1 metric-
default=10 metric-connected=10 metric-static=10 metric-rip=0 metric-bgp=0
```

```
redistribute-connected=as-type-1 redistribute-static=as-type-1 distribute-
default=if-installed-as-type-1 numbers=0

[admin@b1-santagema] > routing ospf network add network=10.10.1.0/28 area=backbone
[admin@b1-santagema] > routing ospf network add network=10.11.1.0/28 area=backbone

[admin@b1-santagema] > routing ospf interface add interface=wlan1 cost=10
[admin@b1-santagema] > routing ospf interface add interface=wlan2 cost=10
```

1.2. Client: Alto Amazonas Health Network

Mikrotik Routerboard 433

```
****************
* RouterOS 4.5 *
****************

Password
*********
[admin@MikroTik] > password
*******


Board name
******************
[admin@MikroTik] > system identity set name= c1-redsalud-yuri

Interface Wireless
******************
[admin@c1-redsalud-yuri] > interface wireless security-profiles add name=psk2-ieee

[admin@c1-redsalud-yuri] > interface wireless security-profiles set psk2-ieee
authentication-types=wpa2-psk group-ciphers=aes-ccm unicast-ciphers=aes-ccm wpa2-
pre-shared-key=******* mode=dynamic-keys
[admin@c1-redsalud-yuri] > interface wireless set wlan1 security-profile=psk2-ieee

[admin@c1-redsalud-yuri] > interface wireless set wlan1 ack-timeout=dynamic
antenna-mode=ant-a band=5ghz frequency=5785 mode=station ssid=PUERTO1 disable-
running-check=yes basic-rates-a/g=6Mbps supported-rates-
a/g=6Mbps,9Mbps,12Mbps,18Mbps rate-set=configured tx-power=17 tx-power-mode=card-
rates disabled=no


IP addresses
**************
[admin@c1-redsalud-yuri] > interface bridge add name=br1
[admin@c1-redsalud-yuri] > interface bridge port add interface=ether2 bridge=br1
[admin@c1-redsalud-yuri] > interface bridge port add interface=ether3 bridge=br1
[admin@c1-redsalud-yuri] > ip address add address=10.11.1.2/28 interface=wlan1
[admin@c1-redsalud-yuri] > ip address add address=192.168.1.2/24 interface=ether1
[admin@c1-redsalud-yuri] > ip address add address=10.13.0.1/28 interface=br1


OSPF
****
[admin@c1-redsalud-yuri] > routing ospf instance set router-id=0.0.1.0 metric-
default=10 metric-connected=10 metric-static=10 metric-rip=0 metric-bgp=0
redistribute-connected=as-type-1 redistribute-static=as-type-1 distribute-
default=always-as-type-1 numbers=0


[admin@c1-redsalud-yuri] > routing ospf area set backbone area-id=0.0.0.0
```

```
[admin@c1-redsalud-yuri] > routing ospf network add network=10.11.1.0/28
area=backbone

[admin@c1-redsalud-yuri] > routing ospf interface add interface=wlan1 cost=10


[admin@c1-redsalud-yuri] > ip route add gateway=192.168.1.1
```

2. SAN JUAN

2.1. San Juan repeater (Tower)

Mikrotik Routerboard 433AH – Board 1 (Tower)

```
****************
* RouterOS 4.5 *
****************

Password
********
[admin@MikroTik] > password
*******

Board name
******************
[admin@MikroTik] > system identity set name=b1-sanjuan


Wireless interface
******************
[admin@b1-sanjuan] > interface wireless security-profiles add name=psk2-ieee

[admin@b1-sanjuan] > interface wireless security-profiles set psk2-ieee
authentication-types=wpa2-psk group-ciphers=aes-ccm unicast-ciphers=aes-ccm wpa2-
pre-shared-key=******* mode=dynamic-keys
[admin@b1-sanjuan] > interface wireless set wlan1 security-profile=psk2-ieee
[admin@b1-sanjuan] > interface wireless set wlan3 security-profile=psk2-ieee

[admin@b1-sanjuan] > interface wireless set wlan1 ack-timeout=dynamic band=5ghz-
onlyn frequency=5825 mode=station ssid=BALSA7 disable-running-check=yes rate-
set=configured tx-power=24 tx-power-mode=card-rates disabled=no ht-extension-
channel=disabled ht-guard-interval=long ht-basic-mcs=mcs-8 ht-supported-mcs=mcs-
0,mcs-1,mcs-2,mcs-3, mcs-4,mcs-5,mcs-6,mcs-7,mcs-8 ht-txchains=0,1 ht-rxchains=0,1

[admin@b1-sanjuan] > interface wireless set wlan3 ack-timeout=dynamic band=5ghz-
onlyn frequency=5765 mode=ap-bridge ssid=BALSA5 disable-running-check=yes rate-
set=configured tx-power=24 tx-power-mode=card-rates disabled=no ht-extension-
channel=disabled ht-guard-interval=any ht-basic-mcs=mcs-15 ht-supported-mcs=mcs-
0,mcs-1,mcs-2,mcs-3, mcs-4,mcs-5,mcs-6,mcs-7,mcs-8,mcs-9,mcs-10,mcs-11,mcs-12,mcs-
13,mcs-14,mcs-15 ht-txchains=0,1 ht-rxchains=0,1


IP addresses
**************
[admin@b1-sanjuan] > interface bridge add name=br1
[admin@b1-sanjuan] > interface bridge port add interface=ether1 bridge=br1
[admin@b1-sanjuan] > interface bridge port add interface=ether2 bridge=br1


[admin@b1-sanjuan] > ip address add address=10.10.2.1/28 interface=wlan1
[admin@b1-sanjuan] > ip address add address=10.10.1.2/28 interface=wlan3
```

```
[admin@b1-sanjuan] > ip address add address=10.12.2.1/28 interface=ether3
[admin@b1-sanjuan] > ip address add address=172.17.2.1/24 interface=br1



OSPF
****
[admin@b1-sanjuan] > routing ospf instance set router-id=0.0.1.2 metric-default=10
metric-connected=10 metric-static=10 metric-rip=0 metric-bgp=0 redistribute-
connected=as-type-1 redistribute-static=as-type-1 distribute-default=if-installed-
as-type-1 numbers=0

[admin@b1-sanjuan] > routing ospf network add network=10.10.2.0/28 area=backbone
[admin@b1-sanjuan] > routing ospf network add network=10.10.1.0/28 area=backbone

[admin@b1-sanjuan] > routing ospf interface add interface=wlan1 cost=10
[admin@b1-sanjuan] > routing ospf interface add interface=wlan3 cost=10
```

Mikrotik Routerboard 433AH – Board 2 (Tower)

```
****************
* RouterOS 4.5 *
****************


Password
*********
[admin@MikroTik] > password
*******


Board name
******************
[admin@MikroTik] > system identity set name=b2-sanjuan


Wireless interface
******************
[admin@b2-sanjuan] > interface wireless security-profiles add name=psk2-ieee

[admin@b2-sanjuan] > interface wireless security-profiles set psk2-ieee
authentication-types=wpa2-psk group-ciphers=aes-ccm unicast-ciphers=aes-ccm wpa2-
pre-shared-key=******* mode=dynamic-keys
[admin@b2-sanjuan] >interface wireless set wlan1 security-profile=psk2-ieee

[admin@b2-sanjuan] > interface wireless set wlan1 ack-timeout=dynamic antenna-
mode=ant-a band=5ghz-onlyn frequency=5785 mode=ap-bridge ssid=PUERTO5 disable-
running-check=yes rate-set=configured tx-power=17 tx-power-mode=card-rates
disabled=no ht-extension-channel=disabled ht-guard-interval=long ht-basic-mcs=mcs-0
ht-supported-mcs=mcs-0,mcs-1,mcs-2,mcs-3


IP addresses
**************
[admin@b2-sanjuan] > interface bridge add name=br1
[admin@b2-sanjuan] > interface bridge port add interface=ether1 bridge=br1
[admin@b2-sanjuan] > interface bridge port add interface=ether2 bridge=br1
[admin@b2-sanjuan] > interface bridge port add interface=ether3 bridge=br1
[admin@b2-sanjuan] > ip address add address=10.11.2.1/28 interface=wlan1
[admin@b2-sanjuan] > ip address add address=10.12.2.2/28 interface=br1


OSPF
****
[admin@b2-sanjuan] > routing ospf instance set router-id=0.0.1.3 metric-default=10
metric-connected=10 metric-static=10 metric-rip=0 metric-bgp=0 redistribute-
```

```
connected=as-type-1 redistribute-static=as-type-1 distribute-default=if-installed-
as-type-1 numbers=0


[admin@b2-sanjuan] > routing ospf network add network=10.11.2.0/28 area=backbone
[admin@b2-sanjuan] > routing ospf network add network=10.12.2.0/28 area=backbone

[admin@b2-sanjuan] > routing ospf interface add interface=wlan1 cost=10
[admin@b2-sanjuan] > routing ospf interface add interface=br1 cost=10
```

2.2. Client: San Juan health post

Mikrotik Routerboard 433 – Board 1

```
****************
* RouterOS 4.5 *
****************

Password
********
[admin@MikroTik] > password
*******


Board name
******************
[admin@MikroTik] > system identity set name=c1-sanjuan-ps


Wireless interface
******************
[admin@c1-sanjuan-ps] > interface wireless security-profiles add name=psk2-ieee

[admin@c1-sanjuan-ps] > interface wireless security-profiles set psk2-ieee
authentication-types=wpa2-psk group-ciphers=aes-ccm unicast-ciphers=aes-ccm wpa2-
pre-shared-key=******* mode=dynamic-keys
[admin@c1-sanjuan-ps] >interface wireless set wlan1 security-profile=psk2-ieee

[admin@c1-sanjuan-ps] > interface wireless set wlan1 ack-timeout=dynamic antenna-
mode=ant-a band=5ghz-onlyn frequency=5785 mode=station ssid=PUERTO5 disable-
running-check=yes rate-set=configured tx-power=17 tx-power-mode=card-rates
disabled=no ht-extension-channel=disabled ht-guard-interval=long ht-basic-mcs=mcs-0
ht-supported-mcs=mcs-0,mcs-1,mcs-2,mcs-3


IP addresses
**************
[admin@c1-sanjuan-ps] > interface bridge add name=br1
[admin@c1-sanjuan-ps] > interface bridge port add interface=ether1 bridge=br1
[admin@c1-sanjuan-ps] > interface bridge port add interface=ether2 bridge=br1
[admin@c1-sanjuan-ps] > interface bridge port add interface=ether3 bridge=br1
[admin@c1-sanjuan-ps] > ip address add address=10.11.2.2/28 interface=wlan1
[admin@c1-sanjuan-ps] > ip address add address=10.13.2.1/28 interface=br1


OSPF
****
[admin@c1-sanjuan-ps] > routing ospf instance set router-id=0.0.1.4 metric-
default=10 metric-connected=10 metric-static=10 metric-rip=0 metric-bgp=0
redistribute-connected=as-type-1 redistribute-static=as-type-1 distribute-
default=if-installed-as-type-1 numbers=0


[admin@c1-sanjuan-ps] > routing ospf network add network=10.11.2.0/28 area=backbone
```

```
[admin@c1-sanjuan-ps] > routing ospf interface add interface=wlan1 cost=10
```

3. VARADERO

3.1. Varadero repeater (Tower)

Mikrotik Routerboard 433AH – Board 1

```
****************
* RouterOS 4.5 *
****************

Password
********
[admin@MikroTik] > password
*******


Board name
******************
[admin@MikroTik] > system identity set name=b1-varadero


Wireless interface
******************
[admin@b1-varadero] > interface wireless security-profiles add name=psk2-ieee

[admin@b1-varadero] > interface wireless security-profiles set psk2-ieee
authentication-types=wpa2-psk group-ciphers=aes-ccm unicast-ciphers=aes-ccm wpa2-
pre-shared-key=******* mode=dynamic-keys
[admin@b1-varadero] > interface wireless set wlan1 security-profile=psk2-ieee
[admin@b1-varadero] > interface wireless set wlan3 security-profile=psk2-ieee

[admin@b1-varadero] > interface wireless set wlan1 ack-timeout=dynamic antenna-
mode=ant-a band=5ghz-onlyn frequency=5765 mode=station ssid=BALSA17 disable-
running-check=yes rate-set=configured tx-power=24 tx-power-mode=card-rates
disabled=no ht-extension-channel=disabled ht-guard-interval=long ht-basic-mcs=mcs-0
ht-supported-mcs=mcs-0,mcs-1,mcs-2,mcs-3

[admin@b1-varadero] > interface wireless set wlan3 ack-timeout=dynamic band=5ghz-
onlyn frequency=5825 mode=ap-bridge ssid=BALSA7 disable-running-check=yes rate-
set=configured tx-power=24 tx-power-mode=card-rates disabled=no ht-extension-
channel=disabled ht-guard-interval=long ht-basic-mcs=mcs-8 ht-supported-mcs=mcs-
0,mcs-1,mcs-2,mcs-3, mcs-4,mcs-5,mcs-6,mcs-7,mcs-8 ht-txchains=0,1 ht-rxchains=0,1


IP addresses
**************
[admin@b1-varadero] > interface bridge add name=br1
[admin@b1-varadero] > interface bridge port add interface=ether1 bridge=br1
[admin@b1-varadero] > interface bridge port add interface=ether2 bridge=br1


