Mathieu Chrétien and Rakul Lynagarathasan

g. 12491

ENVIRONMENTAL TELEMETRY SYSTEM MOUNTED ON BUOY FOR LAC À L'ANGUILLE

PROGRAM SYNTHESIS EXAMINATION (ESP)

Work presented to

Sebastian Richard

As part of the course

243-668-RK

Realization of a telecommunications project

Cegep of Rimouski

May 25 2020

For the end of our studies, as part of the course “Realization of a project in telecommunications”, we have a project to do during our last semester. Which summarizes everything you will have learned during the DEC.This project is in pairs there were several project choices.

The Eel Lake telemetry project consists of creating a system for obtaining several different data including humidity, pressure and temperature at different depths on a buoy on the lake. The data must then be transmitted remotely from a hut next to the lake using an RF link to get to the CEGEP. A computer network to allow access to data for study.

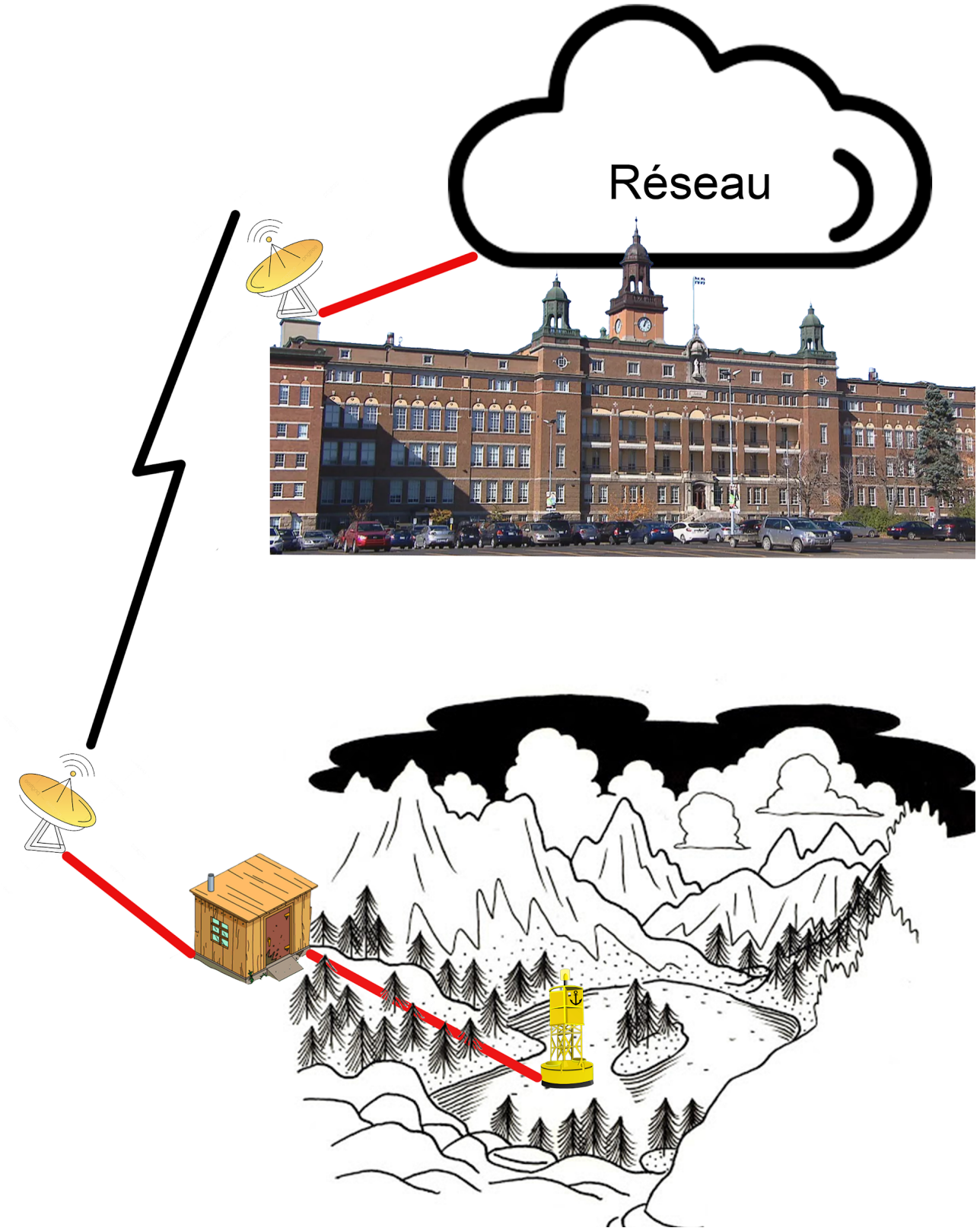
The distribution of the project was done naturally as Mathieu already had knowledge of the network part and Rakul in the part embarked on the buoy. And for the antenna part, we had chosen to do it later. And the same for the simulations.

The part of the on-board system on the buoy was made by Rakul IYNGARATHASAN. I have to create a system to take temperature measurements in the lake at different depths, measure the atmospheric pressure and the relative humidity at the surface. There was a research part for suitable sensors for temperatures. You had to learn how to use the DAQ. The DAQ is a module that allows you to acquire data via USB. I have to make a man-machine interface with graphs and measurement readings. The data must be documented in files and saved.

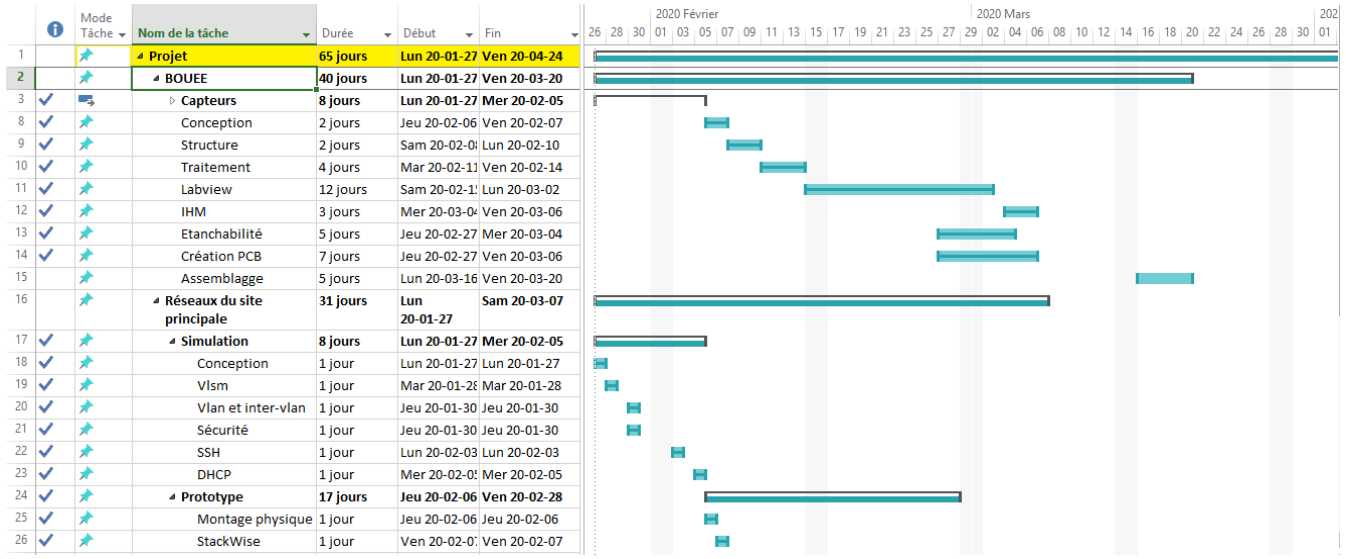
The wireless part with the use of a Ubiquiti type radio frequency system is required. As for the on-board system part, there was a research part to find out which antenna we could use.

The part of the computer network was made by Mathieu Chrétien. The computer network consists of a network that links several computer stations of four different types of users who have access to different parts of the network and the distribution of data obtained from the buoy to the lake. You must first create a simulation of the network that will give an overview of the real network that must be mounted. Then you have to mount the network devices in the support, make the necessary connection and configure all the switches so that the network works correctly. I also need to monitor this network using SolarWinds.

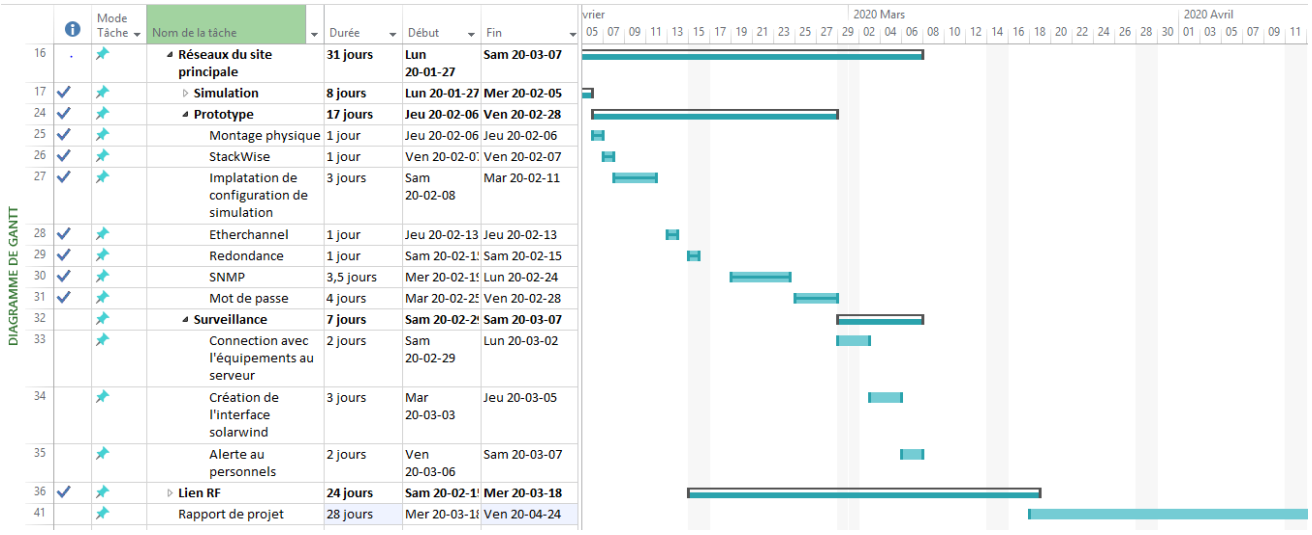
At the beginning we did a planning on WBS and then we did a GANTT to have clear objectives and not get lost. As you know with my current situation, we have reviewed our GANTT to modify it. The project therefore stopped just before the mid-term.


Réseau

During the beginning of the session, the time constraints were respected. At the level of the buoy, all that was missing was the PCB to be finished and the assembly of the components for the prototype. For the network, all that was needed was to make the SolarWinds interface and the network access lists. The RF link was ahead of schedule and we even had time to finish it before mid-term. In the context of the Covid-19 pandemic it was impossible for us to finish the project and the rest of the session was intended to do the project report and prepare for the oral presentation.



	Mode Tâche	Nom de la tâche	Durée	Début	Fin
1		**Projet**	**65 jours**	**Lun 20-01-27**	**Ven 20-04-24**
2		**BOUEE**	**40 jours**	**Lun 20-01-27**	**Ven 20-03-20**
3		**Capteurs**	**8 jours**	**Lun 20-01-27**	**Mer 20-02-05**
8		Conception	2 jours	Jeu 20-02-06	Ven 20-02-07
9		Structure	2 jours	Sam 20-02-0	Lun 20-02-10
10		Traitement	4 jours	Mar 20-02-11	Ven 20-02-14
11		Labview	12 jours	Sam 20-02-1	Lun 20-03-02
12		IHM	3 jours	Mer 20-03-0	Ven 20-03-06
13		Etanchabilité	5 jours	Jeu 20-02-27	Mer 20-03-04
14		Création PCB	7 jours	Jeu 20-02-27	Ven 20-03-06
15		Assemblagge	5 jours	Lun 20-03-16	Ven 20-03-20
16		**Réseaux du site principale**	**31 jours**	**Lun 20-01-27**	**Sam 20-03-07**
17		**Simulation**	**8 jours**	**Lun 20-01-27**	**Mer 20-02-05**
18		Conception	1 jour	Lun 20-01-27	Lun 20-01-27
19		Vlsm	1 jour	Mar 20-01-28	Mar 20-01-28
20		Vlan et inter-vlan	1 jour	Jeu 20-01-30	Jeu 20-01-30
21		Sécurité	1 jour	Jeu 20-01-30	Jeu 20-01-30
22		SSH	1 jour	Lun 20-02-03	Lun 20-02-03
23		DHCP	1 jour	Mer 20-02-0	Mer 20-02-05
24		**Prototype**	**17 jours**	**Jeu 20-02-06**	**Ven 20-02-28**
25		Montage physique	1 jour	Jeu 20-02-06	Jeu 20-02-06
26		StackWise	1 jour	Ven 20-02-0	Ven 20-02-07



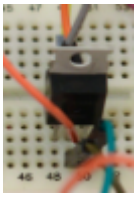
	Mode Tâche	Nom de la tâche	Durée	Début	Fin
16		**Réseaux du site principale**	**31 jours**	**Lun 20-01-27**	**Sam 20-03-07**
17		**Simulation**	**8 jours**	**Lun 20-01-27**	**Mer 20-02-05**
24		**Prototype**	**17 jours**	**Jeu 20-02-06**	**Ven 20-02-28**
25		Montage physique	1 jour	Jeu 20-02-06	Jeu 20-02-06
26		StackWise	1 jour	Ven 20-02-0	Ven 20-02-07
27		Implatation de configuration de simulation	3 jours	Sam 20-02-08	Mar 20-02-11
28		Etherchannel	1 jour	Jeu 20-02-13	Jeu 20-02-13
29		Redondance	1 jour	Sam 20-02-1	Sam 20-02-15
30		SNMP	3,5 jours	Mer 20-02-1	Lun 20-02-24
31		Mot de passe	4 jours	Mar 20-02-2	Ven 20-02-28
32		**Surveillance**	**7 jours**	**Sam 20-02-2**	**Sam 20-03-07**
33		Connection avec l'équipements au serveur	2 jours	Sam 20-02-29	Lun 20-03-02
34		Création de l'interface solarwind	3 jours	Mar 20-03-03	Jeu 20-03-05
35		Alerte au personnels	2 jours	Ven 20-03-06	Sam 20-03-07
36		**Lien RF**	**24 jours**	**Sam 20-02-1**	**Mer 20-03-18**
41		Rapport de projet	28 jours	Mer 20-03-1	Ven 20-04-24

DIAGRAMME DE GANTT

Rakul

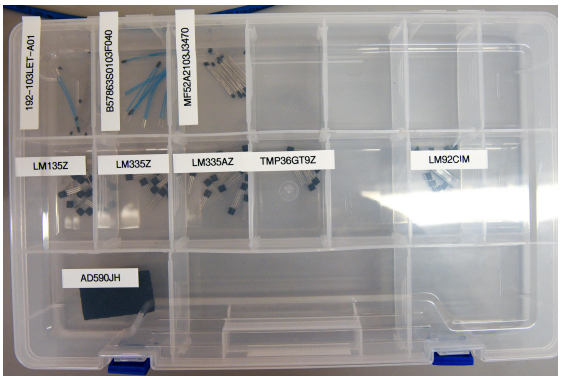
To start the project, there is a phase of research and reflection in relation to the project. For the design of the project, I studied the possible constraints. The biggest constraint is that the sensors must be waterproof and the other constraints are the distances, the temperatures (freezing), for the sensors were sought with the constraints of the project.