[admin@b1-varadero] > ip address add address=10.11.3.1/28 interface=wlan1
[admin@b1-varadero] > ip address add address=10.10.2.2/28 interface=wlan3
[admin@b1-varadero] > ip address add address=10.12.3.1/28 interface=ether3
[admin@b1-varadero] > ip address add address=172.17.3.1/24 interface=br1


OSPF
****
```

```
[admin@b1-varadero] > routing ospf instance set router-id=0.0.1.6 metric-default=10
metric-connected=10 metric-static=10 metric-rip=0 metric-bgp=0 redistribute-
connected=as-type-1 redistribute-static=as-type-1 distribute-default=if-installed-
as-type-1 numbers=0

[admin@b1-varadero] > routing ospf network add network=10.11.3.0/28 area=backbone
[admin@b1-varadero] > routing ospf network add network=10.10.2.0/28 area=backbone


[admin@b1-varadero] > routing ospf interface add interface=wlan2 cost=10
[admin@b1-varadero] > routing ospf interface add interface=wlan3 cost=10
```


Mikrotik Routerboard 433AH – Board 2 (Tower)

```
****************
* RouterOS 4.5 *
****************


Password
*********
[admin@MikroTik] > password
*******


Board name
******************
[admin@MikroTik] > system identity set name=b2-varadero


Wireless interface
******************
[admin@b2-varadero] > interface wireless security-profiles add name=psk2-ieee

[admin@b2-varadero] > interface wireless security-profiles set psk2-ieee
authentication-types=wpa2-psk group-ciphers=aes-ccm unicast-ciphers=aes-ccm wpa2-
pre-shared-key=******* mode=dynamic-keys
[admin@b2-varadero] >interface wireless set wlan1 security-profile=psk2-ieee

[admin@b2-varadero] > interface wireless set wlan1 ack-timeout=dynamic antenna-
mode=ant-a band=5ghz-onlyn frequency=5785 mode=ap-bridge ssid=PUERTO7 disable-
running-check=yes rate-set=configured tx-power=17 tx-power-mode=card-rates
disabled=no ht-extension-channel=above-control ht-guard-interval=any ht-basic-
mcs=mcs-0 ht-supported-mcs=mcs-0,mcs-1,mcs-2,mcs-3


IP addresses
**************
[admin@b2-varadero] > interface bridge add name=br1
[admin@b2-varadero] > interface bridge port add interface=ether1 bridge=br1
[admin@b2-varadero] > interface bridge port add interface=ether2 bridge=br1
[admin@b2-varadero] > interface bridge port add interface=ether3 bridge=br1
[admin@b2-varadero] > ip address add address=10.10.3.1/28 interface=wlan1
[admin@b2-varadero] > ip address add address=10.12.3.2/28 interface=br1


OSPF
****
[admin@b2-varadero] > routing ospf instance set router-id=0.0.1.7 metric-default=10
metric-connected=10 metric-static=10 metric-rip=0 metric-bgp=0 redistribute-
connected=as-type-1 redistribute-static=as-type-1 distribute-default=if-installed-
as-type-1 numbers=0


[admin@b2-varadero] > routing ospf network add network=10.10.3.0/28 area=backbone
```

```
[admin@b2-varadero] > routing ospf network add network=10.12.3.0/28 area=backbone

[admin@b2-varadero] > routing ospf interface add interface=wlan1 cost=10
[admin@b2-varadero] > routing ospf interface add interface=br1 cost=10
```

3.2. Client: Varadero health post

Mikrotik Routerboard 433 –Board 1

```
<****************
* RouterOS 4.5 *
***************

Password
********
[admin@MikroTik] > password
*******


Board name
******************
[admin@MikroTik] > system identity set name=c1-varadero-ps


Wireless interface
******************
[admin@c1-varadero-ps] > interface wireless security-profiles add name=psk2-ieee

[admin@c1-varadero-ps] > interface wireless security-profiles set psk2-ieee
authentication-types=wpa2-psk group-ciphers=aes-ccm unicast-ciphers=aes-ccm wpa2-
pre-shared-key=****** mode=dynamic-keys
[admin@c1-varadero-ps] >interface wireless set wlan1 security-profile=psk2-ieee

[admin@c1-varadero-ps] > interface wireless set wlan1 ack-timeout=dynamic antenna-
mode=ant-a band=5ghz-onlyn frequency=5785 mode=station ssid=PUERTO7 disable-
running-check=yes rate-set=configured tx-power=17 tx-power-mode=card-rates
disabled=no ht-extension-channel=above-control ht-guard-interval=any ht-basic-
mcs=mcs-0 ht-supported-mcs=mcs-0,mcs-1,mcs-2,mcs-3

IP addresses
**************
[admin@c1-varadero-ps] > interface bridge add name=br1
[admin@c1-varadero-ps] > interface bridge port add interface=ether1 bridge=br1
[admin@c1-varadero-ps] > interface bridge port add interface=ether2 bridge=br1
[admin@c1-varadero-ps] > interface bridge port add interface=ether3 bridge=br1
[admin@c1-varadero-ps] > ip address add address=10.11.3.2/28 interface=wlan1
[admin@c1-varadero-ps] > ip address add address=10.13.3.1/28 interface=br1


OSPF
****
[admin@c1-varadero-ps] > routing ospf instance set router-id=0.0.1.5 metric-
default=10 metric-connected=10 metric-static=10 metric-rip=0 metric-bgp=0
redistribute-connected=as-type-1 redistribute-static=as-type-1 distribute-
default=if-installed-as-type-1 numbers=0


[admin@c1-varadero-ps] >routing ospf network add network=10.11.3.0/28 area=backbone

[admin@c1-varadero-ps] > routing ospf interface add interface=wlan1 cost=10
```

4. BALSAPUERTO

4.1. Balsapuerto repeater (Tower)

Mikrotik Routerboard 433AH – Board 1 (Tower)

```
****************
* RouterOS 4.5 *
****************

Password
********
[admin@MikroTik] > password
*******


Board name
******************
[admin@MikroTik] > system identity set name=b1-balsapuerto


Wireless interface
******************
[admin@b1-balsapuerto] > interface wireless security-profiles add name=psk2-ieee

[admin@b1-balsapuerto] > interface wireless security-profiles set psk2-ieee
authentication-types=wpa2-psk group-ciphers=aes-ccm unicast-ciphers=aes-ccm wpa2-
pre-shared-key=****** mode=dynamic-keys
[admin@b1-balsapuerto] > interface wireless set wlan1 security-profile=psk2-ieee
[admin@b1-balsapuerto] > interface wireless set wlan2 security-profile=psk2-ieee

[admin@b1-balsapuerto] > interface wireless set wlan1 ack-timeout=dynamic antenna-
mode=ant-a band=5ghz-onlyn frequency=5765 mode=ap-bridge ssid=BALSA17 disable-
running-check=yes rate-set=configured tx-power=24 tx-power-mode=card-rates
disabled=no ht-extension-channel=disabled ht-guard-interval=long ht-basic-mcs=mcs-0
ht-supported-mcs=mcs-0,mcs-1,mcs-2,mcs-3

[admin@b1-balsapuerto] > interface wireless set wlan2 ack-timeout=dynamic antenna-
mode=ant-a band=5ghz-onlyn frequency=5745 mode=ap-bridge ssid=PUERTO17 disable-
running-check=yes rate-set=configured tx-power=17 tx-power-mode=card-rates
disabled=no ht-extension-channel=disabled ht-guard-interval=long ht-basic-mcs=mcs-0
ht-supported-mcs=mcs-0,mcs-1,mcs-2,mcs-3


IP addresses
*************
[admin@b1-balsapuerto] > interface bridge add name=br1
[admin@b1-balsapuerto] > interface bridge port add interface=ether1 bridge=br1
[admin@b1-balsapuerto] > interface bridge port add interface=ether2 bridge=br1
[admin@b1-balsapuerto] > interface bridge port add interface=ether3 bridge=br1


[admin@b1-balsapuerto] > ip address add address=10.10.3.2/28 interface=wlan1
[admin@b1-balsapuerto] > ip address add address=10.11.4.1/28 interface=wlan2
[admin@b1-balsapuerto] > ip address add address=10.12.4.1/28 interface=br1


OSPF
****
[admin@b1-balsapuerto] > routing ospf instance set router-id=0.0.1.8 metric-
default=10 metric-connected=10 metric-static=10 metric-rip=0 metric-bgp=0
redistribute-connected=as-type-1 redistribute-static=as-type-1 distribute-
default=if-installed-as-type-1 numbers=0
```

```
[admin@b1-balsapuerto] > routing ospf network add network=10.10.3.0/28
area=backbone
[admin@b1-balsapuerto] > routing ospf network add network=10.11.4.0/28
area=backbone

[admin@b1-balsapuerto] > routing ospf interface add interface=wlan1 cost=10
[admin@b1-balsapuerto] > routing ospf interface add interface=wlan2 cost=10
```

4.2. Client: Balsapuerto health center

Mikrotik Routerboard 433

```
****************
* RouterOS 4.5 *
****************

Password
*********
[admin@MikroTik] > password
*******


Board name
******************
[admin@MikroTik] > system identity set name=c1-balsapuerto-ps


Wireless interface
******************
[admin@c1-balsapuerto-ps] > interface wireless security-profiles add name=psk2-ieee

[admin@c1-balsapuerto-ps] > interface wireless security-profiles set psk2-ieee
authentication-types=wpa2-psk group-ciphers=aes-ccm unicast-ciphers=aes-ccm wpa2-
pre-shared-key=******* mode=dynamic-keys
[admin@c1-balsapuerto-ps] > interface wireless set wlan1 security-profile=psk2-ieee

[admin@c1-balsapuerto-ps] > interface wireless set wlan1 ack-timeout=dynamic
antenna-mode=ant-a band=5ghz-onlyn frequency=5745 mode=station ssid=PUERTO17
disable-running-check=yes rate-set=configured tx-power=17 tx-power-mode=card-rates
disabled=no ht-extension-channel=disabled ht-guard-interval=long ht-basic-mcs=mcs-0
ht-supported-mcs=mcs-0,mcs-1,mcs-2,mcs-3


IP addresses
**************
[admin@c1-balsapuerto-ps] > interface bridge add name=br1
[admin@c1-balsapuerto-ps] > interface bridge port add interface=ether1 bridge=br1
[admin@c1-balsapuerto-ps] > interface bridge port add interface=ether2 bridge=br1
[admin@c1-balsapuerto-ps] > interface bridge port add interface=ether3 bridge=br1
[admin@c1-balsapuerto-ps] > ip address add address=10.11.4.2/28 interface=wlan1
[admin@c1-balsapuerto-ps] > ip address add address=10.13.4.1/28 interface=br1


OSPF
****
[admin@c1-balsapuerto-ps] > routing ospf instance set router-id=0.0.1.9 metric-
default=10 metric-connected=10 metric-static=10 metric-rip=0 metric-bgp=0
redistribute-connected=as-type-1 redistribute-static=as-type-1 distribute-
default=always-as-type-1 numbers=0


[admin@c1-balsapuerto-ps] > routing ospf network add network=10.11.4.0/28
area=backbone

[admin@c1-balsapuerto-ps] > routing ospf interface add interface=wlan1 cost=10
```

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Annex 2: Performance tests in Balsapuerto network

Tests from the command line of the router located at the repeater in Santa Gema Hospital

```
     a.  Verification of the IP addresses assigned to the interfaces
[admin@b1-santagema] > ip address print

Flags: X - disabled, I - invalid, D - dynamic
 #   ADDRESS              NETWORK         BROADCAST        INTERFACE
 0   10.10.1.1/28         10.10.1.0       10.10.1.15       wlan1
 1   10.11.1.1/28         10.11.1.0       10.11.1.15       wlan2
 2   10.12.1.1/28         10.12.1.0       10.12.1.15       br1
 3   10.13.1.1/28         10.13.1.0       10.13.1.15       ether1


     b.  Verification of routing tables
[admin@b1-santagema] > ip route print

Flags: X - disabled, A - active, D - dynamic, C - connect, S - static, r -
rip, b - bgp, o - ospf, m - mme,
B - blackhole, U - unreachable, P - prohibit
 #      DST-ADDRESS          PREF-SRC         GATEWAY             DISTANCE
 0 A S  0.0.0.0/0                             10.11.1.2           1
 1 ADC  10.10.1.0/28         10.10.1.1        wlan1               0
 2 ADo  10.10.2.0/28                          10.10.1.2           110
 3 ADo  10.10.3.0/28                          10.10.1.2           110
 4 ADC  10.11.1.0/28         10.11.1.1        wlan2               0
 5 ADo  10.11.2.0/28                          10.10.1.2           110
 6 ADo  10.11.3.0/28                          10.10.1.2           110
 7 ADC  10.12.1.0/28         10.12.1.1        br1                 0
 8 ADo  10.12.2.0/28                          10.10.1.2           110
 9 ADo  10.12.3.0/28                          10.10.1.2           110
10 ADo  10.13.0.0/28                          10.11.1.2           110
11 ADC  10.13.1.0/28         10.13.1.1        ether1              0
12 ADo  10.13.3.0/28                          10.10.1.2           110
13 ADo  172.17.2.0/24                         10.10.1.2           110
14 ADo  172.17.3.0/24                         10.10.1.2           110
15 ADo  192.168.1.0/24                        10.11.1.2           110


     c.  Verification of dynamic routing
[admin@b1-santagema] > routing ospf route print
# DST-ADDRESS           STATE           COST        GATEWAY          INTERFACE
 0 0.0.0.0/0            imported-ext-1 10
 1 10.10.1.0/28         intra-area      10          0.0.0.0          wlan1
 2 10.10.2.0/28         intra-area      20          10.10.1.2        wlan1
 3 10.10.3.0/28         intra-area      40          10.10.1.2        wlan1
 4 10.11.1.0/28         intra-area      10          0.0.0.0          wlan2
 5 10.11.2.0/28         intra-area      30          10.10.1.2        wlan1
 6 10.11.3.0/28         intra-area      30          10.10.1.2        wlan1
 7 10.12.1.0/28         imported-ext-1 10
 8 10.12.2.0/28         intra-area      20          10.10.1.2        wlan1
 9 10.12.3.0/28         intra-area      30          10.10.1.2        wlan1
10 10.13.0.0/28         ext-1           20          10.11.1.2        wlan2
11 10.13.1.0/28         imported-ext-1 10
12 10.13.3.0/28         intra-area      40          10.10.1.2        wlan1
13 172.17.2.0/24        ext-1           20          10.10.1.2        wlan1
14 172.17.3.0/24        ext-1           30          10.10.1.2        wlan1
```