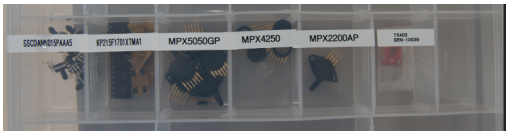
SENSORS



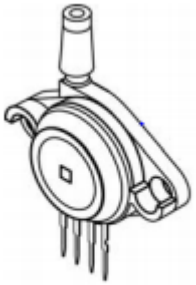
Before starting all the sensors are supplied with 5V using a 5V voltage regulator. We use it because during my tests there are values that were wrong. And you will find all the technical documents will be linked in the appendix. All the sensors are chosen with respect to the constraints. There is a box with already several sensors. The sensors are chosen by their characteristics and their price.

For atmospheric pressure sensors, there have been several tests. We already have sensors available in the lab.

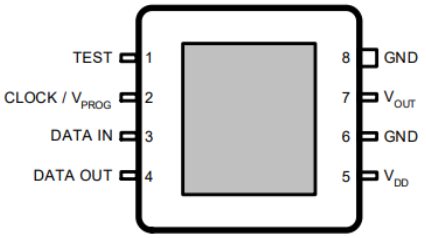




To begin with, the sensor chosen for the atmospheric pressure is the**MPX2200ap** .



There were several tests and yet there was a problem; the sensor gave two values each time it gave us 200 kPa and 99 kPa. After reading the technical document, the sensor operates in differential mode, which means that there are two subtractions then make a subtraction. As the inputs were free (nothing connected), the sensor had no reference so the sensor returns false values. Mathieu told me about a very easy-to-use sensor. The sensor can operate in normal or differential mode. The sensor is the KP215F1701XTMA1.



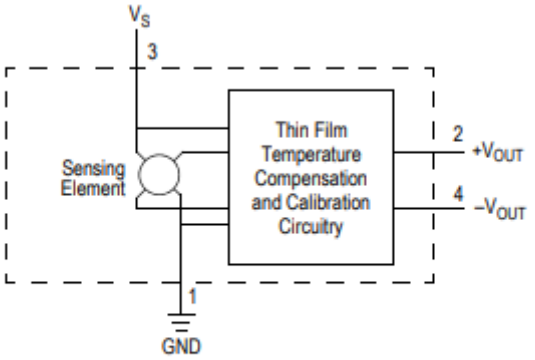
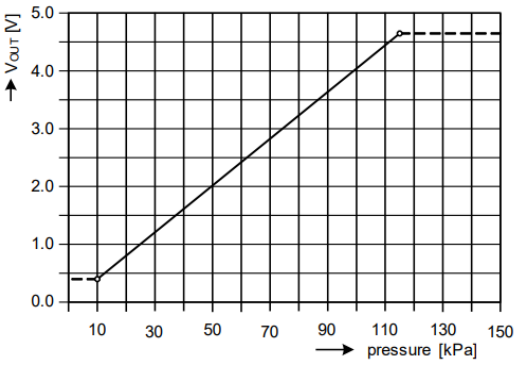


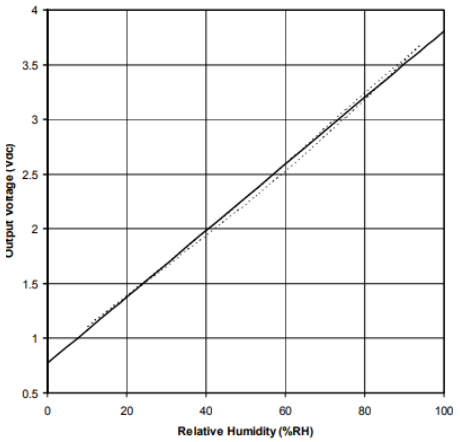
Figure 1. Temperature Compensated and Calibrated Pressure Sensor Schematic

For this sensor there was a formula as for most sensors. The formula here to go from voltage to kPa is to multiply the output voltage by 25. The number 25 comes from the calculation of the leading coefficient.



After doing the atmospheric pressure sensor adjustment. We moved on to humidity sensors. In the component box there were several humidity sensors after researching the constraints of the project. The selected sensor is the**HIH-4020**.

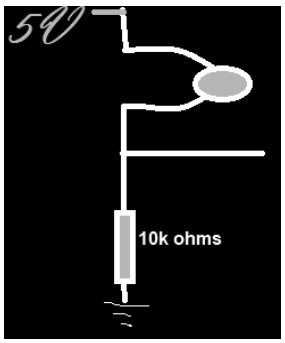
Voltage output (1st order curve fit)	$V_{OUT}=(V_{SUPPLY})(0.0062(\text{sensor RH}) + 0.16)$, typical at 25 °C



((Vhu/5)-0.16)/0.0062 so here is the calculation to go from voltage to humidity.

For the temperature sensors, it was impossible to use digital sensors, but it was necessary to use thermistors. There were many thermistors on the market, but we chose the**B57863S0103+040**. Upon reflection there were already thermistors in the box. This

allowed us to see that there are several types of thermistor: CTN and CTP. Our sensor is an easier CTN to set it up. To recover the value of the resistance it was necessary to set up a divider bridge.

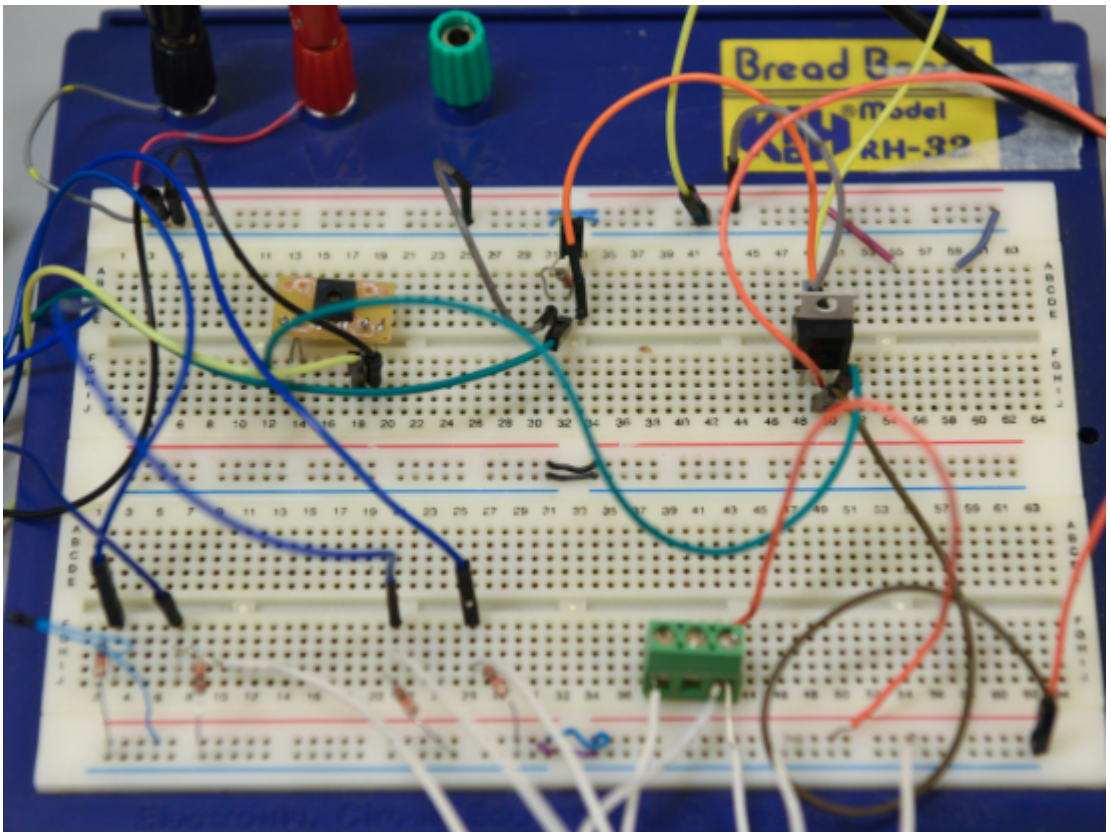


With this assembly we can find the value of the resistance with this calculation$((Ro * 5)/Ve) - Ro$ with R0= 10kΩ, Ve output of the voltage across the resistor.

After obtaining the resistance of the thermistor, it was necessary to return the formula to obtain a temperature.

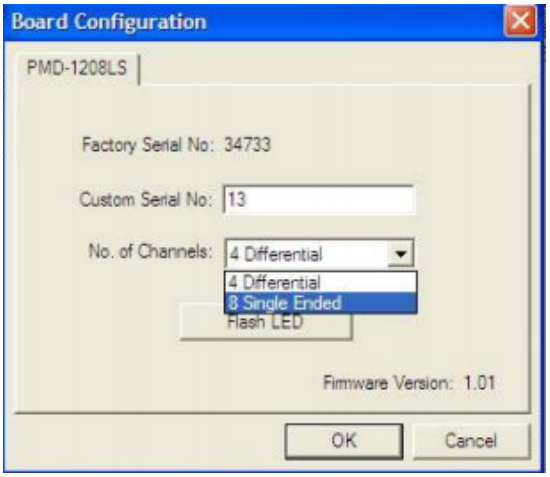
$$\frac{R_T}{R_0} = \exp\left(\beta \times \left(\frac{1}{T + 273,15} - \frac{1}{T_0 + 273,15}\right)\right)$$

(((To+273.5)*B)/(ln(Rt/Ro)*(To+273.15)+B))-273.15 with To = 25°C, B=3988 (given in the technical document), R0= 10kΩ.
After setting all the sensors on a labdec plate.

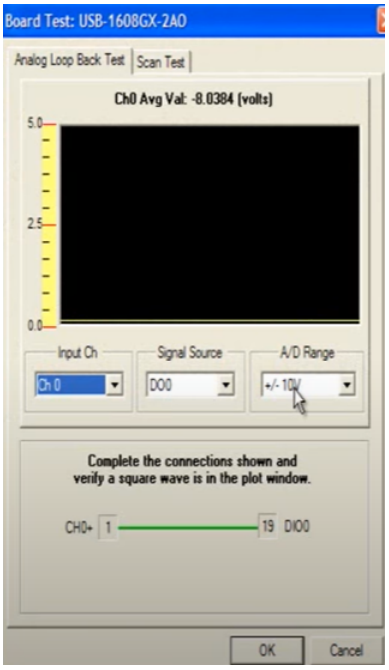


Processing / Analysis / Documentation

The data processing software is Labview. Thanks to this software, it is possible to analyze the data and then document it. The recovery of voltage values to go to labview via USB is using the DAQ module. The DAQ has several types of use. For our project, it had to be configured with the InstaCal software. The mode chosen for the inputs is Single Ended.

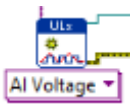
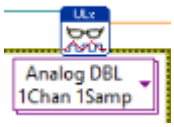
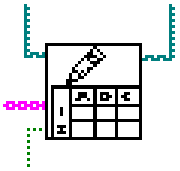
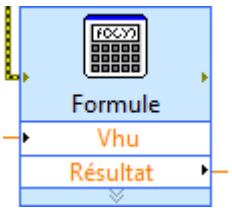


We could do some tests with this software. And we also took advantage of seeing if the DAQ is properly calibrated.

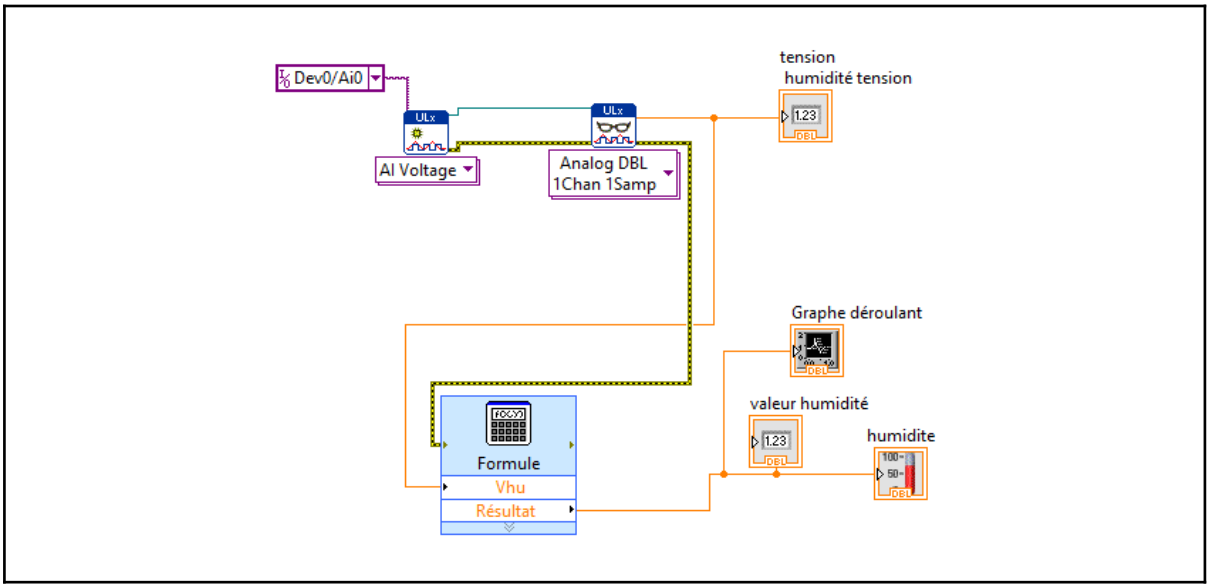


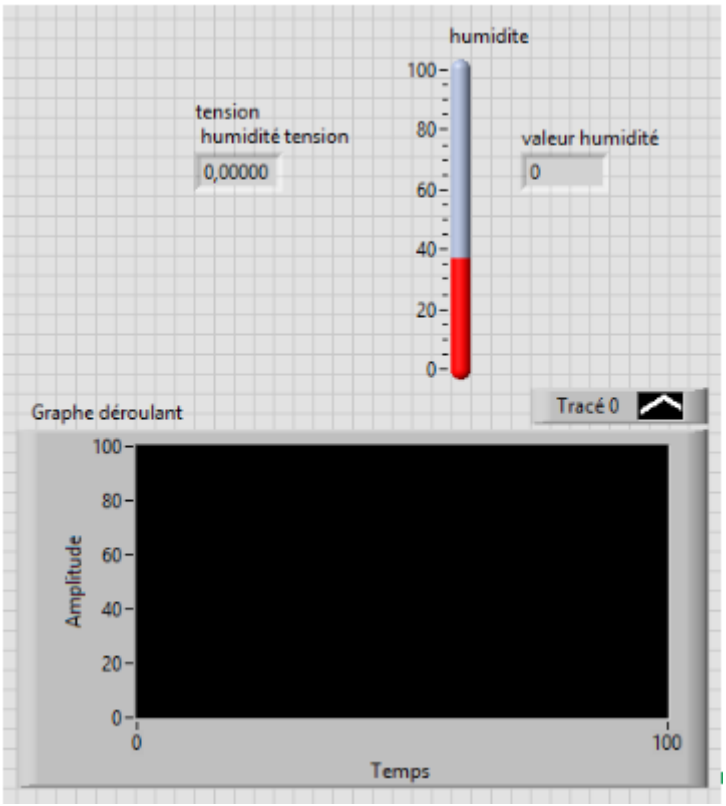
LABVIEW

For each sensor there is a labview to start with. For all labviews we use the same blocks for processing.