```
15 192.168.1.0/24      ext-1             20            10.11.1.2       wlan2
```

[admin@b1-santagema] > *routing ospf instance print*

```
Flags: X - disabled
 0   name="default" router-id=0.0.1.1 distribute-default=if-installed-as-
     type-1 redistribute-connected=as-type-1 redistribute-static=as-type-1
     redistribute-rip=no redistribute-bgp=no redistribute-other-ospf=no
     metric-default=10 metric-connected=10 metric-static=10 metric-rip=0
     metric-bgp=0 metric-other-ospf=auto in-filter=ospf-in out-filter=ospf-
     out
```

    d. Verification of the configuration parameters of the wireless interfaces

[admin@b1-santagema] > *interface wireless print advanced detail*

```
Flags: X - disabled, R - running
0      R name="wlan1" mtu=1500 mac-address=00:0C:42:64:60:03 arp=enabled
       disable-running-check=yes interface-type=Atheros 11>
       radio-name="StaGema-SanJuan" mode=station ssid="BALSA5" area=""
       frequency-mode=manual-txpower country=no_country_set antenna-gain=0
       frequency=5765 band=5ghz-onlyn scan-list=default rate-set=configured
       supported-rates-b=1Mbps,2Mbps,5.5Mbps,11Mbps
       supported-rates-a/g=6Mbps,9Mbps,12Mbps,18Mbps,24Mbps,36Mbps,48Mbps
       54Mbps basic-rates-b=1Mbps basic-rates-a/g=6Mbps max-station-
       count=2007 ack-timeout=dynamic tx-power=24 tx-power-mode=card-rates
       periodic-calibration=default periodic-calibration-interval=60
       dfs-mode=none wds-mode=disabled wds-default-bridge=none
       wds-default-cost=100 wds-cost-range=50-150 wds-ignore-ssid=no
       update-stats-interval=disabled default-authentication=yes
       default-forwarding=yes default-ap-tx-limit=0
       default-client-tx-limit=0 proprietary-extensions=post-2.9.25
       wmm-support=disabled hide-ssid=no security-profile=default
       disconnect-timeout=3s on-fail-retry-time=100ms preamble-mode=both
       compression=no allow-sharedkey=no station-bridge-clone-
       mac=00:00:00:00:00:00 ht-ampdu-priorities=0 ht-guard-interval=any
       ht-extension-channel=disabled ht-supported-mcs=mcs-0,mcs-1,mcs-2,
       mcs-3,mcs-4,mcs-5,mcs-6,mcs-7,mcs-8,mcs-9,mcs-10,mcs-11,mcs-12,
       mcs-13,mcs-14,mcs-15 ht-basic-mcs=mcs-15 ht-txchains=0,1
       ht-rxchains=0,1 ht-amsdu-limit=8192 ht-amsdu-threshold=8192
       hw-retries=4 frame-lifetime=0 adaptive-noise-immunity=none
       hw-fragmentation-threshold=disabled hw-protection-mode=none
       hw-protection-threshold=0 frequency-offset=0

 1     R name="wlan2" mtu=1500 mac-address=00:0C:42:64:59:62 arp=enabled
       disable-running-check=yes interface-type=Atheros 11>
       radio-name="StaGema-RdS" mode=ap-bridge ssid="PUERTO1" area=""
       frequency-mode=manual-txpower country=no_country_set antenna-gain=0
       frequency=5785 band=5ghz scan-list=default rate-set=configured
       supported-rates-b=1Mbps,2Mbps,5.5Mbps,11Mbps
       supported-rates-a/g=6Mbps,9Mbps,12Mbps,18Mbps basic-rates-b=1Mbps
       basic-rates-a/g=6Mbps max-station-count=2007 ack-timeout=dynamic
       tx-power=25 tx-power-mode=card-rates periodic-calibration=default
       periodic-calibration-interval=60 dfs-mode=none wds-mode=disabled
       wds-default-bridge=none wds-default-cost=100 wds-cost-range=50-150
       wds-ignore-ssid=no update-stats-interval=disabled
       default-authentication=yes default-forwarding=yes default-ap-tx-
       limit=0
       default-client-tx-limit=0 proprietary-extensions=post-2.9.25
       wmm-support=disabled hide-ssid=no security-profile=psk2-ieee
       disconnect-timeout=3s on-fail-retry-time=100ms preamble-mode=both
```

```
        compression=no allow-sharedkey=no
        station-bridge-clone-mac=00:00:00:00:00:00 ht-ampdu-priorities=0
        ht-guard-interval=any ht-extension-channel=disabled
        ht-supported-mcs=mcs-0,mcs-1,mcs-2,mcs-3,mcs-4,mcs-5,mcs-6,mcs-7,
        mcs-8,mcs-9,mcs-10,mcs-11,mcs-12,mcs-13,mcs-14,mcs-15
        ht-basic-mcs=mcs-0,mcs-1,mcs-2,mcs-3,mcs-4,mcs-5,mcs-6,mcs-7
        ht-txchains=0 ht-rxchains=0 ht-amsdu-limit=8192
        ht-amsdu-threshold=8192 hw-retries=4 frame-lifetime=0
        adaptive-noise-immunity=none hw-fragmentation-threshold=disabled
        hw-protection-mode=none hw-protection-threshold=0 frequency-offset=0
```

e. Verification of the stations connected to the Access Point

[admin@b1-santagema] > *interface wireless registration-table print*

```
# INTERFACE       RADIO-NAME       MAC-ADDRESS       AP  SIGNAL-STRENGTH TX-RATE
UPTIME
 0 wlan1          SanJuan-StaGema  00:0C:42:64:5F:F9 yes -64dBm@6Mbps     104....
10m46s
 1 wlan2          RdS-StaGema      00:0C:42:1F:80:36 no  -77dBm@18Mbps    18Mbps
3m57s
```

f. Verification of the received signal level (only possible when the interface is in "STATION" mode)

[admin@b1-santagema] > *interface wireless monitor wlan1*

```
                  status: connected-to-ess
                    band: 5ghz-11n
               frequency: 5765MHz
                 tx-rate: "117.0Mbps-HT"
                 rx-rate: "6Mbps"
                    ssid: "BALSA5"
                   bssid: 00:0C:42:64:5F:F9
              radio-name: "SanJuan-StaGema"
         signal-strength: -64dBm
      tx-signal-strength: -65dBm
             noise-floor: -106dBm
         signal-to-noise: 42dB
                  tx-ccq: 75%
                  rx-ccq: 78%
            p-throughput: 89362
          overall-tx-ccq: 75%
    authenticated-clients: 1
      current-ack-timeout: 408
                wds-link: no
                 nstreme: no
            framing-mode: none
         routeros-version: "4.11"
                 last-ip: 10.13.3.2
      802.1x-port-enabled: yes
             compression: no
             wmm-enabled: yes
        current-tx-powers:
6Mbps:24(24/27),9Mbps:22(22/25),12Mbps:22(22/25),18Mbps:22(22/25),24Mbps:22
(22/25),
```

g. Measurement of bandwidth in the link with San Juan repeater, with a duration of 20 seconds
[admin@b1-santagema] > *tool bandwidth-test address=10.10.1.2 duration=20*

```
                status: done testing
              duration: 20s
            rx-current: 65.3Mbps
  rx-10-second-average: 62.5Mbps
      rx-total-average: 51.0Mbps
          lost-packets: 157
           random-data: no
             direction: receive
               rx-size: 1500
```

h. Measurement of bandwidth in the link with Varadero repeater, with a duration of 20 seconds
[admin@b1-santagema] > *tool bandwidth-test address=10.10.2.2 duration=20*

```
status: done testing
              duration: 20s
            rx-current: 28.1Mbps
  rx-10-second-average: 28.7Mbps
      rx-total-average: 27.9Mbps
          lost-packets: 79
           random-data: no
             direction: receive
               rx-size: 1500
```

Tests from the command line of the router located at San Juan repeater

a. Verification of the IP addresses assigned to the interfaces
[admin@b1-sanjuan] > *ip address print*

```
Flags: X - disabled, I - invalid, D - dynamic
 #   ADDRESS            NETWORK          BROADCAST        INTERFACE
 0   172.17.2.1/24      172.17.2.0       172.17.2.255     br1
 1   10.10.2.1/28       10.10.2.0        10.10.2.15       wlan1
 2   10.10.1.2/28       10.10.1.0        10.10.1.15       wlan3
 3   10.12.2.1/28       10.12.2.0        10.12.2.15       ether3
```

b. Verification of routing tables
[admin@b1-sanjuan] > *ip route print*

```
Flags: X - disabled, A - active, D - dynamic,
C - connect, S - static, r - rip, b - bgp, o - ospf, m - mme,
B - blackhole, U - unreachable, P - prohibit
 #      DST-ADDRESS       PREF-SRC         GATEWAY            DISTANCE
 0   S  0.0.0.0/0                          20.20.5.2          1
 1 ADo  0.0.0.0/0                          10.10.1.1          110
 2 ADC  10.10.1.0/28      10.10.1.2        wlan3              0
 3 ADC  10.10.2.0/28      10.10.2.1        wlan1              0
 4 ADo  10.10.3.0/28                       10.10.2.2          110
 5 ADo  10.11.1.0/28                       10.10.1.1          110
 6 ADo  10.11.2.0/28                       10.12.2.2          110
 7 ADo  10.11.3.0/28                       10.10.2.2          110
```

```
 8 ADo  10.12.1.0/28                          10.10.1.1        110
 9 ADC  10.12.2.0/28         10.12.2.1        ether3           0
10 ADo  10.12.3.0/28                          10.10.2.2        110
11 ADo  10.13.0.0/28                          10.10.1.1        110
12 ADo  10.13.1.0/28                          10.10.1.1        110
13 ADo  10.13.3.0/28                          10.10.2.2        110
14 ADC  172.17.2.0/24        172.17.2.1       br1              0
15 ADo  172.17.3.0/24                         10.10.2.2        110
16 ADo  192.168.1.0/24                        10.10.1.1        110
```

    c.   Verification of dynamic routing

[admin@b1-sanjuan] > *routing ospf route print*

```
# DST-ADDRESS          STATE          COST    GATEWAY         INTERFACE
 0 0.0.0.0/0            ext-1          30      10.10.1.1       wlan3
 1 10.10.1.0/28         intra-area     10      0.0.0.0         wlan3
 2 10.10.2.0/28         intra-area     10      0.0.0.0         wlan1
 3 10.10.3.0/28         intra-area     30      10.10.2.2       wlan1
 4 10.11.1.0/28         intra-area     20      10.10.1.1       wlan3
 5 10.11.2.0/28         intra-area     20      10.12.2.2       ether3
 6 10.11.3.0/28         intra-area     20      10.10.2.2       wlan1
 7 10.12.1.0/28         ext-1          20      10.10.1.1       wlan3
 8 10.12.2.0/28         intra-area     10      0.0.0.0         ether3
 9 10.12.3.0/28         intra-area     20      10.10.2.2       wlan1
10 10.13.0.0/28         ext-1          30      10.10.1.1       wlan3
11 10.13.1.0/28         ext-1          20      10.10.1.1       wlan3
12 10.13.3.0/28         intra-area     30      10.10.2.2       wlan1
13 172.17.2.0/24        imported-ext-1 10
14 172.17.3.0/24        ext-1          20      10.10.2.2       wlan1
15 192.168.1.0/24       ext-1          30      10.10.1.1       wlan3
```

[admin@b1-sanjuan] > *routing ospf instance print*

```
Flags: X - disabled
 0   name="default" router-id=0.0.1.2
     distribute-default=if-installed-as-type-1
     redistribute-connected=as-type-1 redistribute-static=as-type-1
     redistribute-rip=no redistribute-bgp=no redistribute-other-ospf=no
     metric-default=10 metric-connected=10 metric-static=10 metric-rip=0
     metric-bgp=0 metric-other-ospf=auto in-filter=ospf-in
     out-filter=ospf-out
```

    d.   Verification of the configuration parameters of the wireless interfaces

[admin@b1-sanjuan] > *interface wireless print advanced detail*

```
Flags: X - disabled, R - running
 0  R name="wlan1" mtu=1500 mac-address=00:0C:42:64:59:6B arp=enabled
     disable-running-check=yes interface-type=Atheros 11N
     radio-name="SanJuan-Varadero" mode=station ssid="BALSA7" area=""
     frequency-mode=manual-txpower country=no_country_set antenna-gain=0
     frequency=5825 band=5ghz-onlyn scan-list=default rate-set=configured
     supported-rates-b=1Mbps,2Mbps,5.5Mbps,11Mbps
     supported-rates-a/g=6Mbps,9Mbps,12Mbps,18Mbps,24Mbps,36Mbps,48Mbps,
                         54Mbps
     basic-rates-b=1Mbps basic-rates-a/g=6Mbps max-station-count=2007
     ack-timeout=dynamic tx-power=24 tx-power-mode=card-rates
     periodic-calibration=default periodic-calibration-interval=60
```

```
        dfs-mode=none wds-mode=disabled wds-default-bridge=none
        wds-default-cost=100 wds-cost-range=50-150 wds-ignore-ssid=no
        update-stats-interval=disabled default-authentication=yes
        default-forwarding=yes default-ap-tx-limit=0 default-client-tx-
limit=0
        proprietary-extensions=post-2.9.25 wmm-support=disabled hide-ssid=no
        security-profile=default disconnect-timeout=3s
        on-fail-retry-time=100ms preamble-mode=both compression=no
        allow-sharedkey=no station-bridge-clone-mac=00:00:00:00:00:00
        ht-ampdu-priorities=0 ht-guard-interval=any
        ht-extension-channel=disabled
        ht-supported-mcs=mcs-0,mcs-1,mcs-2,mcs-3,mcs-4,mcs-5,mcs-6,mcs-7,mcs-
8,
        mcs-9,mcs-10,mcs-11,mcs-12,mcs-13,mcs-14,mcs-15
        ht-basic-mcs=mcs-15 ht-txchains=0,1 ht-rxchains=0,1
        ht-amsdu-limit=8192 ht-amsdu-threshold=8192 hw-retries=4
        frame-lifetime=0 adaptive-noise-immunity=none
        hw-fragmentation-threshold=disabled hw-protection-mode=none
        hw-protection-threshold=0 frequency-offset=0

 1  R name="wlan3" mtu=1500 mac-address=00:0C:42:64:5F:F9 arp=enabled
        disable-running-check=yes interface-type=Atheros 11N
        radio-name="SanJuan-StaGema" mode=ap-bridge ssid="BALSA5" area=""
        frequency-mode=manual-txpower country=no_country_set antenna-gain=0
        frequency=5765 band=5ghz-onlyn scan-list=default rate-set=configured
        supported-rates-b=1Mbps,2Mbps,5.5Mbps,11Mbps
        supported-rates-a/g=6Mbps,9Mbps,12Mbps,18Mbps,24Mbps,36Mbps,48Mbps,
                       54Mbps
        basic-rates-b=1Mbps basic-rates-a/g=6Mbps max-station-count=2007
        ack-timeout=dynamic tx-power=24 tx-power-mode=card-rates
        periodic-calibration=default periodic-calibration-interval=60
        dfs-mode=none wds-mode=disabled wds-default-bridge=none
        wds-default-cost=100 wds-cost-range=50-150 wds-ignore-ssid=no
        update-stats-interval=disabled default-authentication=yes
        default-forwarding=yes default-ap-tx-limit=0 default-client-tx-
limit=0
        proprietary-extensions=post-2.9.25 wmm-support=disabled hide-ssid=no
        security-profile=default disconnect-timeout=3s
        on-fail-retry-time=100ms preamble-mode=both compression=no
        allow-sharedkey=no station-bridge-clone-mac=00:00:00:00:00:00
        ht-ampdu-priorities=0 ht-guard-interval=any
        ht-extension-channel=disabled
        ht-supported-mcs=mcs-0,mcs-1,mcs-2,mcs-3,mcs-4,mcs-5,mcs-6,mcs-7,mcs-
8,
                       mcs-9,mcs-10,mcs-11,mcs-12,mcs-13,mcs-14,mcs-15
        ht-basic-mcs=mcs-15 ht-txchains=0,1 ht-rxchains=0,1
        ht-amsdu-limit=8192 ht-amsdu-threshold=8192 hw-retries=4
        frame-lifetime=0 adaptive-noise-immunity=none
        hw-fragmentation-threshold=disabled hw-protection-mode=none
        hw-protection-threshold=0 frequency-offset=0
```

   e.   Verification of the stations connected to the Access Point

[admin@b1-sanjuan] > *interface wireless registration-table print*

```
# INTERFACE          RADIO-NAME        MAC-ADDRESS        AP  SIGNAL... TX-RATE
 0 wlan1              000C4264591D      00:0C:42:64:59:1D yes -62dBm...
65.0...
 1 wlan3              StaGema-SanJuan   00:0C:42:64:60:03 no  -73dBm...
117....
```

    f.   Verification of the received signal level (only possible when the interface is in "STATION" mode)

[admin@b1-sanjuan] > *interface wireless monitor wlan1*

```
                    status: connected-to-ess
                      band: 5ghz-11n
                 frequency: 5825MHz
                   tx-rate: "65.0Mbps-HT"
                   rx-rate: "6Mbps"
                      ssid: "BALSA7"
                     bssid: 00:0C:42:64:59:1D
                radio-name: "000C4264591D"
           signal-strength: -62dBm
        tx-signal-strength: -62dBm
               noise-floor: -120dBm
           signal-to-noise: 58dB
                    tx-ccq: 87%
                    rx-ccq: 86%
              p-throughput: 56751
             overall-tx-ccq: 87%
      authenticated-clients: 1
        current-ack-timeout: 150
                   wds-link: no
                    nstreme: no
               framing-mode: none
           routeros-version: "4.11"
```

    g.   Measurement of bandwidth in the link with Varadero repeater, with a duration of 20 seconds

[admin@b1-sanjuan] > *tool bandwidth-test address=10.10.2.2 duration=20*

```
                    status: done testing
                  duration: 20s
                rx-current: 43.7Mbps
        rx-10-second-average: 44.2Mbps
           rx-total-average: 38.4Mbps
               lost-packets: 20
                random-data: no
                  direction: receive
                    rx-size: 1500
```

Tests from the command line of the router located at Varadero repeater

    a.   Verification of the IP addresses assigned to the interfaces

[admin@b1-varadero] > *ip address print*

```
Flags: X - disabled, I - invalid, D - dynamic
 #   ADDRESS             NETWORK         BROADCAST        INTERFACE
 0   172.17.3.1/24       172.17.3.0      172.17.3.255     br1
 1   10.11.3.1/28        10.11.3.0       10.11.3.15       wlan1
 2   10.10.2.2/28        10.10.2.0       10.10.2.15       wlan3
 3   10.12.3.1/28        10.12.3.0       10.12.3.15       ether3
```

    b.   Verification of routing tables

[admin@b1-varadero] > *ip route print*

```
Flags: X - disabled, A - active, D - dynamic, C - connect, S - static, r -
rip, b - bgp, o - ospf, m - mme,
B - blackhole, U - unreachable, P - prohibit
 #      DST-ADDRESS          PREF-SRC          GATEWAY              DISTANCE
 0   S  0.0.0.0/0                              20.20.7.2            1
 1 ADo  0.0.0.0/0                              10.10.2.1            110
 2 ADo  10.10.1.0/28                           10.10.2.1            110
 3 ADC  10.10.2.0/28         10.10.2.2         wlan3                0
 4 ADo  10.10.3.0/28                           10.12.3.2            110
 5 ADo  10.11.1.0/28                           10.10.2.1            110
 6 ADo  10.11.2.0/28                           10.10.2.1            110
 7 ADC  10.11.3.0/28         10.11.3.1         wlan1                0
 8 ADo  10.12.1.0/28                           10.10.2.1            110
 9 ADo  10.12.2.0/28                           10.10.2.1            110
10 ADC  10.12.3.0/28         10.12.3.1         ether3               0
11 ADo  10.13.0.0/28                           10.10.2.1            110
12 ADo  10.13.1.0/28                           10.10.2.1            110
13 ADo  10.13.3.0/28                           10.11.3.2            110
14 ADo  172.17.2.0/24                          10.10.2.1            110
15 ADC  172.17.3.0/24        172.17.3.1        br1                  0
16 ADo  192.168.1.0/24                         10.10.2.1            110
```

    c.   Verification of dynamic routing

[admin@b1-varadero] > *routing ospf route print*

```
# DST-ADDRESS           STATE            COST           GATEWAY           INTERFACE
 0 0.0.0.0/0            ext-1            40             10.10.2.1         wlan3
 1 10.10.1.0/28         intra-area      20             10.10.2.1         wlan3
 2 10.10.2.0/28         intra-area      10             0.0.0.0           wlan3
 3 10.10.3.0/28         intra-area      20             10.12.3.2         ether3
 4 10.11.1.0/28         intra-area      30             10.10.2.1         wlan3
 5 10.11.2.0/28         intra-area      30             10.10.2.1         wlan3
 6 10.11.3.0/28         intra-area      10             0.0.0.0           wlan1
 7 10.12.1.0/28         ext-1           30             10.10.2.1         wlan3
 8 10.12.2.0/28         intra-area      20             10.10.2.1         wlan3
 9 10.12.3.0/28         intra-area      10             0.0.0.0           ether3
10 10.13.0.0/28         ext-1           40             10.10.2.1         wlan3
11 10.13.1.0/28         ext-1           30             10.10.2.1         wlan3
12 10.13.3.0/28         intra-area      20             10.11.3.2         wlan1
13 172.17.2.0/24        ext-1           20             10.10.2.1         wlan3
14 172.17.3.0/24        imported-ext-1 10
15 192.168.1.0/24       ext-1           40             10.10.2.1         wlan3
```

[admin@b1-varadero] > *routing ospf instance print*

```
Flags: X - disabled
name="default"  router-id=0.0.1.6  distribute-default=if-installed-as-type-1
redistribute-connected=as-type-1               redistribute-static=as-type-1
redistribute-rip=no  redistribute-bgp=no  redistribute-other-ospf=no  metric-
default=10 metric-connected=10 metric-static=10 metric-rip=0 metric-bgp=0
metric-other-ospf=auto in-filter=ospf-in out-filter=ospf-out
```

    d.   Verification of the configuration parameters of the wireless interfaces

[admin@b1-varadero] > *interface wireless print advanced detail*

```
Flags: X - disabled, R - running
 0     R name="wlan3" mtu=1500 mac-address=00:0C:42:64:59:1D arp=enabled
       disable-running-check=yes interface-type=Atheros 11N
       radio-name="000C4264591D" mode=ap-bridge ssid="BALSA7" area=""
```

```
           frequency-mode=manual-txpower country=no_country_set
           antenna-gain=0 frequency=5825 band=5ghz-onlyn scan-list=default
           rate-set=configured supported-rates-b=1Mbps,2Mbps,5.5Mbps,11Mbps
           supported-rates-a/g=6Mbps,9Mbps,12Mbps,18Mbps,24Mbps,36Mbps,48Mbps,
           54Mbps basic-rates-b=1Mbps basic-rates-a/g=6Mbps max-station-
           count=2007 ack-timeout=dynamic tx-power=24 tx-power-mode=card-rates
           periodic-calibration=default periodic-calibration-interval=60
           dfs-mode=none wds-mode=disabled wds-default-bridge=none
           wds-default-cost=100 wds-cost-range=50-150 wds-ignore-ssid=no
           update-stats-interval=disabled default-authentication=yes
           default-forwarding=yes default-ap-tx-limit=0 default-client-tx-
           limit=0 proprietary-extensions=post-2.9.25 wmm-support=disabled hide-
           ssid=no security-profile=default disconnect-timeout=3s on-fail-retry-
           time=100ms
           preamble-mode=both compression=no allow-sharedkey=no
           station-bridge-clone-mac=00:00:00:00:00:00 ht-ampdu-priorities=0 ht-
           guard-interval=any ht-extension-channel=disabled
           ht-supported-mcs=mcs-0,mcs-1,mcs-2,mcs-3,mcs-4,mcs-5,mcs-6,mcs-7,mcs-
           8 ht-basic-mcs=mcs-8 ht-txchains=0,1 ht-rxchains=0,1 ht-amsdu-
           limit=8192 ht-amsdu-threshold=8192 hw-retries=4 frame-lifetime=0
           adaptive-noise-immunity=none hw-fragmentation-threshold=disabled
           hw-protection-mode=none hw-protection-threshold=0 frequency-offset=0

 1     R name="wlan1" mtu=1500 mac-address=00:0C:42:6C:44:35 arp=enabled
           disable-running-check=yes interface-type=Atheros 11N
           radio-name="000C426C4435" mode=ap-bridge ssid="PUERTO7" area=""
           frequency-mode=manual-txpower country=no_country_set antenna-gain=0
           frequency=5765 band=5ghz-onlyn scan-list=default rate-set=configured
           supported-rates-b=1Mbps,2Mbps,5.5Mbps,11Mbps
           supported-rates-a/g=6Mbps,9Mbps,12Mbps,18Mbps,24Mbps,36Mbps,48Mbps,
           54Mbps basic-rates-b=1Mbps basic-rates-a/g=6Mbps
           max-station-count=2007 ack-timeout=dynamic tx-power=17
           tx-power-mode=card-rates periodic-calibration=default
           periodic-calibration-interval=60 dfs-mode=none wds-mode=disabled
           wds-default-bridge=none wds-default-cost=100
           wds-cost-range=50-150 wds-ignore-ssid=no
           update-stats-interval=disabled default-authentication=yes
           default-forwarding=yes default-ap-tx-limit=0 default-client-tx-
           limit=0 proprietary-extensions=post-2.9.25 wmm-support=disabled hide-
           ssid=no security-profile=psk2-ieee disconnect-timeout=3s
           on-fail-retry-time=100ms preamble-mode=both compression=no
           allow-sharedkey=no station-bridge-clone-mac=00:00:00:00:00:00
           ht-ampdu-priorities=0 ht-guard-interval=any
           ht-extension-channel=above-control ht-supported-mcs=mcs-0,mcs-1,
           mcs-2,mcs-3 ht-basic-mcs=mcs-0 ht-txchains=0 ht-rxchains=0
           ht-amsdu-limit=8192 ht-amsdu-threshold=8192 hw-retries=4
           frame-lifetime=0 adaptive-noise-immunity=none
           hw-fragmentation-threshold=disabled hw-protection-mode=none
           hw-protection-threshold=0 frequency-offset=0
```

e. Verification of the stations connected to the Access Point
[admin@b1-varadero] > *interface wireless registration-table print*