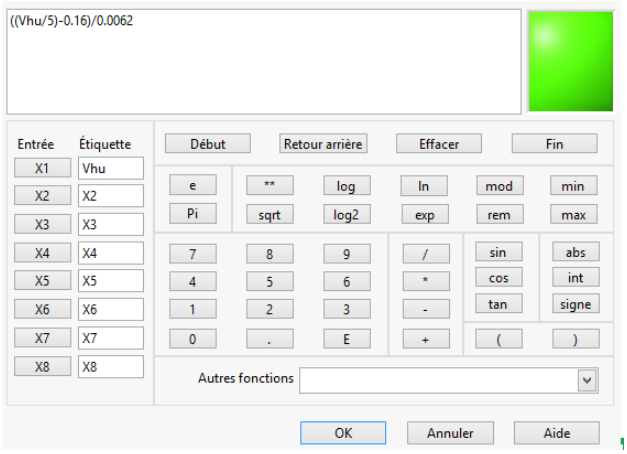
create channel 	Create files 
Read Analog 	 write to a file
Formula 	

The first sensor that is put in place is the humidity sensor.

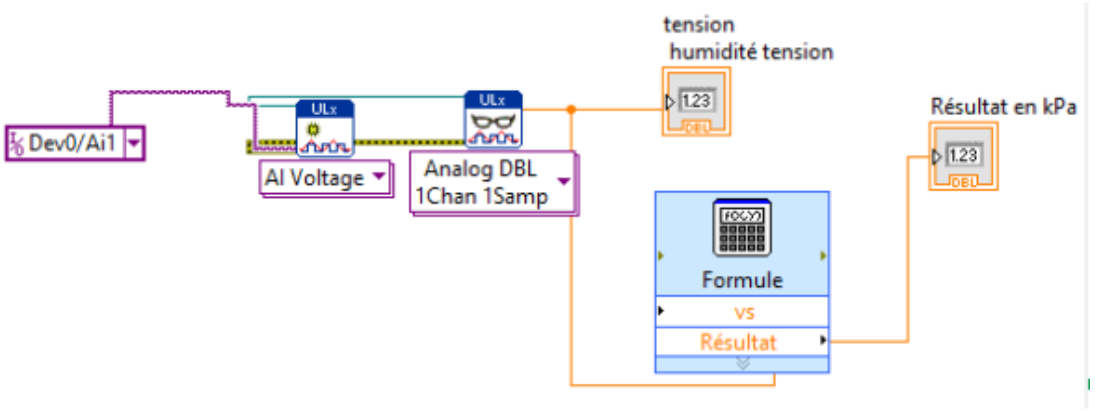


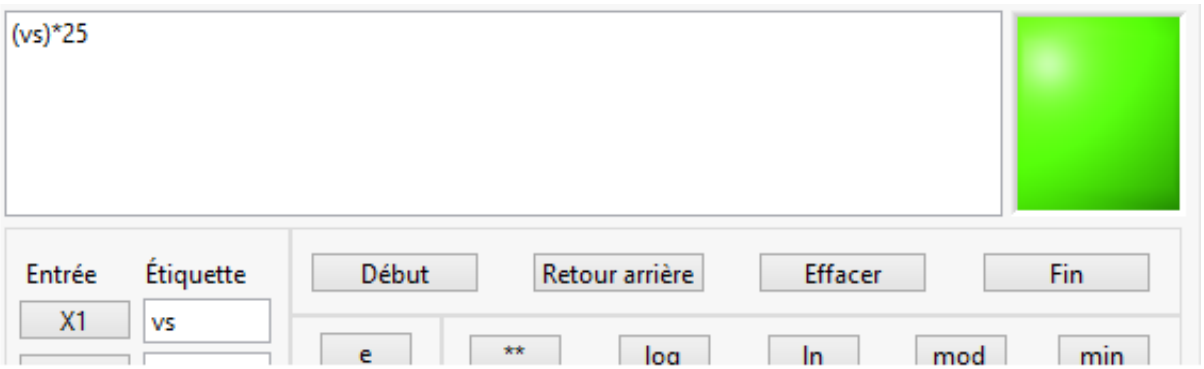


The formula is returned to the formula box.

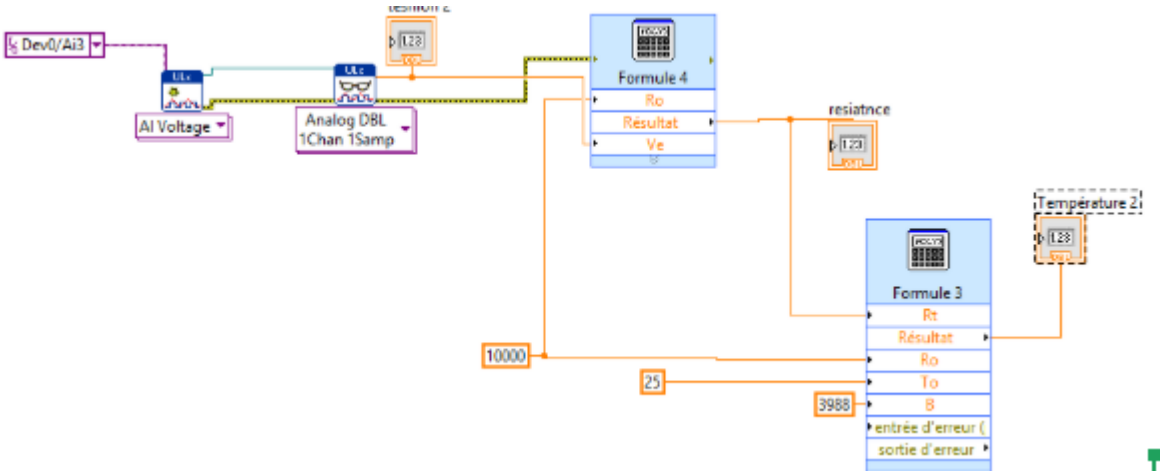


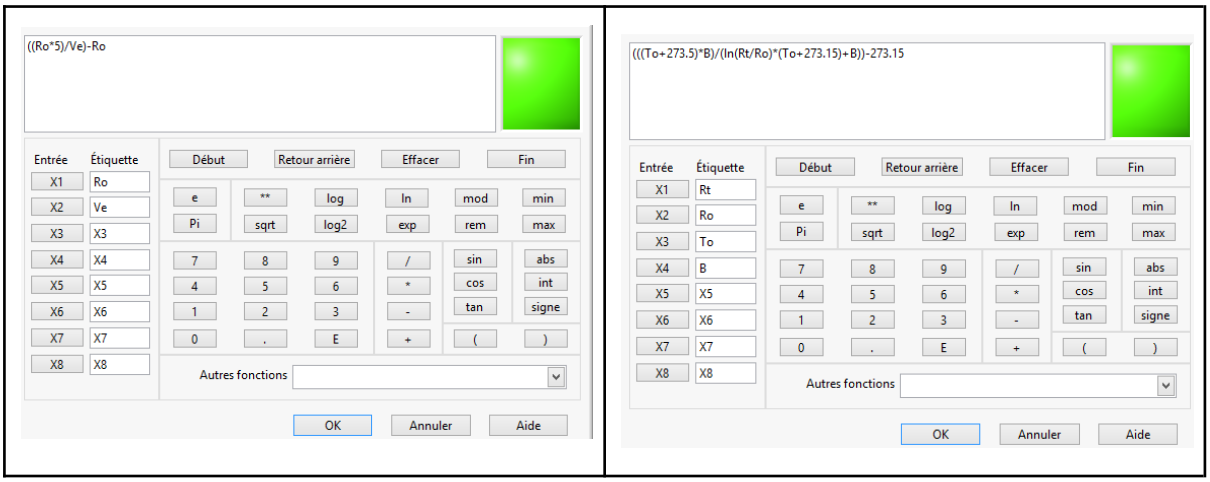
Then we repeat this for all the sensors.
The pressure sensor:





The temperature sensor is different because there are two formula boxes.


Dev0/Ai3
AI Voltage
Analog DBL
1Chan 1Samp
Formule 4
Ro
Résultat
Ve
resiatnce
Température 2
Formule 3
Rt
Résultat
Ro
To
B
entrée d'erreur (
sortie d'erreur
10000
25
3988


((Ro*5)/Ve)-Ro
Entrée
Étiquette
X1
Ro
X2
Ve
X3
X3
X4
X4
X5
X5
X6
X6
X7
X7
X8
X8
Début
Retour arrière
Effacer
Fin
e
Pi
**
sqrt
log
log2
ln
exp
mod
rem
min
max
7
8
9
/
4
5
6
*
1
2
3
-
0
.
E
+
sin
cos
tan
abs
int
signe
(
)
Autres fonctions
OK
Annuler
Aide
(((To+273.5)*B)/(ln(Rt/Ro)*(To+273.15)+B))-273.15
Entrée
Étiquette
X1
Rt
X2
Ro
X3
To
X4
B
X5
X5
X6
X6
X7
X7
X8
X8
Début
Retour arrière
Effacer
Fin
e
Pi
**
sqrt
log
log2
ln
exp
mod
rem
min
max
7
8
9
/
4
5
6
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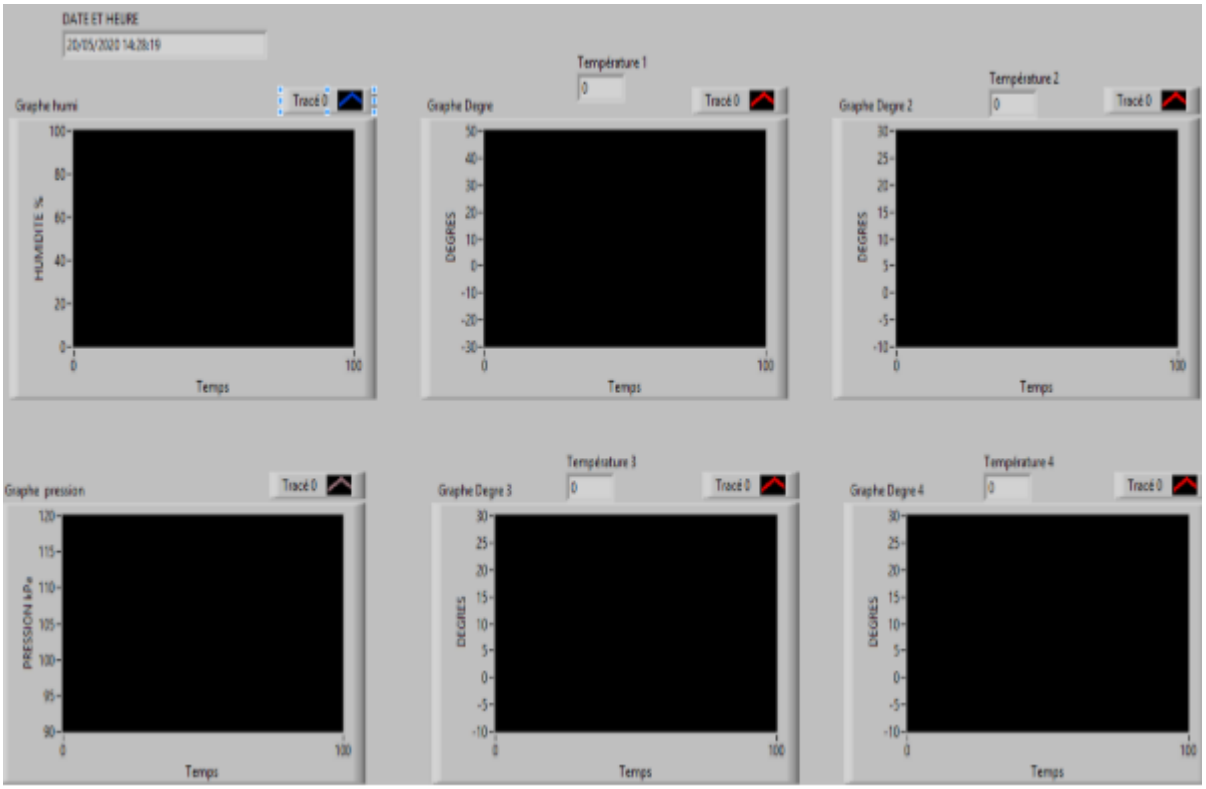
2
3
-
0
.
E
+
sin
cos
tan
abs
int
signe
(
)
Autres fonctions
OK
Annuler
Aide

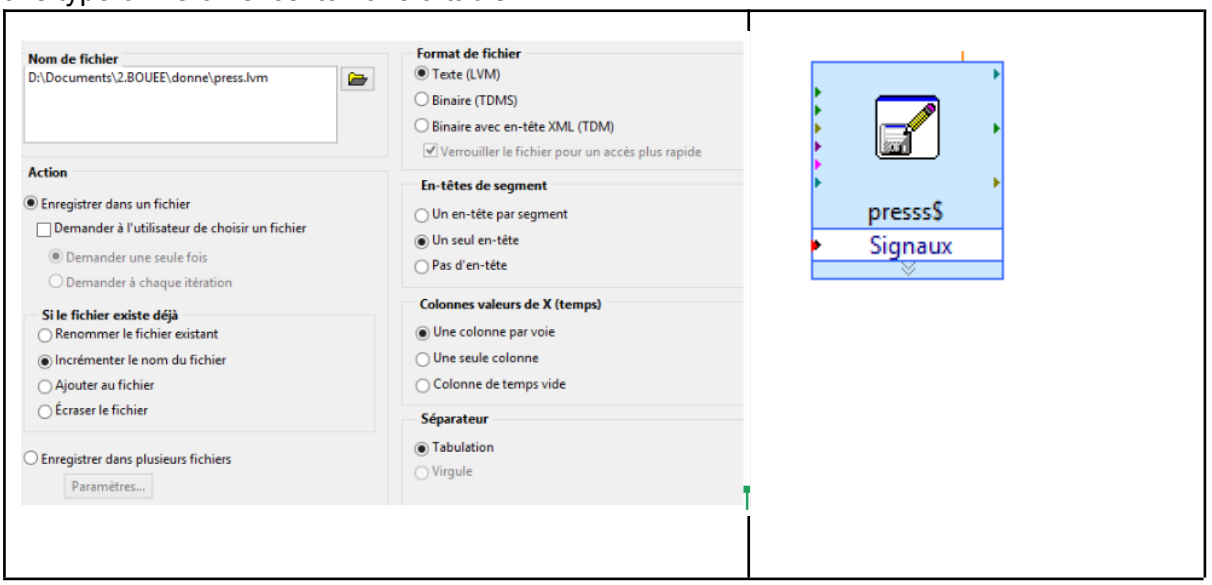
After having made each sensor, it was necessary to group them all together to have a single application. There was the creation of SUB-VI.

Here is the user interface

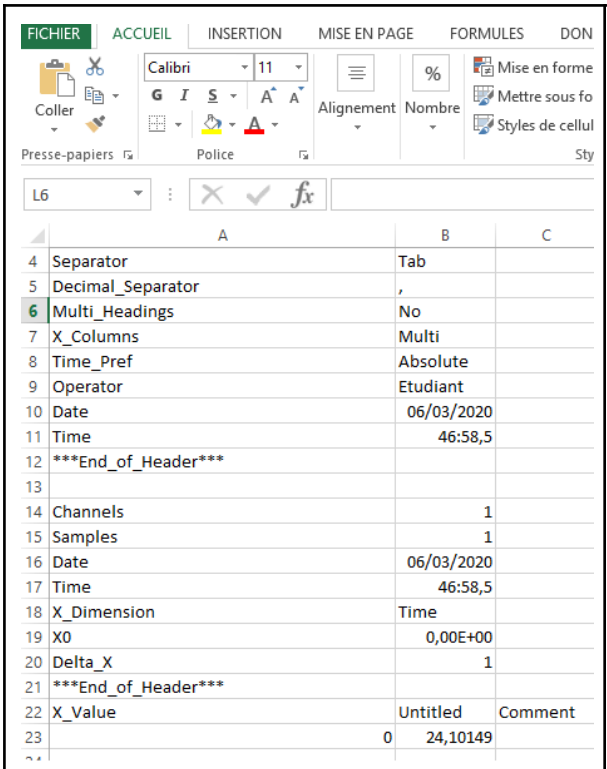


Documentation

The documentation of the data processed by labview is saved in an .lvm file. We can open this type of file on excel to have a table.



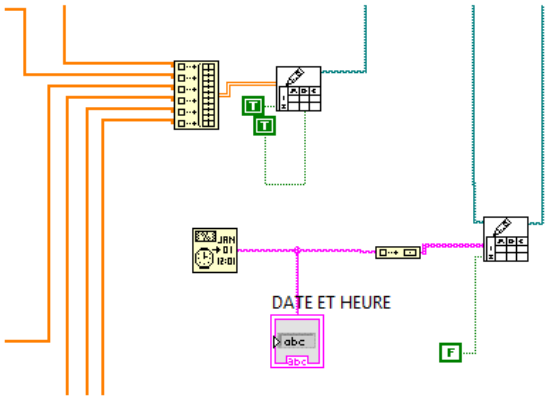
Here is an example of a saved file:



	A	B	C
4	Separator	Tab	
5	Decimal_Separator	,	
6	Multi_Headings	No	
7	X_Columns	Multi	
8	Time_Pref	Absolute	
9	Operator	Etudiant	
10	Date	06/03/2020	
11	Time	46:58,5	
12	***End_of_Header***		
13			
14	Channels	1	
15	Samples	1	
16	Date	06/03/2020	
17	Time	46:58,5	
18	X_Dimension	Time	
19	X0	0,00E+00	
20	Delta_X	1	
21	***End_of_Header***		
22	X_Value	Untitled	Comment
23	0	24,10149	

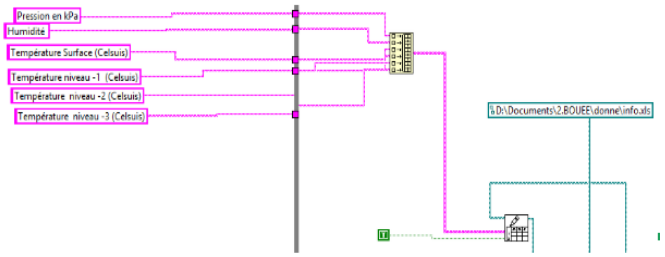
the values are saved at the end of the simulation. There is a file for each sensor.

There is a method that allows to gather all the values in an excel. There are several parameters.



the orange lines are the sensor values.

there is also the date and time part



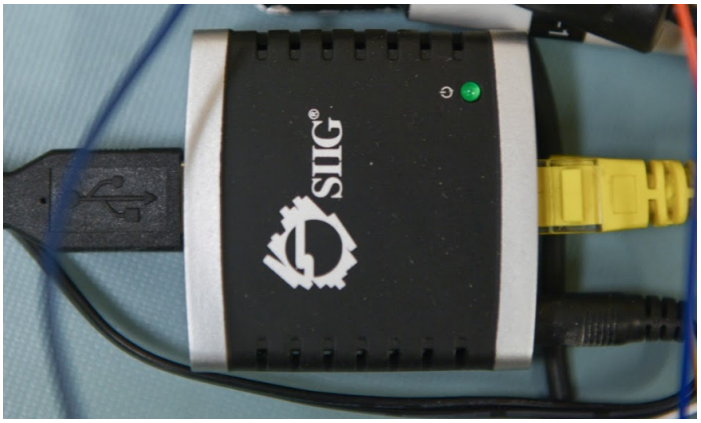
adding titles for each column

With the covid-19 situation I could not have an example of a clean excel file. I redid a file that looks like the project file.

1	20/05/2020 15:43					
2	pression en Kpa	Himidité	temperature Surface (celuis)	T°C -1	T°C -2	T°C -3
3	xxx	xx	xx	xx	xx	xx
4	xxx	xx	xx	xx	xx	xx
5	xxx	xx	xx	xx	xx	xx
6	xxx	xx	xx	xx	xx	xx

With the RF link, we encountered problems because as the link was quite long, the Labview software sent us error messages. Error handling is missing.

We have a problem from the beginning of the project the distance between the buoy and the hut. A USB cable cannot be used over a maximum distance of 5 meters. So my colleague advised me the RJ45 cable. So we use a USB to RJ45 converter. In addition, the RJ45 cable is resistant to water and temperatures in Canada.

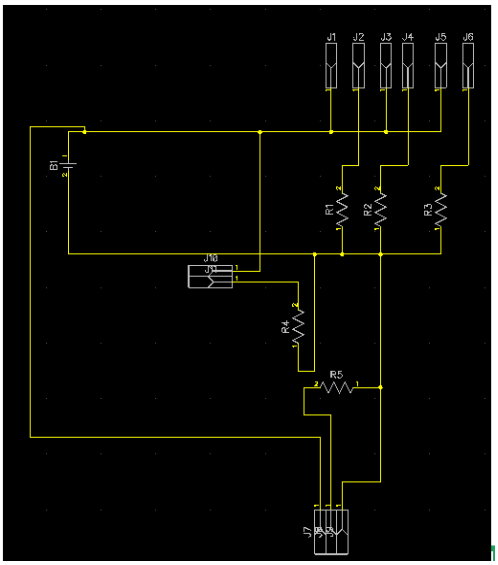


The setup was quite simple. it has a very intuitive software. You have to be in the same network.
One of the big constraints of this project is of course on the water. We had to think about the question of sealing. for those who are thermistors, there was the use of sheath heat shrinkable.

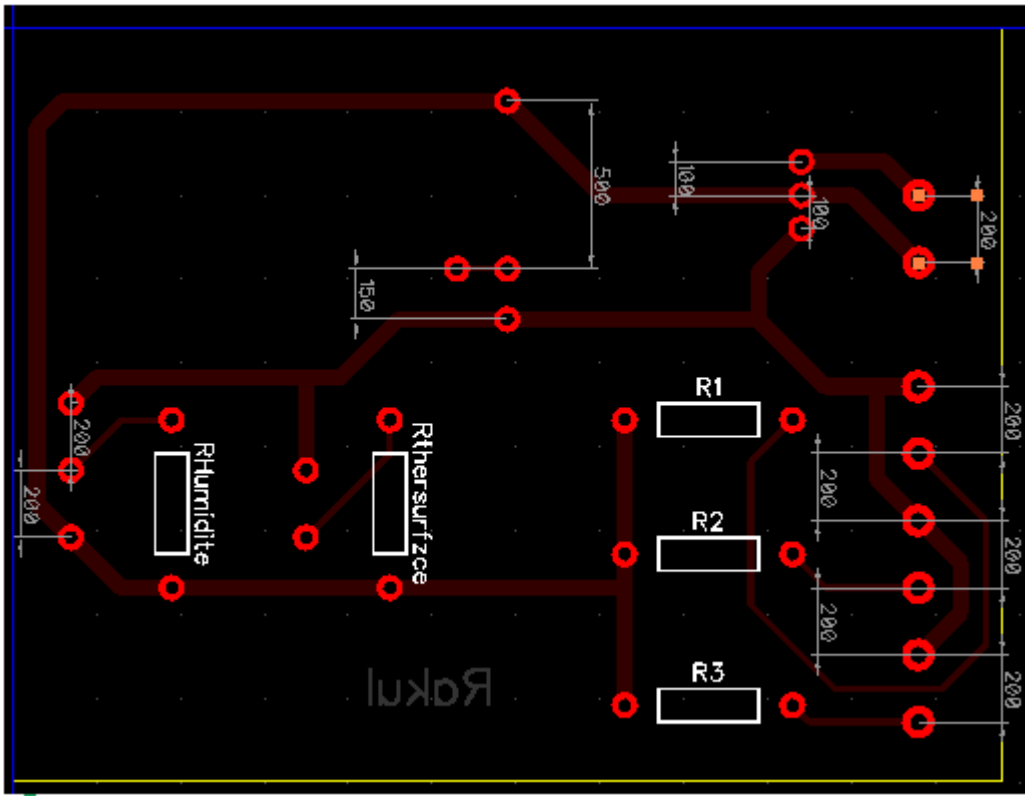
After tests are performed on a thermistor then when it all worked we repeat this step 3 times as there are four different levels.

PCB

In the middle of the project, like the part on the breadboard is finished. The teacher advised me to make a pcb to put them all in a waterproof box. Thanks to DIptrace software.

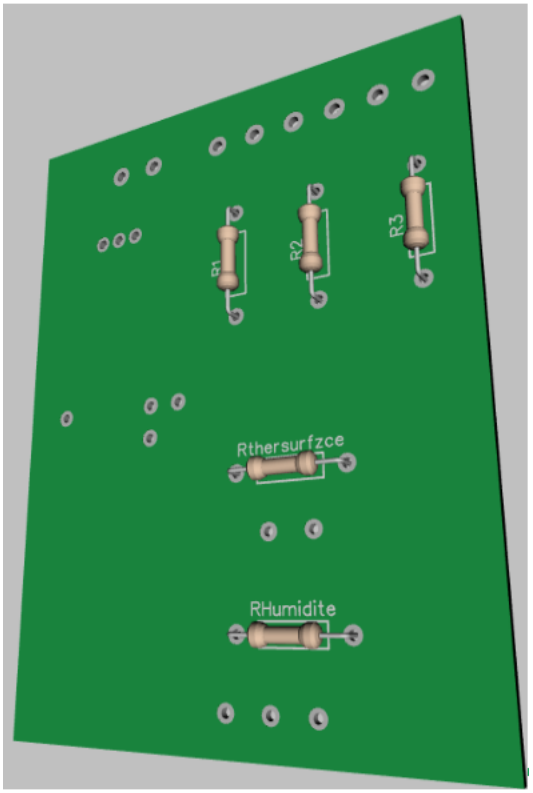


The screenshot above is an electrical schematic. But the software did not include all the components so we had to create footprints.



it was necessary to create footprints for connectors. The technician advised me to increase the size of the holes.

Here is the 3D version of the PCB.



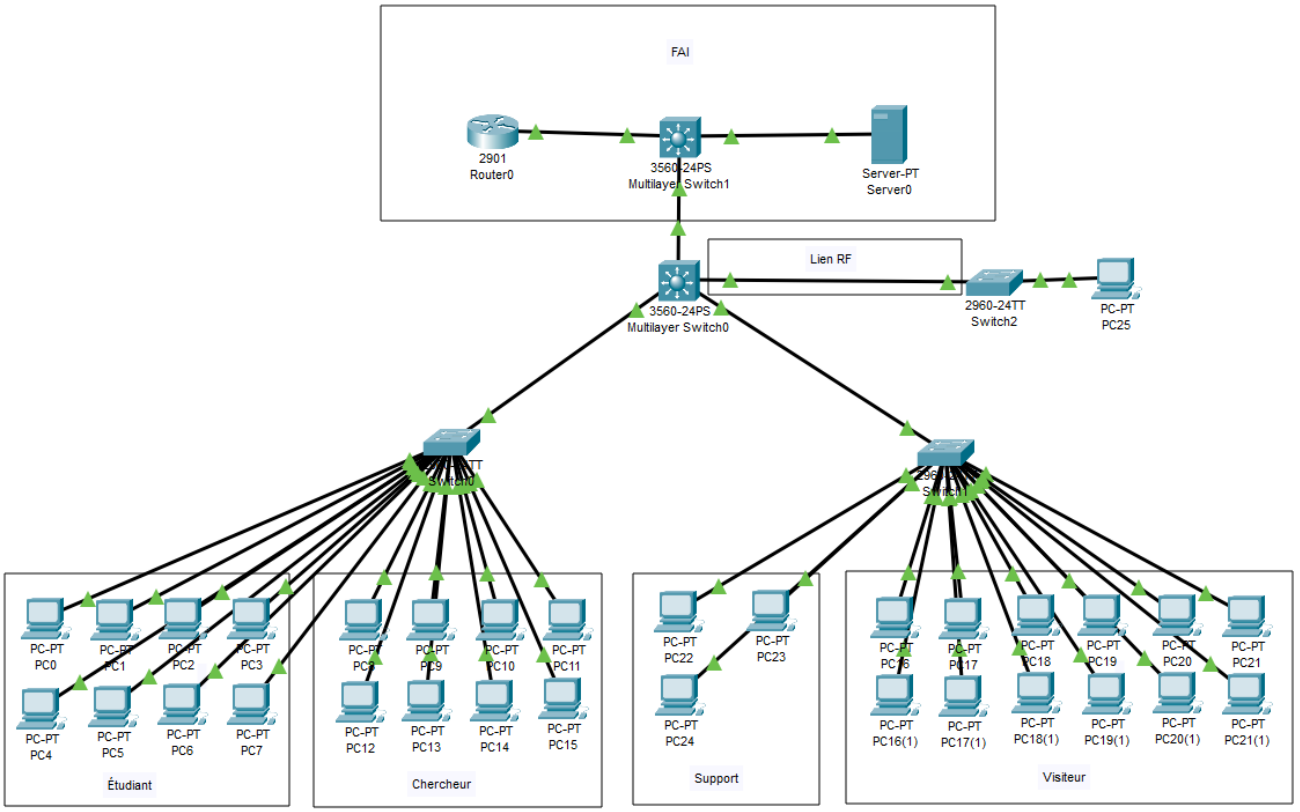
Possible developments.