```
# INTERFACE      RADIO-NAME       MAC-ADDRESS        AP  SIGNAL-STRENGTH TX-RATE
UPTIME
 0 wlan1         000C42645969     00:0C:42:64:59:69  no  -72dBm@6Mbps      40.5...
25m24s
 1 wlan3         SanJuan-Varadero 00:0C:42:64:59:6B  no  -71dBm@HT20-7     58.5...
23m47s
```

f. Measurement of bandwidth in the link with the repeater located at Santa Gema Hospital, with a duration of 20 seconds

[admin@b1-varadero] > ***tool bandwidth-test address=10.11.1.1 duration=20***

```
[admin@b1-varadero] > tool bandwidth-test address=10.11.1.1 duration=20
                status: done testing
              duration: 20s
            rx-current: 28.9Mbps
  rx-10-second-average: 27.6Mbps
      rx-total-average: 27.9Mbps
          lost-packets: 54
           random-data: no
             direction: receive
               rx-size: 1500
```

g. Measurement of bandwidth in the link with San Juan repeater, with a duration of 20 seconds

[admin@b1-varadero] > ***tool bandwidth-test address=10.10.2.1 duration=20***

```
status: done testing
              duration: 20s
            rx-current: 51.5Mbps
  rx-10-second-average: 50.0Mbps
      rx-total-average: 42.5Mbps
          lost-packets: 54
           random-data: no
             direction: receive
               rx-size: 1500
```

Annex 3: Maintenance forms of the Napo network

Maintenance format of repeater station - Tuta Pishco

Description		Condition	Comments
Battery	Status	Good	1 unit of 12Vdc
	Voltage (Vdc)	13.15	
	Condition of the connection plugs	OK	Cleaning was done
	Greased connection plugs	OK	
Controller	Condition	OK	Operational
	Tight connections	OK	Each connection was verified
	Connectors in good condition	OK	
	Screws are complete	OK	
	Type of selected battery	OK	Gel
	Panel voltage (Vdc)	13.17	
	Battery voltage (Vdc)	13.15	
	Load voltage (Vdc)	13.14	
Panel stand	Condition of the stand	OK	
	Condition of the bolts	OK	The tightness of each bolt was verified
Solar modules	Condition	OK	Operational
	Tilt angle	OK	
	Tight cable glands	OK	Checked one by one
	Tight bolts	OK	Checked one by one
	Tight connections	OK	Each connection was verified
	Panels without obstruction	OK	Cleaning was done
	Power wiring	OK	
	Open circuit voltage (V)	19.23	Sunny day
Grounding system	Condition	Good	Maintenance was done in the well
	Type of soil	Clayey	
	Measurement of the grounding system (Ω)	10.00	Digital tellurometer
	Lightning rod	OK	The 4 pointed terminals were tight
	Line protector	OK	Altelicom N-female N-male
	Tower grounding	OK	Requires changing the 8AWG cable
Antennas	Grid for MikroTik 2.4GHz	OK	Horizontal polarization 24dBi
	Grid for MikroTik 2.4GHz	OK	Vertical polarization 24dBi
	Panel for Alix 2.4GHz	OK	Vertical polarization 14dBi
	Coaxial cables and connectors	OK	Checked one by one
Electrical box	Condition	Average	Corrosion in the bottom corners
	Tight connection plugs	OK	Checked one by one
	Condition of grounding	OK	
MikroTiK router	Condition	New	
	Wireless cards (2 units)	New	
	Cable de alimentación	OK	
	Condition of the RJ45 connectors	OK	Patch cord was changed
	Pigtails (2 unidades)	New	MMCX - N-female
	Coaxial cable and connectors	OK	
ALIX router	Condition	OK	
	Wireless cards (1 unit)	OK	
	CF Memory	OK	SanDisk Extreme III 2GB
	Power cable	OK	

Description		Condition	Comments
	Condition of RJ45 connectors	OK	
	Pigtail (1 unit)	OK	UFL - N-female
	Coaxial cable and connectors	OK	
Infrastructure of the tower	Condition	OK	Requires painting and maintenance

Maintenance format of repeater station - Negro Urco

Description		Condition	Comments
Battery	Status	Good	1 unit of 12Vdc
	Voltage (Vdc)	13.00	
	Condition of the connection plugs	OK	Cleaning was done
	Greased connection plugs	OK	
Controller	Condition	OK	Operational
	Tight connections	OK	Each connection was verified
	Connectors in good condition	OK	
	Screws are complete	OK	
	Type of selected battery	OK	Gel
	Panel voltage (Vdc)	13.03	
	Battery voltage (Vdc)	13.00	
	Load voltage (Vdc)	12.92	
Panel stand	Condition of the stand	OK	
	Condition of the bolts	OK	The tightness of each bolt was verified
Solar modules	Condition	OK	Operational
	Tilt angle	OK	
	Tight cable glands	OK	Checked one by one
	Tight bolts	OK	Checked one by one
	Tight connections	OK	Each connection was verified
	Panels without obstruction	OK	Cleaning was done
	Power wiring	OK	
	Open circuit voltage (V)	18.89	Partially cloudy day
Grounding system	Condition	Good	Maintenance was done in the well
	Type of soil	Clayey	
	Measurement of the grounding system (Ω)	9.89	Digital tellurometer
	Lightning rod	OK	The 4 pointed terminals were tight
	Line protector	OK	Altelicom N-female N-male
	Tower grounding	OK	Requires changing the 8AWG cable
Antennas	Grid for MikroTik 2.4GHz	OK	Horizontal polarization 24dBi
	Grid for MikroTik 2.4GHz	OK	Vertical polarization 24dBi
	Panel for Alix 2.4GHz	OK	Vertical polarization 14dBi
	Coaxial cables and connectors	OK	Checked one by one
Electrical box	Condition	OK	Does not have considerable corrosion
	Tight connection plugs	OK	Checked one by one
	Condition of grounding	OK	
MikroTiK router	Condition	New	
	Wireless cards (2 units)	New	
	Cable de alimentación	OK	
	Condition of the RJ45 connectors	OK	Patch cord was changed
	Pigtails (2 unidades)	New	MMCX - N-female
	Coaxial cable and connectors	OK	
ALIX router	Condition	OK	
	Wireless cards (1 unit)	OK	

	CF Memory	OK	SanDisk Extreme III 2GB
	Power cable	OK	
	Condition of RJ45 connectors	OK	
	Pigtail (1 unit)	OK	UFL - N-female
	Coaxial cable and connectors	OK	
Infrastructure of the tower	Condition	OK	Requires painting and maintenance

Maintenance format of repeater station - Tacsha Curaray

	Description	Condition	Comments
Battery	Status	Good	1 unit of 12Vdc
	Voltage (Vdc)	13.10	
	Condition of the connection plugs	OK	Cleaning was done
	Greased connection plugs	OK	
Controller	Condition	OK	Operational
	Tight connections	OK	Each connection was verified
	Connectors in good condition	OK	
	Screws are complete	OK	
	Type of selected battery	OK	Gel
	Panel voltage (Vdc)	13.12	
	Battery voltage (Vdc)	13.10	
	Load voltage (Vdc)	13.10	
Panel stand	Condition of the stand	OK	
	Condition of the bolts	OK	The tightness of each bolt was verified
Solar modules	Condition	OK	Operational
	Tilt angle	OK	
	Tight cable glands	OK	Checked one by one
	Tight bolts	OK	Checked one by one
	Tight connections	OK	Each connection was verified
	Panels without obstruction	OK	Cleaning was done
	Power wiring	OK	
	Open circuit voltage (V)	18.95	Partially cloudy day
Grounding system	Condition	Good	Maintenance was done in the well
	Type of soil	Clayey	
	Measurement of the grounding system (Ω)	9.58	Digital tellurometer
	Lightning rod	OK	The 4 pointed terminals were tight
	Line protector	OK	Altelicom N-female N-male
	Tower grounding	OK	Requires changing the 8AWG cable
Antennas	Grid for MikroTik 2.4GHz	OK	Horizontal polarization 24dBi
	Grid for MikroTik 2.4GHz	OK	Vertical polarization 24dBi
	Panel for Alix 2.4GHz	OK	Vertical polarization 14dBi
	Coaxial cables and connectors	OK	Checked one by one
Electrical box	Condition	OK	Does not have considerable corrosion
	Tight connection plugs	OK	Checked one by one
	Condition of grounding	OK	
MikroTiK router	Condition	New	
	Wireless cards (2 units)	New	
	Cable de alimentación	OK	
	Condition of the RJ45 connectors	OK	Patch cord was changed
	Pigtails (2 unidades)	New	MMCX - N-hembra

Description		Condition	Comments
	Coaxial cable and connectors	OK	
ALIX router	Condition	OK	
	Wireless cards (1 unit)	OK	
	CF Memory	OK	SanDisk Extreme III 2GB
	Power cable	OK	
	Condition of RJ45 connectors	OK	
	Pigtail (1 unit)	OK	UFL - N-female
	Coaxial cable and connectors	OK	
Infrastructure of the tower	Condition	OK	Requires painting and maintenance

Maintenance format of repeater station – Santa Clotilde

Description		Condition	Comments
Battery	Status	Good	1 unit of 12Vdc
	Voltage (Vdc)	13.45	
	Condition of the connection plugs	OK	Cleaning was done
	Greased connection plugs	OK	
Controller	Condition	OK	Operational
	Tight connections	OK	Each connection was verified
	Connectors in good condition	OK	
	Screws are complete	OK	
	Type of selected battery	OK	Gel
	Panel voltage (Vdc)	13.47	
	Battery voltage (Vdc)	13.45	
	Load voltage (Vdc)	13.44	
Panel stand	Condition of the stand	OK	
	Condition of the bolts	OK	The tightness of each bolt was verified
Solar modules	Condition	OK	Operational
	Tilt angle	OK	
	Tight cable glands	OK	Checked one by one
	Tight bolts	OK	Checked one by one
	Tight connections	OK	Each connection was verified
	Panels without obstruction	OK	Cleaning was done
	Power wiring	OK	
	Open circuit voltage (V)	19.25	Sunny day
Grounding system	Condition	Good	Maintenance was done in the well
	Type of soil	Clayey	
	Measurement of the grounding system (Ω)	8.30	Digital tellurometer
	Lightning rod	OK	The 4 pointed terminals were tight
	Line protector	OK	Altelicom N-female N-male
	Tower grounding	OK	Requires changing the 8AWG cable
Antennas	Grid for MikroTik 2.4GHz	OK	Horizontal polarization 24dBi
	Grid for MikroTik 2.4GHz	OK	Vertical polarization 24dBi
	Panel for Alix 2.4GHz	OK	Vertical polarization 14dBi
	Coaxial cables and connectors	OK	Checked one by one
Electrical box	Condition	OK	Does not have considerable corrosion
	Tight connection plugs	OK	Checked one by one
	Condition of grounding	OK	
MikroTiK router	Condition	New	
	Wireless cards (2 units)	New	
	Cable de alimentación	OK	

	Condition of the RJ45 connectors	OK	Patch cord was changed
	Pigtails (2 unidades)	New	MMCX - N-hembra
	Coaxial cable and connectors	OK	
ALIX router	Condition	OK	
	Wireless cards (1 unit)	OK	
	CF Memory	OK	SanDisk Extreme III 2GB
	Power cable	OK	
	Condition of RJ45 connectors	OK	
	Pigtail (1 unit)	OK	UFL - N-female
	Coaxial cable and connectors	OK	
Infrastructure of the tower	Condition	OK	Requires painting and maintenance

Maintenance format of client station - Tuta Pishco

	Description	**Condition**	**Comments**
Battery	Status	Good	2 units of 12Vdc
	Voltage (Vdc)	12.95	
	Condition of the connection plugs	OK	Cleaning was done
	Greased connection plugs	OK	
Controller	Condition	OK	Operational
	Tight connections	OK	Each connection was verified
	Connectors in good condition	OK	
	Screws are complete	OK	
	Type of selected battery	OK	Gel
	Panel voltage (Vdc)	12.93	
	Battery voltage (Vdc)	12.95	
	Load voltage (Vdc)	12.90	
Panel stand	Condition of the stand	OK	
	Condition of the bolts	OK	The tightness of each bolt was verified
Solar modules	Condition	OK	Operational
	Tilt angle	OK	
	Tight cable glands	OK	Checked one by one
	Tight bolts	OK	Checked one by one
	Tight connections	OK	Each connection was verified
	Panels without obstruction	OK	Cleaning was done
	Power wiring	OK	
	Open circuit voltage (V)	19.15	Sunny day
Grounding system	Condition	Good	Maintenance was done in the well
	Type of soil	Clayey	
	Measurement of the grounding system (Ω)	9.98	Digital tellurometer
	Line protector	OK	Altelicom N-female N-male
Antennas	Panel for Alix 2.4GHz	OK	Vertical polarization 14dBi
	Coaxial cables and connectors	OK	Checked one by one
Electrical box	Condition	OK	
	Tight connection plugs	OK	Checked one by one
	Condition of grounding	OK	
ALIX router	Condition	OK	
	Wireless cards (1 unit)	OK	
	CF Memory	OK	SanDisk Extreme III 2GB
	Power cable	OK	

Description	Condition	Comments
Condition of RJ45 connectors	OK	
Pigtail (1 unit)	OK	UFL - N-female
Coaxial cable and connectors	OK	

Maintenance format of client station - Negro Urco

	Description	Condition	Comments
Battery	Status	Good	2 unitss of 12Vdc
	Voltage (Vdc)	13.12	
	Condition of the connection plugs	OK	Cleaning was done
	Greased connection plugs	OK	
Controller	Condition	OK	Operational
	Tight connections	OK	Each connection was verified
	Connectors in good condition	OK	
	Screws are complete	OK	
	Type of selected battery	OK	Gel
	Panel voltage (Vdc)	13.14	
	Battery voltage (Vdc)	13.12	
	Load voltage (Vdc)	13.11	
Panel stand	Condition of the stand	OK	
	Condition of the bolts	OK	The tightness of each bolt was verified
Solar modules	Condition	OK	Operational
	Tilt angle	OK	
	Tight cable glands	OK	Checked one by one
	Tight bolts	OK	Checked one by one
	Tight connections	OK	Each connection was verified
	Panels without obstruction	OK	Cleaning was done
	Power wiring	OK	
	Open circuit voltage (V)	18.95	Partially cloudy day
Grounding system	Condition	Good	Maintenance was done in the well
	Type of soil	Clayey	
	Measurement of the grounding system (Ω)	9.90	Digital tellurometer
	Line protector	OK	Altelicom N-female N-male
Antennas	Panel for Alix 2.4GHz	OK	Vertical polarization 14dBi
	Coaxial cables and connectors	OK	Checked one by one
Electrical box	Condition	OK	
	Tight connection plugs	OK	Checked one by one
	Condition of grounding	OK	
ALIX router	Condition	OK	
	Wireless cards (1 unit)	OK	
	CF Memory	OK	SanDisk Extreme III 2GB
	Power cable	OK	
	Condition of RJ45 connectors	OK	
	Pigtail (1 unit)	OK	UFL - N-female
	Coaxial cable and connectors	OK	

Maintenance format of client station - Tacsha Curaray

Description		Condition	Comments
Battery	Status	Good	2 units of 12Vdc
	Voltage (Vdc)	12.97	
	Condition of the connection plugs	OK	Cleaning was done
	Greased connection plugs	OK	
Controller	Condition	OK	Operational
	Tight connections	OK	Each connection was verified
	Connectors in good condition	OK	
	Screws are complete	OK	
	Type of selected battery	OK	Gel
	Panel voltage (Vdc)	12.97	
	Battery voltage (Vdc)	12.97	
	Load voltage (Vdc)	12.95	
Panel stand	Condition of the stand	OK	
	Condition of the bolts	OK	The tightness of each bolt was verified
Solar modules	Condition	OK	Operational
	Tilt angle	OK	
	Tight cable glands	OK	Checked one by one
	Tight bolts	OK	Checked one by one
	Tight connections	OK	Each connection was verified
	Panels without obstruction	OK	Cleaning was done
	Power wiring	OK	
	Open circuit voltage (V)	18.88	Partially cloudy day
Grounding system	Condition	Good	Maintenance was done in the well
	Type of soil	Clayey	
	Measurement of the grounding system (Ω)	7.30	Digital tellurometer
	Line protector	OK	Altelicom N-female N-male
Antennas	Panel for Alix 2.4GHz	OK	Vertical polarization 14dBi
	Coaxial cables and connectors	OK	Checked one by one
Electrical box	Condition	OK	
	Tight connection plugs	OK	Se verificó una por una
	Condition of grounding	OK	
ALIX router	Condition	OK	
	Wireless cards (1 unit)	OK	
	CF Memory	OK	SanDisk Extreme III 2GB
	Power cable	OK	
	Condition of RJ45 connectors	OK	
	Pigtail (1 unit)	OK	UFL - N-female
	Coaxial cable and connectors	OK	

Maintenance format of client station - Santa Clotilde

Description		Condition	Comments
Battery	Status	Good	2 units of 12Vdc
	Voltage (Vdc)	13.21	
	Condition of the connection plugs	OK	Cleaning was done
	Greased connection plugs	OK	
Controller	Condition	OK	Operational
	Tight connections	OK	Each connection was verified
	Connectors in good condition	OK	
	Screws are complete	OK	
	Type of selected battery	OK	Gel
	Panel voltage (Vdc)	13.23	
	Battery voltage (Vdc)	13.21	
	Load voltage (Vdc)	13.21	
Panel stand	Condition of the stand	OK	
	Condition of the bolts	OK	Se verificó el ajuste de cada perno
Solar modules	Condition	OK	Operativos
	Tilt angle	OK	
	Tight cable glands	OK	Checked one by one
	Tight bolts	OK	Checked one by one
	Tight connections	OK	Each connection was verified
	Panels without obstruction	OK	Cleaning was done
	Power wiring	OK	
	Open circuit voltage (V)	19.22	Sunny day
Grounding system	Condition	Good	Maintenance was done in the well
	Type of soil	Clayey	
	Measurement of the grounding system (Ω)	6.50	Digital tellurometer
	Line protector	OK	Altelicom N-female N-male
Antennas	Panel for Alix 2.4GHz	OK	Vertical polarization 14dBi
	Coaxial cables and connectors	OK	Checked one by one
Electrical box	Condition	OK	
	Tight connection plugs	OK	Checked one by one
	Condition of grounding	OK	
ALIX router	Condition	OK	
	Wireless cards (1 unit)	OK	
	CF Memory	OK	SanDisk Extreme III 2GB
	Power cable	OK	
	Condition of RJ45 connectors	OK	
	Pigtail (1 unit)	OK	UFL - N-female
	Coaxial cable and connectors	OK	

Annex 4: Performance tests before making changes in the Napo network

Tuta Pishco – Negro Urco link