With the covid-19 it was impossible to design a structure for the buoy but the idea is to use an RJ45 cable for the thermistors. After soldering all the components on the pcb, put in a waterproof box with the DAQ and the USB to RJ45 converter. Use a wooden or metal structure to immerse it in the lake with the thermistors. For the energy question was optional but it was possible to put a battery connected to a solar panel or a wind turbine as one is in a lake.

The network

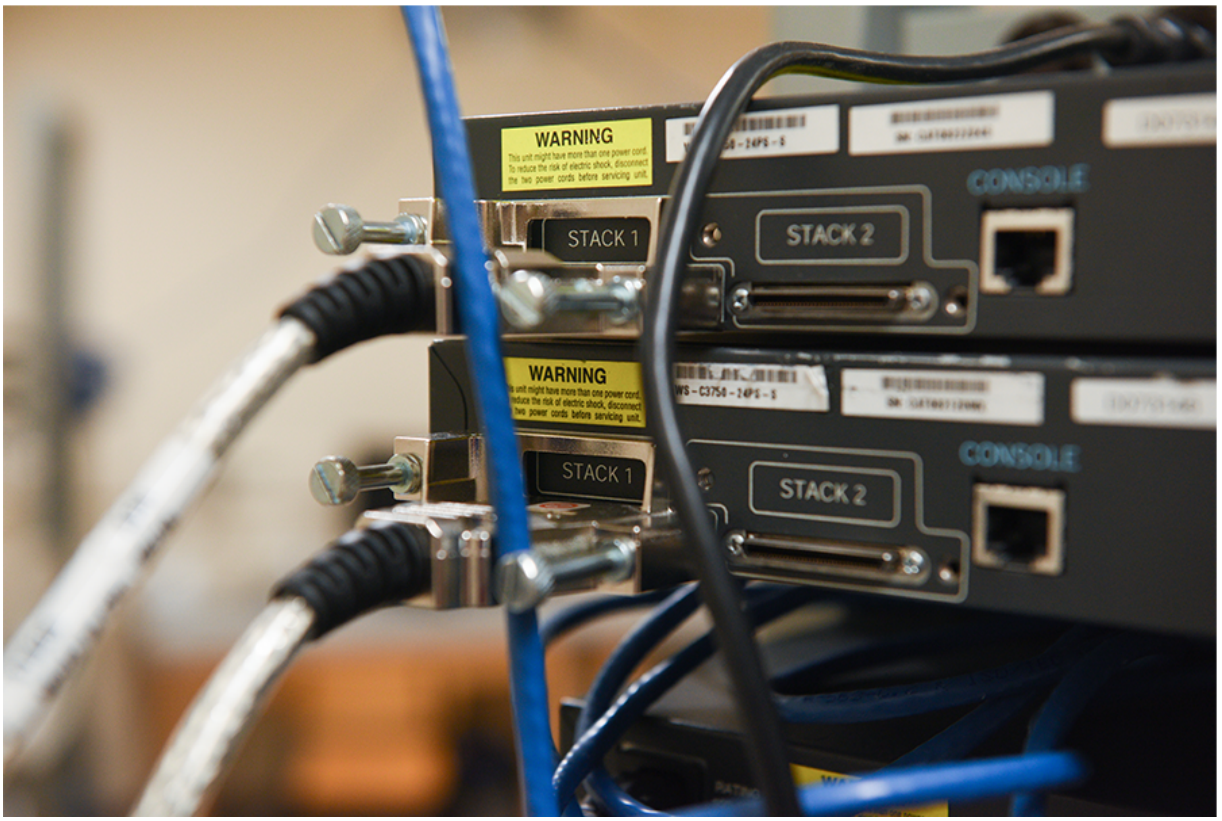
Conception

The network consists of two 3750 switches configured in StackWise and three other 2950 switches to complete the distribution of the network. One of the switches is placed close to the lake on the other side of the RF link to connect to the buoy and the USB to RG-45 adapter. At the end devices there are a total of 31 computer stations including 8 for students, 8 for researchers, 12 stations for visitors and 3 stations with access to SSH and Telnet for network support.


FAI
2901
Router0
3560-24PS
Multilayer Switch1
Server-PT
Server0
Lien RF
3560-24PS
Multilayer Switch0
2960-24TT
Switch2
PC-PT
PC25
PC-PT
PC0
PC-PT
PC1
PC-PT
PC2
PC-PT
PC3
PC-PT
PC4
PC-PT
PC5
PC-PT
PC6
PC-PT
PC7
Étudiant
PC-PT
PC8
PC-PT
PC9
PC-PT
PC10
PC-PT
PC11
PC-PT
PC12
PC-PT
PC13
PC-PT
PC14
PC-PT
PC15
Chercheur
PC-PT
PC22
PC-PT
PC23
PC-PT
PC24
Support
PC-PT
PC16
PC-PT
PC17
PC-PT
PC18
PC-PT
PC19
PC-PT
PC20
PC-PT
PC21
PC-PT
PC16(1)
PC-PT
PC17(1)
PC-PT
PC18(1)
PC-PT
PC19(1)
PC-PT
PC20(1)
PC-PT
PC21(1)
Visiteur

StackWise

StackWise configuration allows multiple switches to be configured as one switch. You should know that the switches must have the same IOS with the command*#show version*. To choose which switch will have the role of master, you must first check that the switches communicate from the StackWise cable with the command*#show switch*. Thereafter it is possible to change the stack member number with the command *#switch (stack-member-number) priority (new- priority-number)* the switch with the highest number will be master after restarting the switches. At the beginning since I had two 3750 switches with different number of ports the stackWise was impossible to solve the problem so I used two switches with the same number of ports.



Vlsm

The largest subnet will be for visitors with 13 IP addresses considering the address on the 3750. The subnet for researchers must contain 10 addresses with the 8 stations, the 3750 switch and the adapter address USB networks. Then the student subnet has 9 addresses needed. Finally, the last subnet is for the support team contains 7 addresses with the 3 stations and the 4 switches. Later I realized that I had forgotten the 4 addresses needed for the antennas, but since the support subnet was already big enough there was no need to redo the vlsm.

Adresse du réseaux: 192.168.2.0/24 = 11000000.10101000.00000010.00000000

Hôte pour sous-réseaux:

Visiteur = 13 hôtes Chercheur = 10 hôtes Étudiant = 9 hôtes Support = 7 hôtes

Masque de sous-réseau décimal à point	Masque de sous-réseau binaire	Notation de barre oblique	Nombre de bits d'hôtes	Hôtes possibles 2^n-2
255.255.255.240	11111111.11111111.11111111.11110000	/28	4	14
255.255.255.248	11111111.11111111.11111111.11111000	/29	3	6
255.255.255.252	11111111.11111111.11111111.11111100	/30	2	2

Visiteur:

Adresse sous-réseaux: 192.168.2.0/28 = xxx.xxx.xxx.00000000

Masque sous-réseaux: 255.255.255.240 = xxx.xxx.xxx.11110000

Adresse de diffussion: 192.168.2.15/28 = xxx.xxx.xxx.00001111

Chercheur:

Adresse sous-réseaux: 192.168.2.16/28 = xxx.xxx.xxx.00010000

Masque sous-réseaux: 255.255.255.240 = xxx.xxx.xxx.11110000

Adresse de diffussion: 192.168.2.31/28 = xxx.xxx.xxx.00011111

Étudiant:

Adresse sous-réseaux: 192.168.2.32/28 = xxx.xxx.xxx.00100000

Masque sous-réseaux: 255.255.255.240 = xxx.xxx.xxx.11110000

Adresse de diffussion: 192.168.2.47/28 = xxx.xxx.xxx.00101111

Support:

Adresse sous-réseaux: 192.168.2.48/28 = xxx.xxx.xxx.00110000

Masque sous-réseaux: 255.255.255.240 = xxx.xxx.xxx.11110000

Adresse de diffussion: 192.168.2.63/28 = xxx.xxx.xxx.00111111

Network name	Host needed	Given host	Address	Masque	Usable address range	Broadcast address
Visitor (Vlan 20)	13	14	192.168.2.0	/28	192.168.2.1 to 192.168.2.14	192.168.2.15
Searcher (Vlan 21)	10	14	192.168.2.16	/28	192.168.2.17 to 192.168.2.30	192.168.2.31
Student (Vlan 22)	9	14	192.168.2.32	/28	192.168.2.33 to 192.168.2.46	192.168.2.47
Support	7	14	192.168.2.48	/28	192.168.2.49	192.168.2.63

(Vlan 23)					to 192.168.2.62	

Vlan et inter-vlan

It is necessary to create a vlan for each subnet determined by the vlsm so there must be 4 new vlans in the network. Vlan 20 is the one used for visitor workstations, vlan 21 is for researcher workstations, vlan 22 is for student workstations and vlan 23 is for support. Each vlan must have an IP address belonging to their respective subnet on the switch 3750 for inter-vlan routing by activating ip routing. Vlans 200 and 100 need to have an address for the inter-vlan. Vlan 99 is the native vlan that will be used as a trunk vlan to tie the different switches together. On 2950 switches it is necessary to associate the vlans with the interfaces that are used and give a support address in vlan 23. It is also necessary to shutdown all the unused interfaces.

```
3750(config)#ip routing

3750(config)#interface Vlan20
3750(config-if)#ip address 192.168.2.14 255.255.255.240
3750(config)#interface Vlan21
3750(config-if)# ip address 192.168.2.30 255.255.255.240
3750(config)#interface Vlan22
3750(config-if)#ip address 192.168.2.46 255.255.255.240
3750(config)#interface Vlan23
3750(config-if)#ip address 192.168.2.62 255.255.255.240
3750(config)#interface Vlan99
3750(config)#interface Vlan100
3750(config-if)#ip address 192.168.100.102 255.255.255.0
3750(config)#interface Vlan200
3750(config-if)#ip address 192.168.200.202 255.255.255.0

2950_1(config)#interface range f0/1 - 12
2950_1(config-if)#switchport access vlan 20
2950_1(config-if)#switchport mode access
```

DHCP

For dhcp you must first exclude all addresses that are already used by switches, antennas and the USB network adapter. Each vlan must have its own dhcp group to give the addresses of the subnets to the right stations according to the vlsm calculation done previously. The default router for each dhcp group is the address of the vlans on the 3750 switch. Each station will therefore receive an ip address that is part of the vlan that is configured on the ports of the 2950 to which the computer is connected.

Address table:

Périphérique	Interface	Adresse IP	Masque de sous-réseau
Distribution	Vlan 20	192.168.2.14	255.255.255.240
	Vlan 21	192.168.2.30	255.255.255.240
	Vlan 22	192.168.2.46	255.255.255.240
	Vlan 23	192.168.2.62	255.255.255.240
	Vlan 100	192.168.100.102	255.255.255.0
	Vlan 200	192.168.200.202	255.255.255.0
Switch1	Vlan 23	192.168.2.61	255.255.255.240
Switch2	Vlan 23	192.168.2.56	255.255.255.240
Switch_Lac	Vlan 23	192.168.2.55	255.255.255.240
Antenne 1	Vlan 23	192.168.2.57	255.255.255.240
Antenne 2	Vlan 23	192.168.2.58	255.255.255.240
Antenne 3	Vlan 23	192.168.2.59	255.255.255.240
Antenne 4	Vlan 23	192.168.2.60	255.255.255.240
USB adapteur RG-45	Vlan 21	192.168.2.29	255.255.255.240

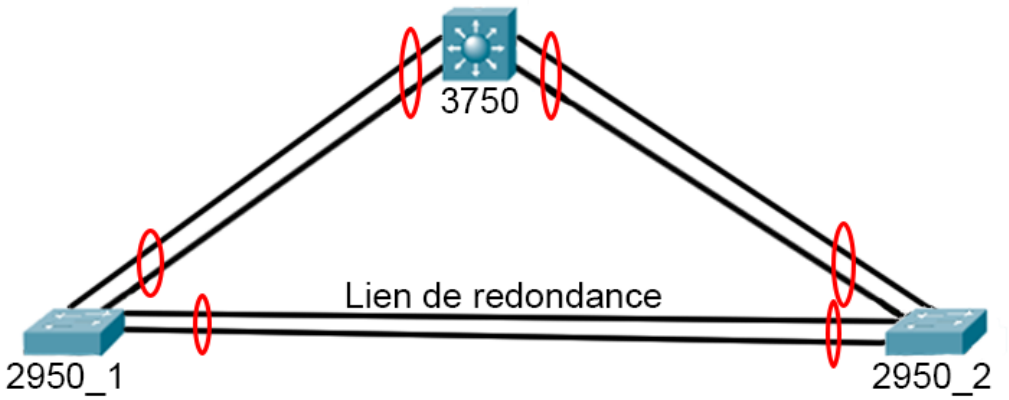
3750(config)#ip dhcp excluded-address 192.168.2.14
3750(config)#ip dhcp excluded-address 192.168.2.29
3750(config)#ip dhcp excluded-address 192.168.2.30
3750(config)#ip dhcp excluded-address 192.168.2.46
3750(config)#ip dhcp excluded-address 192.168.2.62
3750(config)#ip dhcp excluded-address 192.168.2.55
3750(config)#ip dhcp excluded-address 192.168.2.56
3750(config)#ip dhcp excluded-address 192.168.2.57
3750(config)#ip dhcp excluded-address 192.168.2.58
3750(config)#ip dhcp excluded-address 192.168.2.59
3750(config)#ip dhcp excluded-address 192.168.2.60
3750(config)#ip dhcp excluded-address 192.168.2.61

3750(config)#ip dhcp pool Visiteur
3750(dhcp-config)# network 192.168.2.0 255.255.255.240
3750(dhcp-config)#default-router 192.168.2.14
3750(config)#ip dhcp pool Finder
3750(dhcp-config)#network 192.168.2.16 255.255.255.240
3750(dhcp-config)#default-router 192.168.2.30
3750(config)#ip dhcp pool Etudiant
3750(dhcp-config)#network 192.168.2.32 255.255.255.240
3750(dhcp-config)#default-router 192.168.2.46
3750(config)#ip dhcp pool Support
3750(dhcp-config)#network 192.168.2.48 255.255.255.240
3750(dhcp-config)#default-router 192.168.2.62

Etherchannel and redundancy

There are a total of 3 etherchannel links to be made in the network two of these links are from the 3750 switch to the other two 2950 switches. The other link is between the two 2950 switches for redundancy. All etherchannel links must be configured in trunk mode to pass all vlans on the network. To ensure that the spanning tree works correctly it is necessary to change the cost of the links in the network to be sure that the cost of the link between the 2950 is the highest of the other links with the command#*show switch spanning-tree*. The protocol used for the links is the LACP there is no real reason I just had to choose a protocol to create the etherchannel link. In the prototype all etherchannel links used all four ports. The cables used between the two 2950s had to be crossover cables since the 2950s do not support MDI-X.

```
3750(config)# interface range f0/20 -24
3750(config-if-range)# switchport encapsulation dot1q
3750(config-if-range)# switchport mode trunk
3750(config-if-range)#switchport trunk allowed vlan 20,21,22,23,100,200
3750(config-if-range)# switchport trunk native vlan 99
3750(config-if-range)# channel-group 1 mode active
3750(config-if-range)# end

3750(config)# interface port-channel 1
3750(config-if)# spanning-tree cost ?(Desired cost for the link)
```



RIP and default route

The rip routing protocol allows several neighboring routers to communicate with each other and share routing information. It is important to declare the network address that was used for the vlsm. The RIP protocol must be configured in version 2 since RIPv1 does not support vlsm. The default route is given automatically by the switch representing the ISP. The port that is connected to the ISP must also be configured as a trunk on vlan 99.

```
3750(config)#router rip
3750(config-router)#version 2
3750(config-router)#network 192.168.2.0
3750(config-router)#no auto-summary
3750(config-router)#end
```

Switch at the hut

The switch installed at the hut is for putting vlan 21 (seeker) on the interface to which the USB to RG-45 adapter is connected. The interface that is connected to the RF link must be configured as a trunk and the 3750 router must have the same trunk configuration as the interface connected to the RF link.