```
tpishco-19n1:~# iwconfig
lo        no wireless extensions.

eth0      no wireless extensions.

eth1      no wireless extensions.

wifi0     no wireless extensions.

wifi1     no wireless extensions.

ath0      IEEE 802.11g  ESSID:"EHAS19"  Nickname:""
          Mode:Master  Frequency:2.437 GHz  Access Point: 00:15:6D:55:0F:D8
          Bit Rate=18 Mb/s   Tx-Power=14 dBm   Sensitivity=1/1
          Retry:off   RTS thr:off   Fragment thr:off
          Encryption key:99FB-2B30-5163-D043-1E8E-3A6D-3F1A-FF77 [2]   Security mode:open
          Power Management:off
          Link Quality=28/70  Signal level=-68 dBm  Noise level=-96 dBm
          Rx invalid nwid:4297  Rx invalid crypt:0  Rx invalid frag:0
          Tx excessive retries:0  Invalid misc:0   Missed beacon:0

ath1      IEEE 802.11g  ESSID:"NAPO19"  Nickname:""
          Mode:Master  Frequency:2.462 GHz  Access Point: 00:0C:42:1F:69:0D
          Bit Rate=9 Mb/s   Tx-Power=17 dBm   Sensitivity=1/1
          Retry:off   RTS thr:off   Fragment thr:off
          Encryption key:1FAF-EAD3-369F-B4EB-3786-631B-0630-431A [2]   Security mode:open
          Power Management:off
          Link Quality=46/70  Signal level=-50 dBm  Noise level=-96 dBm
          Rx invalid nwid:2235  Rx invalid crypt:0  Rx invalid frag:0
          Tx excessive retries:0  Invalid misc:0   Missed beacon:0

tpishco-19n1:~# iperf -s
------------------------------------------------------------
Server listening on TCP port 5001
TCP window size: 85.3 KByte (default)
------------------------------------------------------------
[  4] local 10.12.19.1 port 5001 connected with 10.11.19.2 port 57364
[  4]  0.0-60.2 sec  70.6 MBytes  9.84 Mbits/sec

nurco-18n2:~# iwconfig
lo        no wireless extensions.

eth0      no wireless extensions.

eth1      no wireless extensions.

wifi0     no wireless extensions.

ath0      IEEE 802.11g  ESSID:"EHAS19"  Nickname:"nurco-18n2-ath0"
          Mode:Managed  Frequency:2.437 GHz  Access Point: 00:15:6D:55:0F:D8
          Bit Rate=18 Mb/s   Tx-Power=14 dBm   Sensitivity=1/1
          Retry:off   RTS thr:off   Fragment thr:off
          Encryption key:0145-263A-4310-FBA6-FB3F-C623-7F69-5EFF   Security mode:restricted
```

```
        Power Management:off
        Link Quality=29/70  Signal level=-67 dBm  Noise level=-96 dBm
        Rx invalid nwid:21  Rx invalid crypt:0  Rx invalid frag:0
        Tx excessive retries:0  Invalid misc:0   Missed beacon:0


nurco-18n2:~# iperf -c 10.12.19.1 -t 60 -i 5
------------------------------------------------------------
Client connecting to 10.12.19.1, TCP port 5001
TCP window size: 16.0 KByte (default)
------------------------------------------------------------
[ 3] local 10.11.19.2 port 57364 connected with 10.12.19.1 port 5001
[ 3]  0.0- 5.0 sec  6.02 MBytes  10.1 Mbits/sec
[ 3]  5.0-10.0 sec  5.84 MBytes  9.80 Mbits/sec
[ 3] 10.0-15.0 sec  5.78 MBytes  9.70 Mbits/sec
[ 3] 15.0-20.0 sec  5.86 MBytes  9.83 Mbits/sec
[ 3] 20.0-25.0 sec  5.91 MBytes  9.91 Mbits/sec
[ 3] 25.0-30.0 sec  5.80 MBytes  9.73 Mbits/sec
[ 3] 30.0-35.0 sec  5.85 MBytes  9.82 Mbits/sec
[ 3] 35.0-40.0 sec  5.89 MBytes  9.88 Mbits/sec
[ 3] 40.0-45.0 sec  5.94 MBytes  9.96 Mbits/sec
[ 3] 45.0-50.0 sec  5.84 MBytes  9.79 Mbits/sec
[ 3] 50.0-55.0 sec  5.90 MBytes  9.90 Mbits/sec
[ 3] 55.0-60.0 sec  5.94 MBytes  9.96 Mbits/sec
[ 3]  0.0-60.0 sec  70.6 MBytes  9.86 Mbits/sec
```

Negro Urco – Tacsha Curaray link

```
nurco-18n1:~# iwconfig
lo        no wireless extensions.

eth0      no wireless extensions.

eth1      no wireless extensions.

wifi0     no wireless extensions.

wifi1     no wireless extensions.

ath0      IEEE 802.11g  ESSID:"EHAS18"  Nickname:""
          Mode:Master  Frequency:2.462 GHz  Access Point: 00:15:6D:54:E3:07
          Bit Rate=18 Mb/s  Tx-Power=14 dBm  Sensitivity=1/1
          Retry:off  RTS thr:off  Fragment thr:off
          Encryption key:DB3E-535F-2645-FAC0-A6B7-44F4-6418-7289 [2]  Security mode:open
          Power Management:off
          Link Quality=36/70  Signal level=-60 dBm  Noise level=-96 dBm
          Rx invalid nwid:109  Rx invalid crypt:0  Rx invalid frag:0
          Tx excessive retries:0  Invalid misc:0   Missed beacon:0

ath1      IEEE 802.11g  ESSID:"NAPO18"  Nickname:""
          Mode:Master  Frequency:2.412 GHz  Access Point: 00:0C:42:1F:9B:3C
          Bit Rate:0 kb/s  Tx-Power=17 dBm  Sensitivity=1/1
          Retry:off  RTS thr:off  Fragment thr:off
          Encryption key:5C94-BD23-2244-EA8A-04FB-7FD7-F416-317F [2]  Security mode:open
          Power Management:off
          Link Quality=41/70  Signal level=-55 dBm  Noise level=-96 dBm
          Rx invalid nwid:97  Rx invalid crypt:0  Rx invalid frag:0
          Tx excessive retries:0  Invalid misc:0   Missed beacon:0
```

```
nurco-18n1:~# iperf -s
------------------------------------------------------------
Server listening on TCP port 5001
TCP window size: 85.3 KByte (default)
------------------------------------------------------------
[  4] local 10.12.18.1 port 5001 connected with 10.11.18.2 port 54510
[  4]  0.0-60.2 sec  51.3 MBytes  7.16 Mbits/sec


tcuraray-17n2:~# iwconfig
lo        no wireless extensions.

eth0      no wireless extensions.

eth1      no wireless extensions.

wifi0     no wireless extensions.