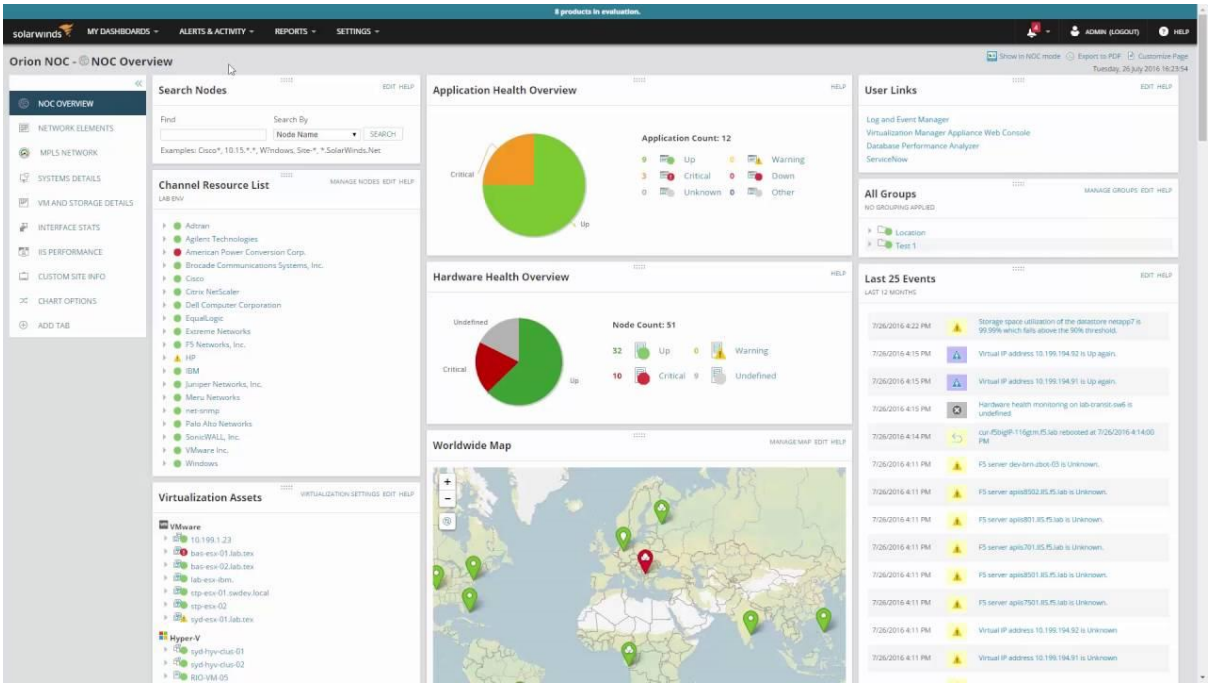
```
2950_Lac(config)# interface range f0/2 - 3
2950_Lac(config-if-range)#switchport access vlan 21
2950_Lac(config-if-range)#switchport mode access

2950_Lac(config)# interface f0/1
2950_Lac(config-if)# switchport encapsulation dot1q
2950_Lac(config-if)# switchport mode trunk
2950_Lac(config-if)# switchport trunk allowed vlan 20,21,22,23,100,200
2950_Lac(config-if)# switchport trunk native vlan 99
```

Network monitoring and SolarWinds

Network monitoring is done with the snmp protocol configured on network devices with a SolarWinds server as the monitoring host. To configure the snmp on a switch, it must be given a community string so that the SolarWinds server can find it. By connecting to the SolarWinds server it is possible to search the networks to find devices with snmp enabled. When all the devices are seen in SolarWinds, it was necessary to create a visualization interface for all the network components, both the switches and the antennas, but this could not be done given the circumstances surrounding the covid-19 pandemic.

```
3750(config)#snmp-server community Equipe2  RO
```

Exemple d’interface SolarWinds:



Security

Each switch has a console password and a privileged exec password. This password is then encrypted with the command#*service password-encryption*.

3750(config)#enable secret support123
3750(config)#line con 0
3750(config-line)#password support321
3750(config-line)#login
3750(config-line)#end
3750(config)#service password-encryption

SSH and Telnet

The only switch supporting SSH is the 3750. The version of SSH used is version 2. A global authentication username and password must be configured. To configure the SSH it is necessary to configure activated the local login on the vty 0 4 to have a maximum of 5 sessions. It must also be specified that the only protocol authorized to configure the switch remotely is SSH. An RSA key must be generated to encrypt SSH communication. A domain name is necessary to give the name of the RSA key.

3750(Config)# ip ssh version2
3750(config)# ip domain-name projet2.com
3750(Config)# username tech password support321
3750(Config) # line VTY 0 4
3750(Config-line)# login local
3750(Config-line)#transport input ssh

3750(Config-line)# exit
3750(Config)# crypto key generate rsa
how many bits in the modulus [512] :1024

For 2950 switches since it does not support SSH, they are configured with Telnet. A password must be configured and the Telnet transport.

2950_1(Config) # line VTY 0 4
2950_1(Config-line)#password support321
2950_1(Config-line)#transport input telnet
2950_1(Config-line)#login
2950_1(Config-line)# Exit

Access list

For access lists it was impossible to even start configuration before the covid-19 pandemic. It was therefore impossible to test the configurations of the access lists so only the explanation of what the access list is supposed to do in the network. The visitor subnet only has access to the internet. The researcher subnet is only blocked on the support subnet. The student subnet is also blocked on the support subnet. The support network has no restrictions to ensure that he can access the entire network.

Lien RF

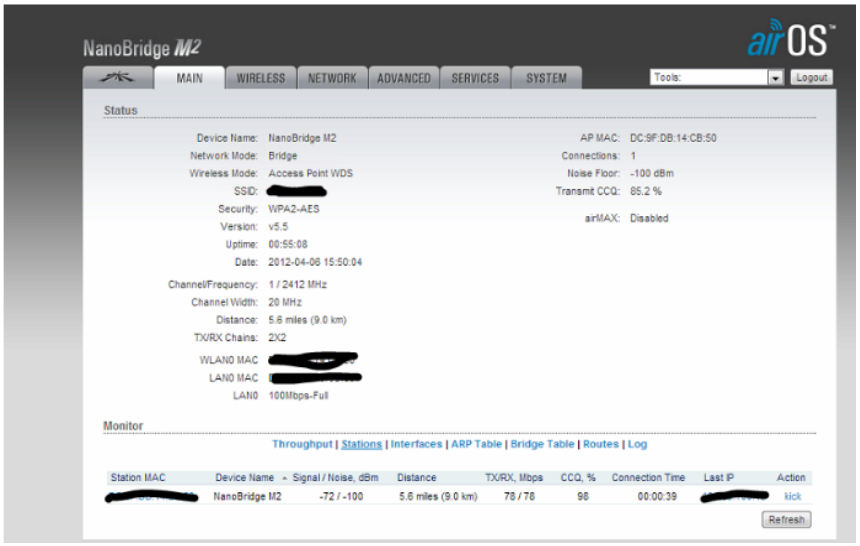
The link that must be made for the project consists of a link between the Cégep de Rimouski and a hut near Lac à l'anguille. Since the lake and the CEGEP are separated by mountains, it is necessary to have 2 repeaters to be able to reach the destination which is the hut. This will therefore create three links to get to the lake. The antennas used are Ubiquitis as requested in the specifications. Then there were already antennas at our disposal. They were NanoBridge M2s. There is a verification of the characteristics of the antennas. Setting up the antennas was simple, you have to put them in the same network.

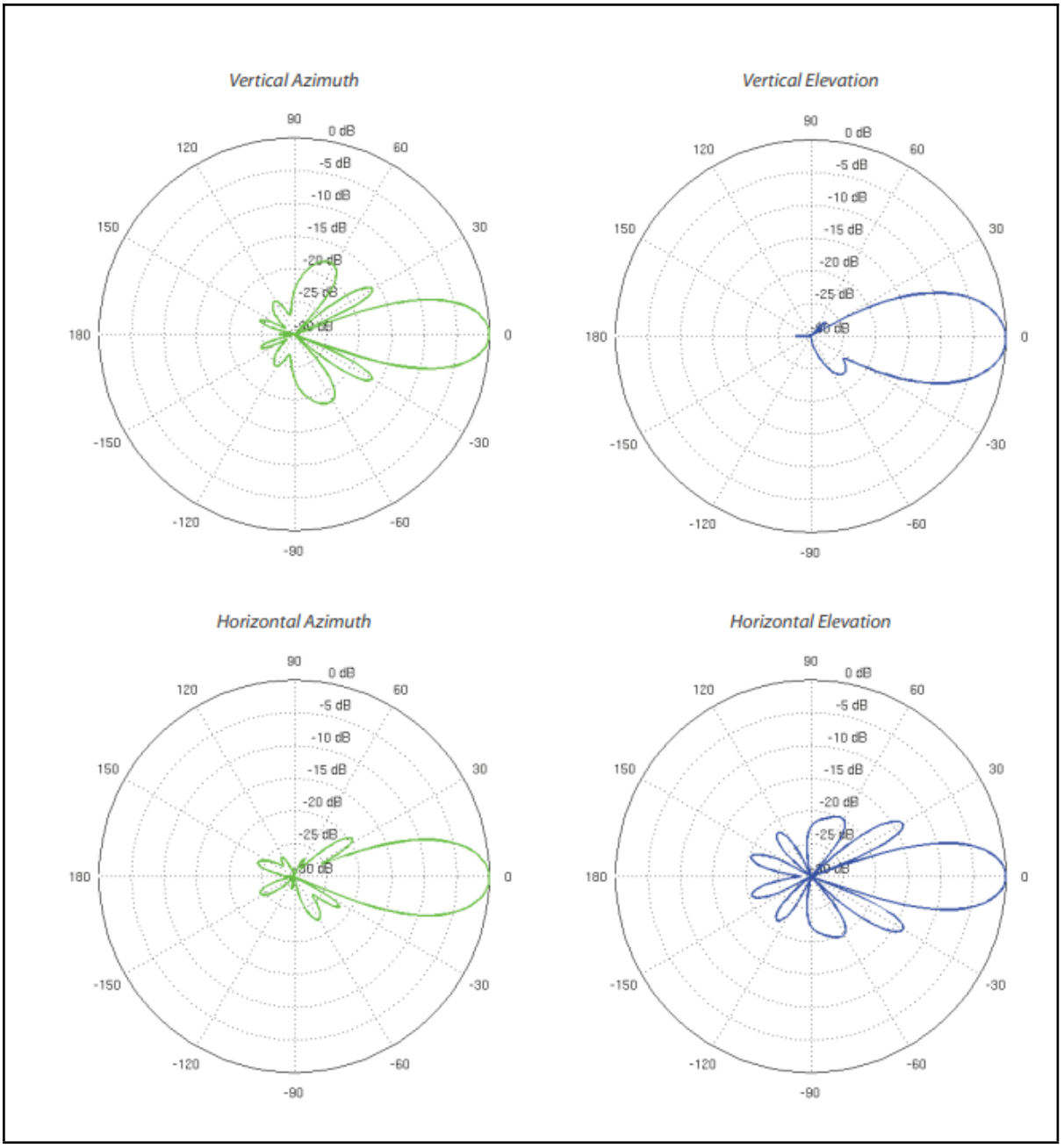
NanoBridge M2

Model	Frequency	Gain
NB-2G18	2.4 GHz	18 dBi

As there are two relays; the prototype is with 4 antennas to simulate a point and relay. The relay antennas are connected with the same lan link with the boxes.

You must choose the access point mode in the antenna settings. Then assign names for each antennas and their roles. The photo below shows an example because we have no access to our equipment with this situation.

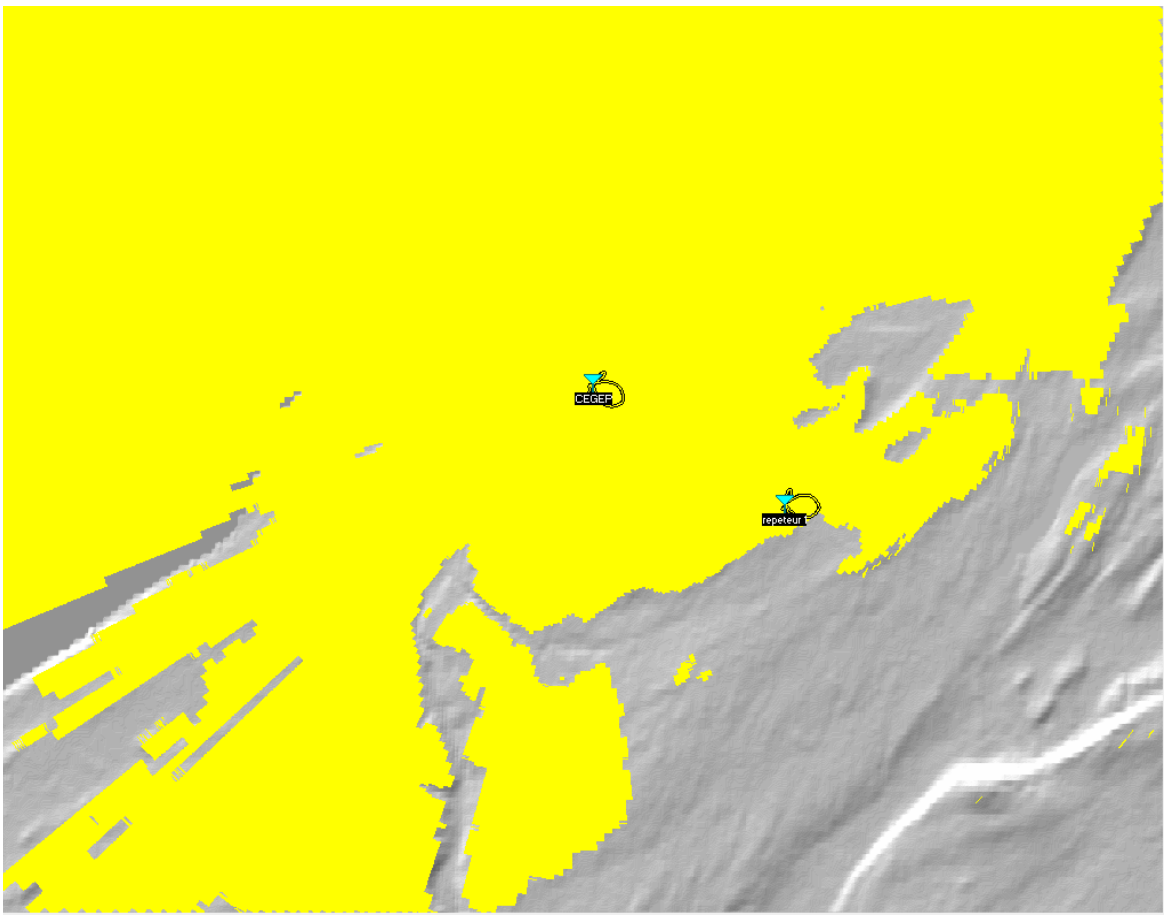


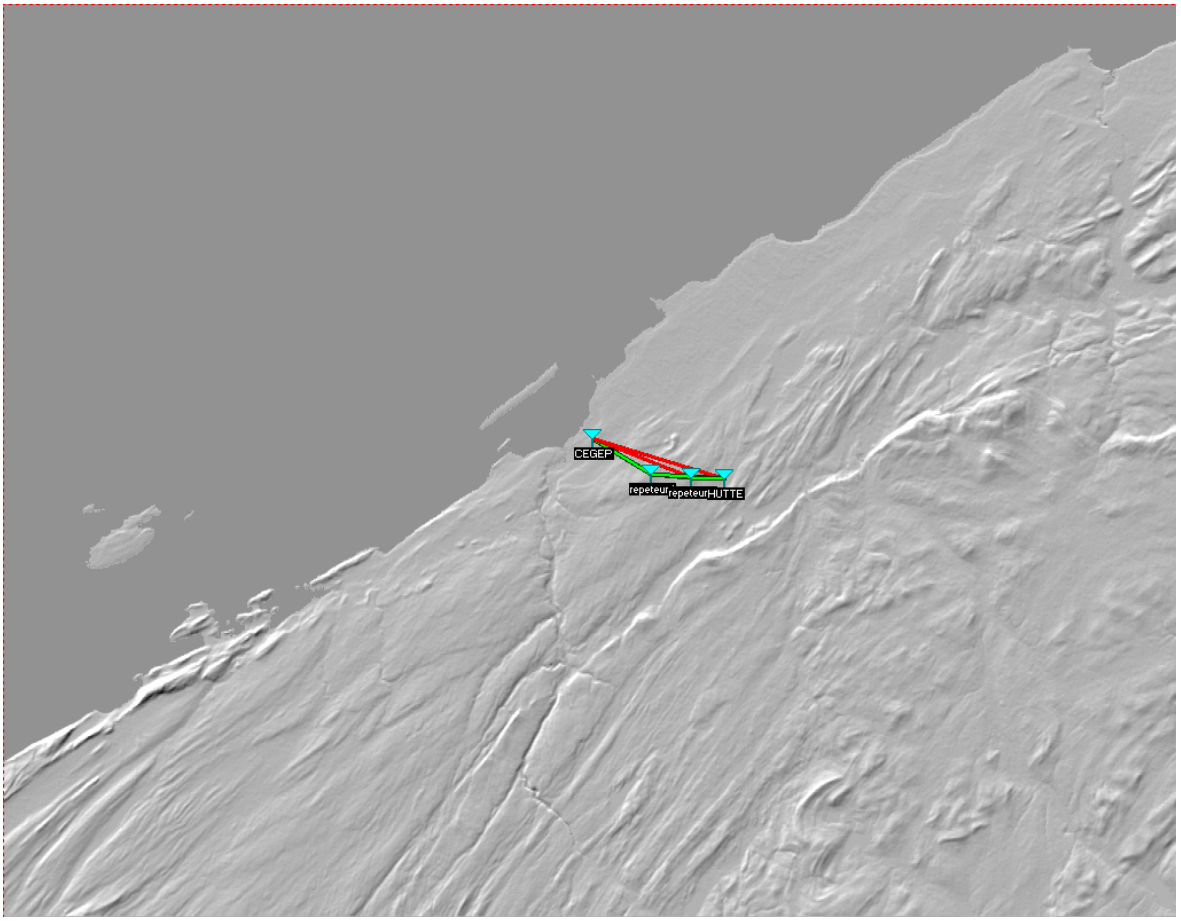


With the patterns, we see that these antennas are directional, which corresponds very well to the project.

Simulation

The simulation was done in the Radio Mobile program which allows to create RF link simulations. During the preparation of the oral presentation it was discovered that the simulation had been configured from the NanoBridge M5 antenna instead of NanoBridge M2, but since it was too late to redo the simulation and all the theoretical calculations the simulation which uses NanoBridge M5 is going to be the one featured in the report. The polar coverage simulation allows to know where it is possible to place the next antenna. With this it was possible to find a way to get to the hut at the eel lake.

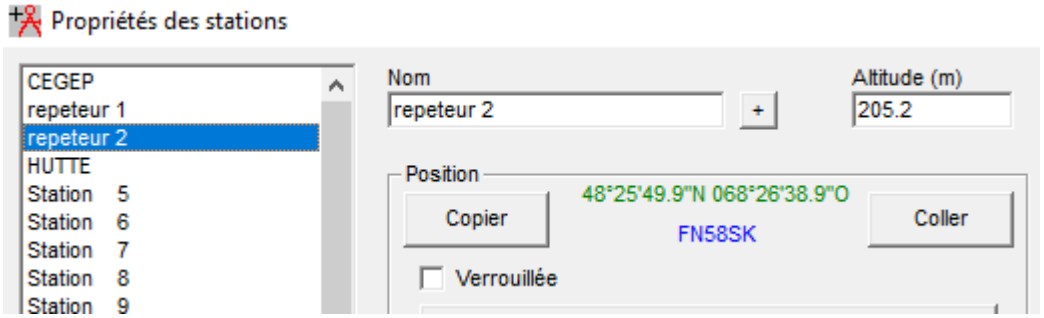

CEGEP
repeteur


CEGEP
repeteur
repeteurHUTTE

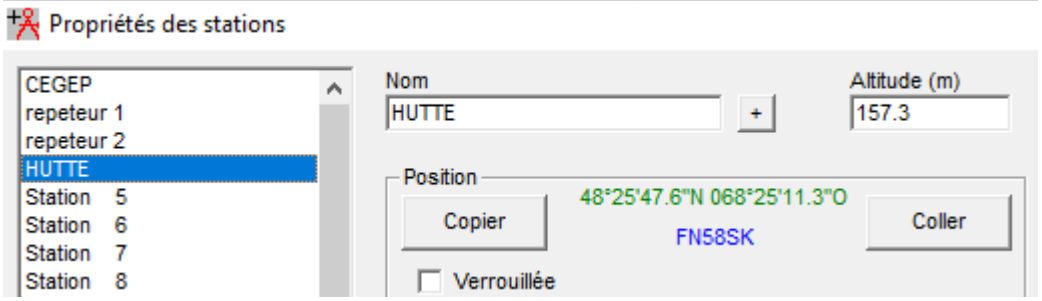
The first station is located at the CEGEP at a height of 46.1 meters above sea level at the position identified by the coordinate.

The second station which represents the first repeater is located at the top of route 20 just above the town at a height of 206 meters above sea level at the position identified by the coordinate.

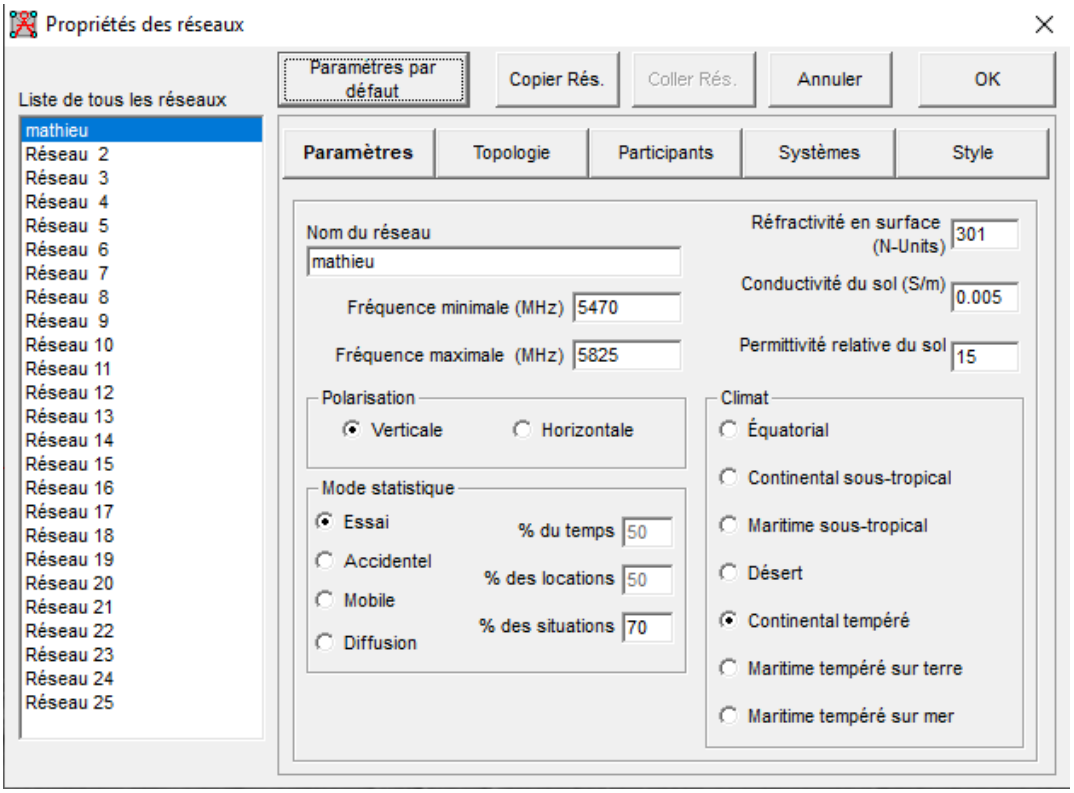
The third station which represents the second repeater is located on a mountain at a height of 205.2 meters above sea level at the position identified by the coordinate.



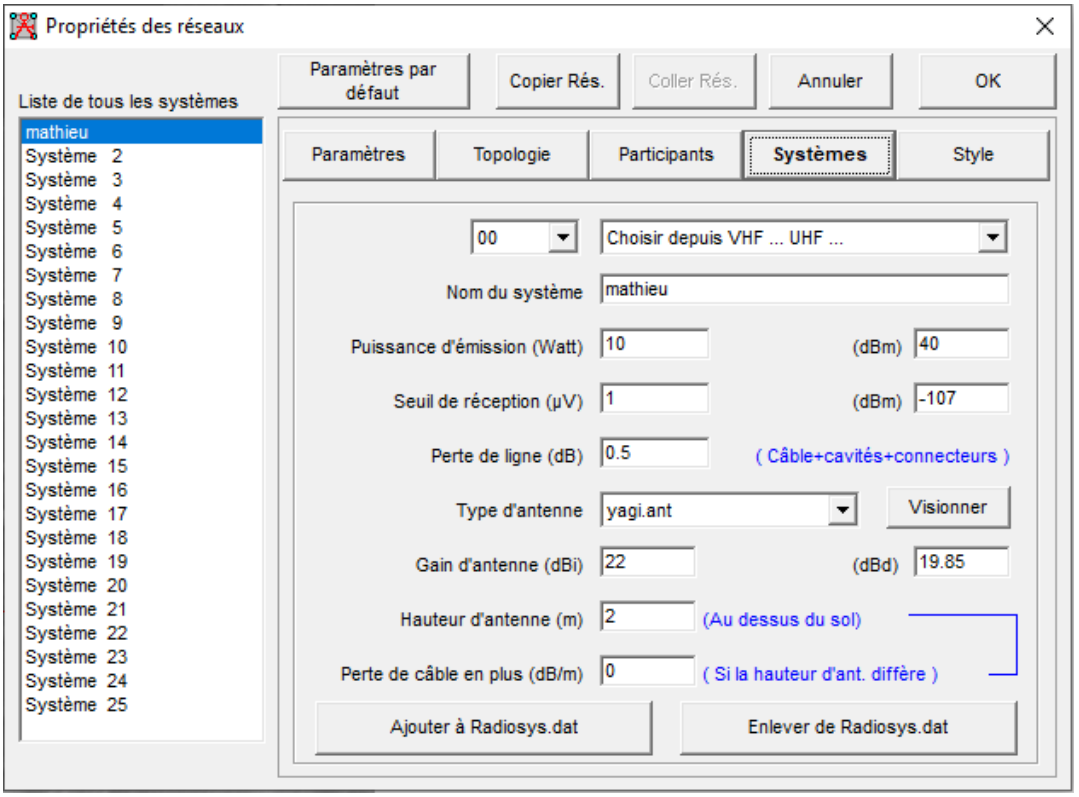
The last station is located at the hut right next to Eel Lake at a height of 157.3 meters above sea level at the position identified by the coordinate.



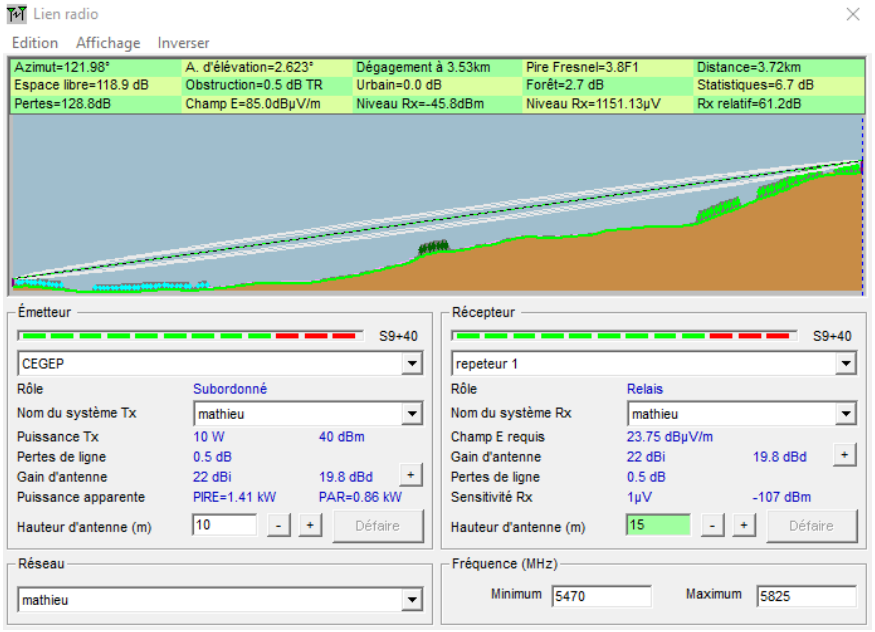
The frequencies used in the RF link networks range from 5.47 GHz to 5.825 Ghz (should be 2.4 GHz) which are frequency bands used for Wi-Fi channels. The climate in Quebec is considered temperate continental.