ath0      IEEE 802.11g  ESSID:"EHAS18"  Nickname:"tcuraray-17n2-ath0"
          Mode:Managed  Frequency:2.462 GHz  Access Point: 00:15:6D:54:E3:07
          Bit Rate=18 Mb/s  Tx-Power=14 dBm  Sensitivity=1/1
          Retry:off  RTS thr:off  Fragment thr:off
          Encryption key:FA7B-C638-ADA0-58B3-9CA3-B15B-BFA1-E680  Security mode:restricted
          Power Management:off
          Link Quality=35/70  Signal level=-60 dBm  Noise level=-95 dBm
          Rx invalid nwid:34250  Rx invalid crypt:0  Rx invalid frag:0
          Tx excessive retries:0  Invalid misc:0  Missed beacon:0


tcuraray-17n2:~# iperf -c 10.12.18.1 -t 60 -i 5
------------------------------------------------------------
Client connecting to 10.12.18.1, TCP port 5001
TCP window size: 16.0 KByte (default)
------------------------------------------------------------
[  3] local 10.11.18.2 port 54510 connected with 10.12.18.1 port 5001
[  3]  0.0- 5.0 sec  4.42 MBytes  7.42 Mbits/sec
[  3]  5.0-10.0 sec  4.26 MBytes  7.14 Mbits/sec
[  3] 10.0-15.0 sec  4.32 MBytes  7.25 Mbits/sec
[  3] 15.0-20.0 sec  4.27 MBytes  7.16 Mbits/sec
[  3] 20.0-25.0 sec  4.25 MBytes  7.13 Mbits/sec
[  3] 25.0-30.0 sec  4.22 MBytes  7.08 Mbits/sec
[  3] 30.0-35.0 sec  4.26 MBytes  7.14 Mbits/sec
[  3] 35.0-40.0 sec  4.25 MBytes  7.13 Mbits/sec
[  3] 40.0-45.0 sec  4.27 MBytes  7.16 Mbits/sec
[  3] 45.0-50.0 sec  4.33 MBytes  7.26 Mbits/sec
[  3] 50.0-55.0 sec  4.26 MBytes  7.14 Mbits/sec
[  3] 55.0-60.0 sec  4.23 MBytes  7.10 Mbits/sec
[  3]  0.0-60.0 sec  51.3 MBytes  7.18 Mbits/sec
```

Negro Urco – Tacsha Curaray link

```
tcuraray-17n1:~# iwconfig
lo        no wireless extensions.

eth0      no wireless extensions.

eth1      no wireless extensions.

wifi0     no wireless extensions.
```

```
wifi1     no wireless extensions.

ath0     IEEE 802.11g  ESSID:"EHAS17"  Nickname:""
         Mode:Master  Frequency:2.437 GHz  Access Point: 00:15:6D:53:32:F8
         Bit Rate=18 Mb/s  Tx-Power=8 dBm  Sensitivity=1/1
         Retry:off  RTS thr:off  Fragment thr:off
         Encryption key:5A1E-280A-3CAE-2246-FB42-F757-484B-72D4 [2]  Security mode:open
         Power Management:off
         Link Quality=30/70  Signal level=-66 dBm  Noise level=-96 dBm
         Rx invalid nwid:0  Rx invalid crypt:0  Rx invalid frag:0
         Tx excessive retries:0  Invalid misc:0  Missed beacon:0

ath1     IEEE 802.11g  ESSID:"NAPO17"  Nickname:""
         Mode:Master  Frequency:2.412 GHz  Access Point: 00:0B:6B:56:21:1A
         Bit Rate=9 Mb/s  Tx-Power=17 dBm  Sensitivity=1/1
         Retry:off  RTS thr:off  Fragment thr:off
         Encryption key:8AF3-B3C8-FC20-9222-6072-2B0D-05D0-2C16 [2]  Security mode:open
         Power Management:off
         Link Quality=44/70  Signal level=-52 dBm  Noise level=-96 dBm
         Rx invalid nwid:0  Rx invalid crypt:0  Rx invalid frag:0
         Tx excessive retries:0  Invalid misc:0  Missed beacon:0

tcuraray-17n1:~# iperf -s
------------------------------------------------------------
Server listening on TCP port 5001
TCP window size: 85.3 KByte (default)
------------------------------------------------------------
[  4] local 10.12.17.1 port 5001 connected with 10.11.17.2 port 58971
[  4]  0.0-60.6 sec  65.2 MBytes  9.02 Mbits/sec

sclotilde-1n2:~# iwconfig
lo        no wireless extensions.

eth0      no wireless extensions.

eth1      no wireless extensions.

wifi0     no wireless extensions.

ath0     IEEE 802.11g  ESSID:"EHAS17"  Nickname:"sclotilde-1n2-ath0"
         Mode:Managed  Frequency:2.437 GHz  Access Point: 00:15:6D:53:32:F8
         Bit Rate=9 Mb/s  Tx-Power:16 dBm  Sensitivity=1/1
         Retry:off  RTS thr:off  Fragment thr:off
         Encryption key:2954-43CE-5EB3-E3E9-86D8-26DC-EBE7-2D4B  Security mode:restricted
         Power Management:off
         Link Quality=31/70  Signal level=-64 dBm  Noise level=-95 dBm
         Rx invalid nwid:92562  Rx invalid crypt:0  Rx invalid frag:0
         Tx excessive retries:0  Invalid misc:0  Missed beacon:0

sclotilde-1n2:~# iperf -c 10.12.17.1 -t 60 -i 5
------------------------------------------------------------
Client connecting to 10.12.17.1, TCP port 5001
TCP window size: 16.0 KByte (default)
------------------------------------------------------------
[  3] local 10.11.17.2 port 58971 connected with 10.12.17.1 port 5001
[  3]  0.0- 5.0 sec  5.99 MBytes  10.1 Mbits/sec
[  3]  5.0-10.0 sec  5.43 MBytes  9.11 Mbits/sec
[  3] 10.0-15.0 sec  5.12 MBytes  8.60 Mbits/sec
[  3] 15.0-20.0 sec  5.41 MBytes  9.08 Mbits/sec
```

```
[  3] 20.0-25.0 sec  5.41 MBytes  9.08 Mbits/sec
[  3] 25.0-30.0 sec  5.40 MBytes  9.06 Mbits/sec
[  3] 30.0-35.0 sec  5.38 MBytes  9.03 Mbits/sec
[  3] 35.0-40.0 sec  5.39 MBytes  9.04 Mbits/sec
[  3] 40.0-45.0 sec  5.46 MBytes  9.16 Mbits/sec
[  3] 45.0-50.0 sec  5.43 MBytes  9.11 Mbits/sec
[  3] 50.0-55.0 sec  5.35 MBytes  8.98 Mbits/sec
[  3] 55.0-60.0 sec  5.36 MBytes  8.99 Mbits/sec
[  3]  0.0-60.1 sec  65.2 MBytes  9.09 Mbits/sec
```

Annex 5: Performance tests after making changes in the Napo network

---

TUTA PISHCO

Tower - Post

```
n2-tutapishco-ps:~# iperf -c 10.14.19.1 -t 60 -i 5
------------------------------------------------------------
Client connecting to 10.14.19.1, TCP port 5001
TCP window size: 16.0 KByte (default)
------------------------------------------------------------
[  3] local 10.13.19.1 port 38155 connected with 10.14.19.1 port 5001
[  3]  0.0- 5.0 sec  8.08 MBytes  13.6 Mbits/sec
[  3]  5.0-10.0 sec  7.90 MBytes  13.3 Mbits/sec
[  3] 10.0-15.0 sec  7.62 MBytes  12.8 Mbits/sec
[  3] 15.0-20.0 sec  7.71 MBytes  12.9 Mbits/sec
[  3] 20.0-25.0 sec  7.71 MBytes  12.9 Mbits/sec
[  3] 25.0-30.0 sec  7.74 MBytes  13.0 Mbits/sec
[  3] 30.0-35.0 sec  7.72 MBytes  12.9 Mbits/sec
[  3] 35.0-40.0 sec  7.62 MBytes  12.8 Mbits/sec
[  3] 40.0-45.0 sec  7.58 MBytes  12.7 Mbits/sec
[  3] 45.0-50.0 sec  7.64 MBytes  12.8 Mbits/sec
[  3] 50.0-55.0 sec  7.54 MBytes  12.6 Mbits/sec
[  3] 55.0-60.0 sec  7.48 MBytes  12.6 Mbits/sec
[  3]  0.0-60.0 sec  92.4 MBytes  12.9 Mbits/sec
```

```
c1-tutapishco-ps:~# iperf -s
------------------------------------------------------------
Server listening on TCP port 5001
TCP window size: 85.3 KByte (default)
------------------------------------------------------------
[  4] local 10.14.19.1 port 5001 connected with 10.13.19.1 port 38155
[  4]  0.0-60.1 sec  92.4 MBytes  12.9 Mbits/sec
```

Post - Tower

```
c1-tutapishco-ps:~# iperf -c 10.12.19.2 -t 60 -i 5
------------------------------------------------------------
Client connecting to 10.12.19.2, TCP port 5001
TCP window size: 16.0 KByte (default)
------------------------------------------------------------
[  3] local 10.13.19.2 port 56863 connected with 10.12.19.2 port 5001
[  3]  0.0- 5.0 sec  8.09 MBytes  13.6 Mbits/sec
[  3]  5.0-10.0 sec  7.90 MBytes  13.3 Mbits/sec
[  3] 10.0-15.0 sec  7.80 MBytes  13.1 Mbits/sec
[  3] 15.0-20.0 sec  7.66 MBytes  12.8 Mbits/sec
[  3] 20.0-25.0 sec  7.79 MBytes  13.1 Mbits/sec
[  3] 25.0-30.0 sec  7.80 MBytes  13.1 Mbits/sec
[  3] 30.0-35.0 sec  7.77 MBytes  13.0 Mbits/sec
[  3] 35.0-40.0 sec  7.75 MBytes  13.0 Mbits/sec
[  3] 40.0-45.0 sec  7.82 MBytes  13.1 Mbits/sec
[  3] 45.0-50.0 sec  7.73 MBytes  13.0 Mbits/sec
[  3] 50.0-55.0 sec  7.48 MBytes  12.5 Mbits/sec
[  3] 55.0-60.0 sec  7.77 MBytes  13.0 Mbits/sec
[  3]  0.0-60.0 sec  93.4 MBytes  13.0 Mbits/sec
```

```
n2-tutapishco-ps:~# iperf -s
------------------------------------------------------------
Server listening on TCP port 5001
```

```
TCP window size: 85.3 KByte (default)
------------------------------------------------------------
[ 4] local 10.12.19.2 port 5001 connected with 10.13.19.2 port 56863
[ 4] 0.0-60.1 sec  93.4 MBytes  13.0 Mbits/sec
```

NEGRO URCO

Tower – Post

```
n2-negrourco-ps:~# iperf -c 10.14.18.1 -t 60 -i 5
------------------------------------------------------------
Client connecting to 10.14.18.1, TCP port 5001
TCP window size: 16.0 KByte (default)
------------------------------------------------------------
[ 3] local 10.13.18.1 port 51144 connected with 10.14.18.1 port 5001
[ 3]  0.0- 5.0 sec  7.96 MBytes  13.4 Mbits/sec
[ 3]  5.0-10.0 sec  7.58 MBytes  12.7 Mbits/sec
[ 3] 10.0-15.0 sec  6.87 MBytes  11.5 Mbits/sec
[ 3] 15.0-20.0 sec  6.91 MBytes  11.6 Mbits/sec
[ 3] 20.0-25.0 sec  6.73 MBytes  11.3 Mbits/sec
[ 3] 25.0-30.0 sec  6.72 MBytes  11.3 Mbits/sec
[ 3] 30.0-35.0 sec  6.85 MBytes  11.5 Mbits/sec
[ 3] 35.0-40.0 sec  6.80 MBytes  11.4 Mbits/sec
[ 3] 40.0-45.0 sec  5.22 MBytes  8.76 Mbits/sec
[ 3] 45.0-50.0 sec  6.96 MBytes  11.7 Mbits/sec
[ 3] 50.0-55.0 sec  6.84 MBytes  11.5 Mbits/sec
[ 3] 55.0-60.0 sec  6.93 MBytes  11.6 Mbits/sec
[ 3]  0.0-60.0 sec  82.4 MBytes  11.5 Mbits/sec


c1-negrourco-ps:~# iperf -s
------------------------------------------------------------
Server listening on TCP port 5001
TCP window size: 85.3 KByte (default)
------------------------------------------------------------
[ 4] local 10.14.18.1 port 5001 connected with 10.13.18.1 port 51144
[ 4] 0.0-60.2 sec  82.4 MBytes  11.5 Mbits/sec
```

Post - Tower

```
c1-negrourco-ps:~# iperf -c 10.12.18.2 -t 60 -i 5
------------------------------------------------------------
Client connecting to 10.12.18.2, TCP port 5001
TCP window size: 16.0 KByte (default)
------------------------------------------------------------
[ 3] local 10.13.18.2 port 46002 connected with 10.12.18.2 port 5001
[ 3]  0.0- 5.0 sec  7.90 MBytes  13.3 Mbits/sec
[ 3]  5.0-10.0 sec  7.52 MBytes  12.6 Mbits/sec
[ 3] 10.0-15.0 sec  7.25 MBytes  12.2 Mbits/sec
[ 3] 15.0-20.0 sec  6.82 MBytes  11.4 Mbits/sec
[ 3] 20.0-25.0 sec  6.99 MBytes  11.7 Mbits/sec
[ 3] 25.0-30.0 sec  7.09 MBytes  11.9 Mbits/sec
[ 3] 30.0-35.0 sec  6.85 MBytes  11.5 Mbits/sec
[ 3] 35.0-40.0 sec  7.00 MBytes  11.7 Mbits/sec
[ 3] 40.0-45.0 sec  6.99 MBytes  11.7 Mbits/sec
[ 3] 45.0-50.0 sec  7.01 MBytes  11.8 Mbits/sec
[ 3] 50.0-55.0 sec  6.93 MBytes  11.6 Mbits/sec
[ 3] 55.0-60.0 sec  6.95 MBytes  11.7 Mbits/sec
[ 3]  0.0-60.0 sec  85.3 MBytes  11.9 Mbits/sec
```

```
n2-negrourco-ps:~# iperf -s
------------------------------------------------------------
Server listening on TCP port 5001
TCP window size: 85.3 KByte (default)
------------------------------------------------------------
[  4] local 10.12.18.2 port 5001 connected with 10.13.18.2 port 46002
[  4]  0.0-60.1 sec  85.3 MBytes  11.9 Mbits/sec
```

TACSHA CURARAY

Tower – Post

```
n2-tcuraray-ps:~# iperf -c 10.14.17.1 -t 60 -i 5
------------------------------------------------------------
Client connecting to 10.14.17.1, TCP port 5001
TCP window size: 16.0 KByte (default)
------------------------------------------------------------
[  3] local 10.13.17.1 port 55099 connected with 10.14.17.1 port 5001
[  3]  0.0- 5.0 sec  8.00 MBytes  13.4 Mbits/sec
[  3]  5.0-10.0 sec  7.82 MBytes  13.1 Mbits/sec
[  3] 10.0-15.0 sec  7.85 MBytes  13.2 Mbits/sec
[  3] 15.0-20.0 sec  7.91 MBytes  13.3 Mbits/sec
[  3] 20.0-25.0 sec  7.85 MBytes  13.2 Mbits/sec
[  3] 25.0-30.0 sec  7.95 MBytes  13.3 Mbits/sec
[  3] 30.0-35.0 sec  7.77 MBytes  13.0 Mbits/sec
[  3] 35.0-40.0 sec  7.85 MBytes  13.2 Mbits/sec
[  3] 40.0-45.0 sec  7.95 MBytes  13.3 Mbits/sec
[  3] 45.0-50.0 sec  7.89 MBytes  13.2 Mbits/sec
[  3] 50.0-55.0 sec  7.88 MBytes  13.2 Mbits/sec
[  3] 55.0-60.0 sec  7.87 MBytes  13.2 Mbits/sec
[  3]  0.0-60.0 sec  94.6 MBytes  13.2 Mbits/sec
```

```
c1-tcuraray-ps:~# iperf -s
------------------------------------------------------------
Server listening on TCP port 5001
TCP window size: 85.3 KByte (default)
------------------------------------------------------------
[  4] local 10.14.17.1 port 5001 connected with 10.13.17.1 port 55099
[  4]  0.0-60.1 sec  94.6 MBytes  13.2 Mbits/sec
```

Post – Tower

```
c1-tcuraray-ps:~# iperf -c 10.12.17.2 -t 60 -i 5
------------------------------------------------------------
Client connecting to 10.12.17.2, TCP port 5001
TCP window size: 16.0 KByte (default)
------------------------------------------------------------
[  3] local 10.13.17.2 port 38035 connected with 10.12.17.2 port 5001
[  3]  0.0- 5.0 sec  8.14 MBytes  13.7 Mbits/sec
[  3]  5.0-10.0 sec  7.88 MBytes  13.2 Mbits/sec
[  3] 10.0-15.0 sec  7.38 MBytes  12.4 Mbits/sec
[  3] 15.0-20.0 sec  7.57 MBytes  12.7 Mbits/sec
[  3] 20.0-25.0 sec  7.30 MBytes  12.2 Mbits/sec
[  3] 25.0-30.0 sec  7.77 MBytes  13.0 Mbits/sec
[  3] 30.0-35.0 sec  7.67 MBytes  12.9 Mbits/sec
[  3] 35.0-40.0 sec  7.91 MBytes  13.3 Mbits/sec
[  3] 40.0-45.0 sec  7.68 MBytes  12.9 Mbits/sec
[  3] 45.0-50.0 sec  7.88 MBytes  13.2 Mbits/sec
[  3] 50.0-55.0 sec  7.82 MBytes  13.1 Mbits/sec
[  3] 55.0-60.0 sec  7.78 MBytes  13.1 Mbits/sec
```

```
[  3]  0.0-60.0 sec  92.8 MBytes  13.0 Mbits/sec

n2-tcuraray-ps:~# iperf -s
------------------------------------------------------------
Server listening on TCP port 5001
TCP window size: 85.3 KByte (default)
------------------------------------------------------------
[  4] local 10.12.17.2 port 5001 connected with 10.13.17.2 port 38035
[  4]  0.0-60.1 sec  92.8 MBytes  12.9 Mbits/sec
```

Santa Clotilde

Tower – Post

```
n2-sclotilde-cs:~# iperf -c 10.14.1.1 -t 60 -i 5
------------------------------------------------------------
Client connecting to 10.14.1.1, TCP port 5001
TCP window size: 16.0 KByte (default)
------------------------------------------------------------
[  3] local 10.13.1.1 port 47773 connected with 10.14.1.1 port 5001
[  3]  0.0- 5.0 sec  8.55 MBytes  14.3 Mbits/sec
[  3]  5.0-10.0 sec  7.71 MBytes  12.9 Mbits/sec
[  3] 10.0-15.0 sec  7.76 MBytes  13.0 Mbits/sec
[  3] 15.0-20.0 sec  7.99 MBytes  13.4 Mbits/sec
[  3] 20.0-25.0 sec  7.52 MBytes  12.6 Mbits/sec
[  3] 25.0-30.0 sec  7.83 MBytes  13.1 Mbits/sec
[  3] 30.0-35.0 sec  7.75 MBytes  13.0 Mbits/sec
[  3] 35.0-40.0 sec  8.02 MBytes  13.4 Mbits/sec
[  3] 40.0-45.0 sec  7.96 MBytes  13.4 Mbits/sec
[  3] 45.0-50.0 sec  7.75 MBytes  13.0 Mbits/sec
[  3] 50.0-55.0 sec  7.27 MBytes  12.2 Mbits/sec
[  3] 55.0-60.0 sec  7.62 MBytes  12.8 Mbits/sec
[  3]  0.0-60.1 sec  93.7 MBytes  13.1 Mbits/sec

c1-sclotilde-cs:~# iperf -s
------------------------------------------------------------
Server listening on TCP port 5001
TCP window size: 85.3 KByte (default)
------------------------------------------------------------
[  4] local 10.14.1.1 port 5001 connected with 10.13.1.1 port 47773
[  4]  0.0-60.4 sec  93.7 MBytes  13.0 Mbits/sec
```

Post – Tower

```
c1-sclotilde-cs:~# iperf -c 10.12.1.2 -t 60 -i 5
------------------------------------------------------------
Client connecting to 10.12.1.2, TCP port 5001
TCP window size: 16.0 KByte (default)
------------------------------------------------------------
[  3] local 10.13.1.2 port 36201 connected with 10.12.1.2 port 5001
[  3]  0.0- 5.0 sec  8.37 MBytes  14.0 Mbits/sec
[  3]  5.0-10.0 sec  8.02 MBytes  13.4 Mbits/sec
[  3] 10.0-15.0 sec  7.99 MBytes  13.4 Mbits/sec
[  3] 15.0-20.0 sec  7.84 MBytes  13.2 Mbits/sec
[  3] 20.0-25.0 sec  7.96 MBytes  13.4 Mbits/sec
[  3] 25.0-30.0 sec  7.73 MBytes  13.0 Mbits/sec
[  3] 30.0-35.0 sec  7.95 MBytes  13.3 Mbits/sec
[  3] 35.0-40.0 sec  7.97 MBytes  13.4 Mbits/sec
[  3] 40.0-45.0 sec  7.95 MBytes  13.3 Mbits/sec
```

```
[  3] 45.0-50.0 sec  7.98 MBytes  13.4 Mbits/sec
[  3] 50.0-55.0 sec  7.83 MBytes  13.1 Mbits/sec
[  3] 55.0-60.0 sec  7.98 MBytes  13.4 Mbits/sec
[  3]  0.0-60.1 sec  95.6 MBytes  13.3 Mbits/sec

n2-sclotilde-cs:~# iperf -s
---------------------------------------------------------
Server listening on TCP port 5001
TCP window size: 85.3 KByte (default)
---------------------------------------------------------
[  4] local 10.12.1.2 port 5001 connected with 10.13.1.2 port 36201
[  4]  0.0-60.4 sec  95.6 MBytes  13.3 Mbits/sec
```

	Tuta Pishco Health Post - Santa Clotilde Health Center	Santa Clotilde Health Center - Tuta Pishco Health Post
Distance (Km)	98.1	
Throughput (Mbps)	5.97	4.04

```
Tuta Pishco – Santa Clotilde

Post - Center

c1-tutapishco-ps:~# iperf -c 10.14.1.1 -t 60 -i  5
---------------------------------------------------------
Client connecting to 10.14.1.1, TCP port 5001
TCP window size: 16.0 KByte (default)
---------------------------------------------------------
[  3] local 10.13.19.2 port 44586 connected with 10.14.1.1 port 5001
[  3]  0.0- 5.0 sec  4.05 MBytes  6.80 Mbits/sec
[  3]  5.0-10.0 sec  3.47 MBytes  5.82 Mbits/sec
[  3] 10.0-15.0 sec  3.73 MBytes  6.27 Mbits/sec
[  3] 15.0-20.0 sec  3.76 MBytes  6.30 Mbits/sec
[  3] 20.0-25.0 sec  3.62 MBytes  6.07 Mbits/sec
[  3] 25.0-30.0 sec  3.21 MBytes  5.39 Mbits/sec
[  3] 30.0-35.0 sec  3.12 MBytes  5.24 Mbits/sec
[  3] 35.0-40.0 sec  3.61 MBytes  6.06 Mbits/sec
[  3] 40.0-45.0 sec  3.59 MBytes  6.02 Mbits/sec
[  3] 45.0-50.0 sec  3.31 MBytes  5.56 Mbits/sec
[  3] 50.0-55.0 sec  3.66 MBytes  6.13 Mbits/sec
[  3] 55.0-60.0 sec  3.62 MBytes  6.08 Mbits/sec
[  3]  0.0-60.0 sec  42.8 MBytes  5.98 Mbits/sec

c1-sclotilde-cs:~# iperf -s
---------------------------------------------------------
Server listening on TCP port 5001
TCP window size: 85.3 KByte (default)
---------------------------------------------------------
[  4] local 10.14.1.1 port 5001 connected with 10.13.19.2 port 44586
[  4]  0.0-60.2 sec  42.8 MBytes  5.96 Mbits/sec

Santa Clotilde – Tuta Pishco

Center - Post
```

```
c1-sclotilde-cs:~# iperf -c 10.14.19.1 -t 60 -i 5
------------------------------------------------------------
Client connecting to 10.14.19.1, TCP port 5001
TCP window size: 16.0 KByte (default)
------------------------------------------------------------
[ 3] local 10.13.1.2 port 37973 connected with 10.14.19.1 port 5001
[ 3]  0.0- 5.0 sec  2.66 MBytes  4.46 Mbits/sec
[ 3]  5.0-10.0 sec  2.82 MBytes  4.73 Mbits/sec
[ 3] 10.0-15.0 sec  3.07 MBytes  5.15 Mbits/sec
[ 3] 15.0-20.0 sec  2.75 MBytes  4.61 Mbits/sec
[ 3] 20.0-25.0 sec  2.73 MBytes  4.59 Mbits/sec
[ 3] 25.0-30.0 sec  2.88 MBytes  4.82 Mbits/sec
[ 3] 30.0-35.0 sec  2.80 MBytes  4.71 Mbits/sec
[ 3] 35.0-40.0 sec  2.48 MBytes  4.17 Mbits/sec
[ 3] 40.0-45.0 sec  1.66 MBytes  2.78 Mbits/sec
[ 3] 45.0-50.0 sec  1.88 MBytes  3.15 Mbits/sec
[ 3] 50.0-55.0 sec  2.38 MBytes  4.00 Mbits/sec
[ 3] 55.0-60.0 sec   944 KBytes  1.55 Mbits/sec
[ 3]  0.0-60.1 sec  29.0 MBytes  4.05 Mbits/sec
```

Post

```
c1-tutapishco-ps:~# iperf -s
------------------------------------------------------------
Server listening on TCP port 5001
TCP window size: 85.3 KByte (default)
------------------------------------------------------------
[ 4] local 10.14.19.1 port 5001 connected with 10.13.1.2 port 37973
[ 4]  0.0-60.4 sec  29.0 MBytes  4.03 Mbits/sec
```

Annex 6: Data sheets of the telecommunications equipment

RouterBOARD RB493G, MikroTik
Product specifications. Accessed: *28/02/2014*. < http://routerboard.com/RB493G >.

RouterBOARD RB433UAH, MikroTik
Product specifications. Accessed: *28/02/2014*. < http://routerboard.com/RB433UAH >.

Interface R52nM, MikroTik
Product specifications. Accessed: *28/02/2014*. < http://routerboard.com/R52NM >.

Interface R52Hn, MikroTik
Product specifications. Accessed: *28/02/2014*. < http://routerboard.com/R52Hn >.

System Board ALIX 2C0, PC Engines
Product specifications. Accessed: *28/02/2014*. < http://www.pcengines.ch/alix2c0.htm >.

Wireless Router Application Platform (WRAP), PC Engines
Product specifications. Accessed: *28/02/2014*. < http://www.pcengines.ch/wrap.htm >.

Interface SR2, Ubiquiti
Product specifications. Accessed: *28/02/2014*. < http://www.ubnt.com/sr2 >.

Interface R52H, MikroTik
Product specifications. Accessed: *28/02/2014*. < http://routerboard.com/R52H >.

Wireless-G Broadband Router WRT54GL, Linksys
Product specifications. Accessed: *28/02/2014.*
< http://support.linksys.com/en-us/support/routers/WRT54GL >.