All stations have the same system with 10 Watt (40dBm) of transmit power and a receive threshold of -107 dBm (1uv). The antenna has a gain of 22dBi (should be 18dBi) directional.



The first Cégep link to the first repeater at a distance of 3.72 km and a loss in the course of 118.9 dB in the simulation, which is very close to the 119.11 dB found in the calculations. The RX power level is not as close since the loss caused by fresnel blocking is not considered in the calculations. The calculation of the radius of the first three fresnels was done at the distance the RF link is the most blocking which is 3.53 km.



Bilan de puissance RF

Puissance de l'émeteur: 10 Watt (40dBm)

Fréquence maximum: 5.825 Ghz

Gain d'antenne: 22 dbi ()

Aucune perte de ligne

Seuil de réception: 107 dBm

Formule de perte de prarcours: Lp = 32,4 + 20 log(FMHz) + 20 log(dkm)

Lp = 32,4 + 20 log(5825 MHz) + 20 log(3,72km)

Lp = 32,4 + 75,306 + 11,4109

Lp = 119.11 dB

Formule de liaison: PRX = PTX - LP + GTX + GRX

PRX = 40 dBm - 119.11 dB + 22 dBi + 22dBi

PRX= -35.11 dBm

Analyse des lentilles de Fresnel

Distance ou les Fresnel bloque: 3.53 km = D1

3,72 - 3,53 = 0,19 km = D2

$$Fn = 17{,}3 * \sqrt{\frac{N}{F\ GHz}\left(\frac{D1*D2}{D1+D2}\right)}$$

$$F3 = 17{,}3 * \sqrt{\frac{3}{5{,}825}\left(\frac{3{,}53*0{,}19}{3{,}53+0{,}19}\right)}$$

$$F3 = 5{,}27\ m$$

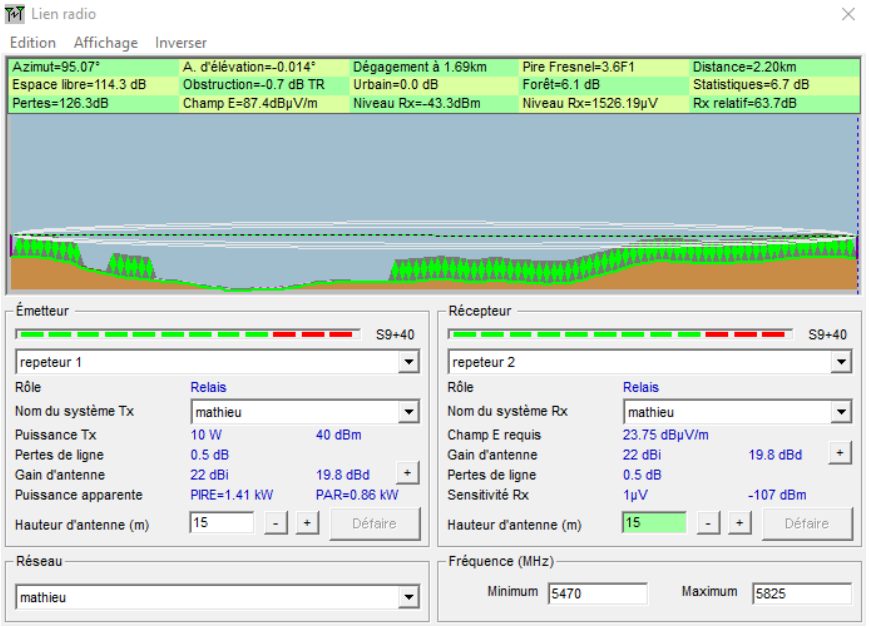
$$F1 = 17{,}3 * \sqrt{\frac{1}{5{,}825}\left(\frac{3{,}53*0{,}19}{3{,}53+0{,}19}\right)}$$

$$F1 = 3{,}04\ m$$

$$F2 = 17{,}3 * \sqrt{\frac{2}{5{,}825}\left(\frac{3{,}53*0{,}19}{3{,}53+0{,}19}\right)}$$

$$F2 = 4.3\ m$$

The second link is between the two repeaters with a distance of 2.2 km with a loss in the path of 114.3 dB in the simulation which is very close to the 114.55 dB found in the calculations. The RX power level is not as close since the loss caused by fresnel blocking is not considered in the calculations. The calculation of the radius of the first three fresnels was done at the distance the RF link is the most blockingwhich is 1.69 km.



Bilan de puissance RF

Puissance de l'émeteur: 10 Watt (40dBm)

Fréquence maximum: 5.825 Ghz

Gain d'antenne: 22 dbi

Aucune perte de ligne

Seuil de réception: 107 dBm

Formule de perte de prarcours: Lp = 32,4 + 20 log(FMHz) + 20 log(dkm)

Lp = 32,4 + 20 log(5825 MHz) + 20 log(2,2km)

Lp = 32,4 + 75,306 + 6,848

Lp = 114,55 dB

Formule de liaison: PRX = PTX - LP + GTX + GRX

PRX = 40 dBm - 114,55 + 22 dBi + 22dBi

PRX= -30,55 dBm

Analyse des lentilles de Fresnel

Distance ou les Fresnel bloque: 1,69 km = D1

2,2 - 1,69 = 0,51 km = D2

$$Fn = 17{,}3 * \sqrt{\frac{N}{F\ GHz}\left(\frac{D1*D2}{D1+D2}\right)}$$

$$F1 = 17{,}3 * \sqrt{\frac{1}{5{,}825}\left(\frac{1{,}69*0{,}51}{1{,}69+0{,}51}\right)}$$

F1 = 4,49 m

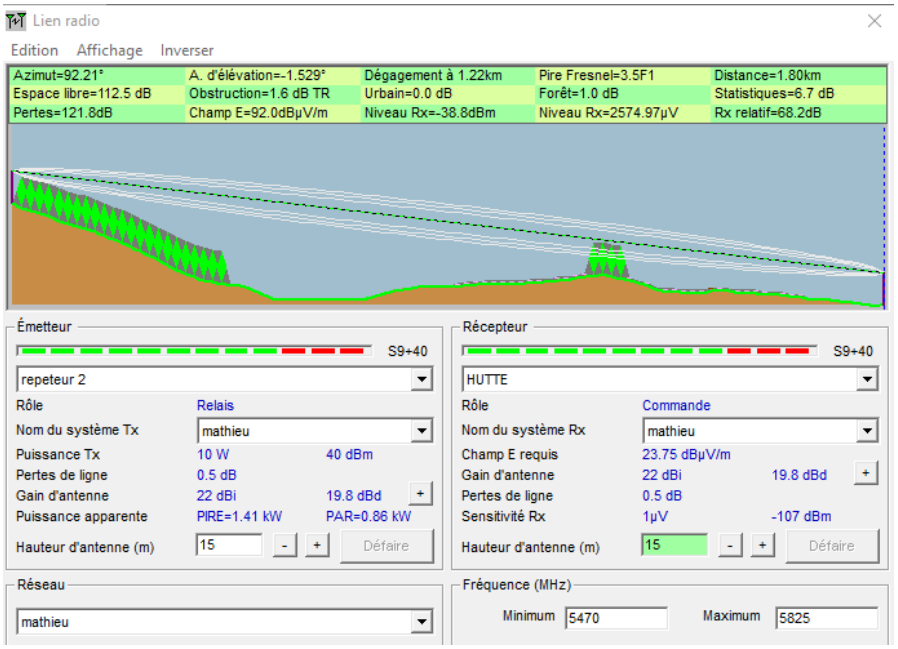
$$F2 = 17{,}3 * \sqrt{\frac{2}{5{,}825}\left(\frac{1{,}69*0{,}51}{1{,}69+0{,}51}\right)}$$

F2 = 6,35 m

$$F3 = 17{,}3 * \sqrt{\frac{3}{5{,}825}\left(\frac{1{,}69*0{,}51}{1{,}69+0{,}51}\right)}$$

F3 = 7,77 m

The third link is between the second repeater and the hut with a distance of 1.8 km with a path loss of 112.5 dB in the simulation which is very close to the 112.81 dB found in the calculations. The RX power level is not as close since the loss caused by fresnel blocking is not considered in the calculations. The calculation of the radius of the first three fresnels was done at the distance the RF link is the most blocking which is 1.22 km.



Bilan de puissance RF

Puissance de l'émeteur: 10 Watt (40dBm)

Gain d'antenne: 22 dbi

Seuil de réception: 107 dBm

Fréquence maximum: 5.825 Ghz

Aucune perte de ligne

Formule de perte de prarcours: Lp = 32,4 + 20 log(FMHz) + 20 log(dkm)

Lp = 32,4 + 20 log(5825 MHz) + 20 log(1,8km)

Lp = 32,4 + 75,306 + 5,1

Lp = 112,81 dB

Formule de liaison: PRX = PTX - LP + GTX + GRX

PRX = 40 dBm - 112,81dB + 22 dBi + 22dBi

PRX= -28,81 dBm

Analyse des lentilles de Fresnel

Distance ou les Fresnel bloque: 1,22 km = D1

$$Fn= 17,3* \sqrt{\frac{N}{F\ GHz}\left(\frac{D1*D2}{D1+D2}\right)}$$

$$F1= 17,3* \sqrt{\frac{1}{5,825}\left(\frac{1,22*0,58}{1,22+0,58}\right)}$$

F1 = 4,49 m

$$F2= 17,3* \sqrt{\frac{2}{5,825}\left(\frac{1,22*0,58}{1,22+0,58}\right)}$$

F2 = 6,36 m

1,8 - 1,22 = 0,58 km = D2

$$F3= 17,3* \sqrt{\frac{3}{5,825}\left(\frac{1,22*0,58}{1,22+0,58}\right)}$$

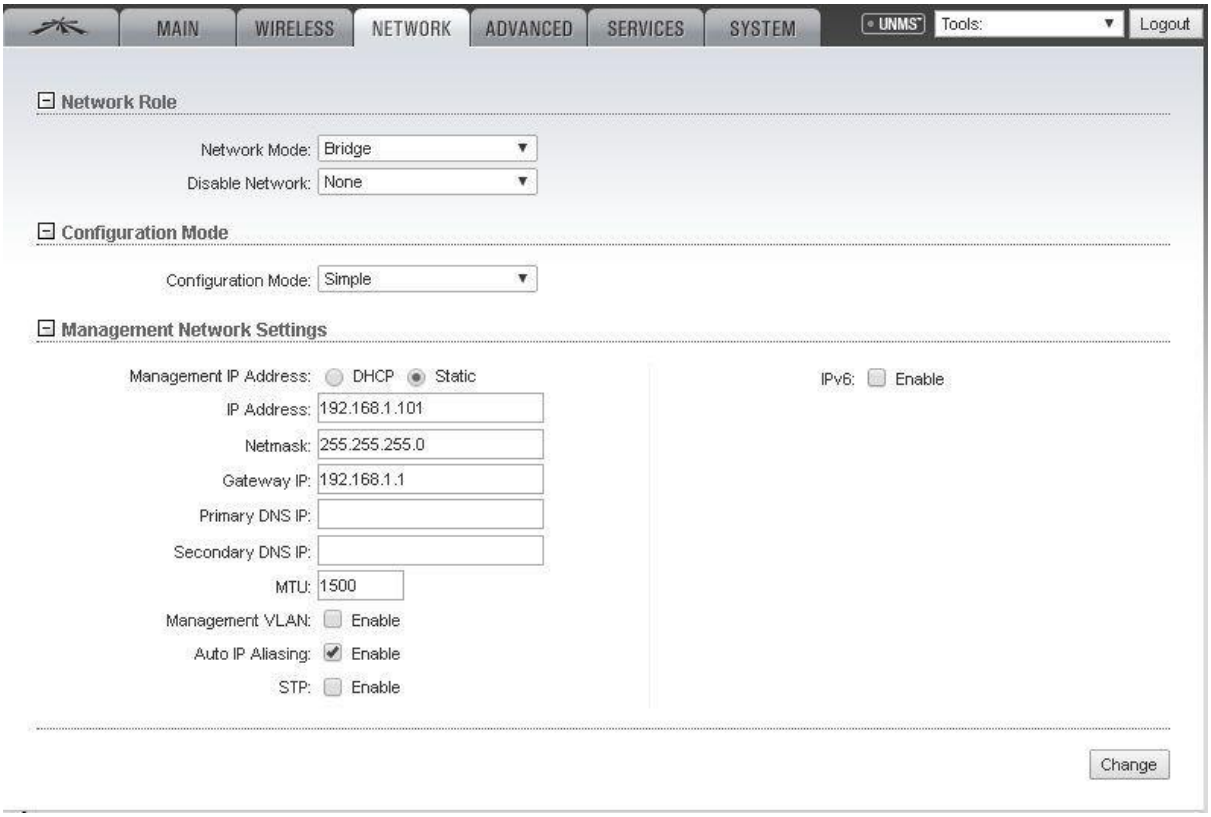
F3 = 7,78 m

The RF link can be exported to google earth to view the link on a satellite image. This helps to give a better idea of where stations are located in the real world.


Places
My Places
Temporary Places
CEGEP - repeteur 1 [mathieu]
La distance entre CEGEP et repeteur 1 est de 3.7 km (2.3 miles)
repeteur 1 - repeteur 2 [mathieu]
La distance entre repeteur 1 et repeteur 2 est de 2.2 km (1.4 miles)
repeteur 2 - HUTTE [mathieu]
La distance entre repeteur 2 et HUTTE est de 1.8 km (1.1 miles)
Layers
Primary Database
Announcements
Borders and Labels
Places
Photos
Roads
3D Buildings
Ocean
Weather
Gallery
Global Awareness
More
Terrain
CEGEP
repeteur 1
repeteur 1
repeteur 2
repeteur 2
HUTTE
Lac à Casse
Lac Bellavance
Route-de-la-Montagne
Autoroute Jean Lesage
Avenue Réseau
Avenue Shois
Boulevard Arthur-Buies-O
Chemin du Sommet
Chemin de la Seigneurie-E
Chemin de la Seigneurie-O
© 2020 Google
Image © 2020 Maxar Technologies
Image © 2020 CNES / Airbus
Google Earth
Imagery Date: 3/6/2020 48°26'04.53" N 68°28'15.47" W elev 195 m eye alt 8.15 km

The management vlan must be configured with vlan 23 for inter-vlan routing to work. The antenna addresses must be configured according to the addresses given in the addressing table.

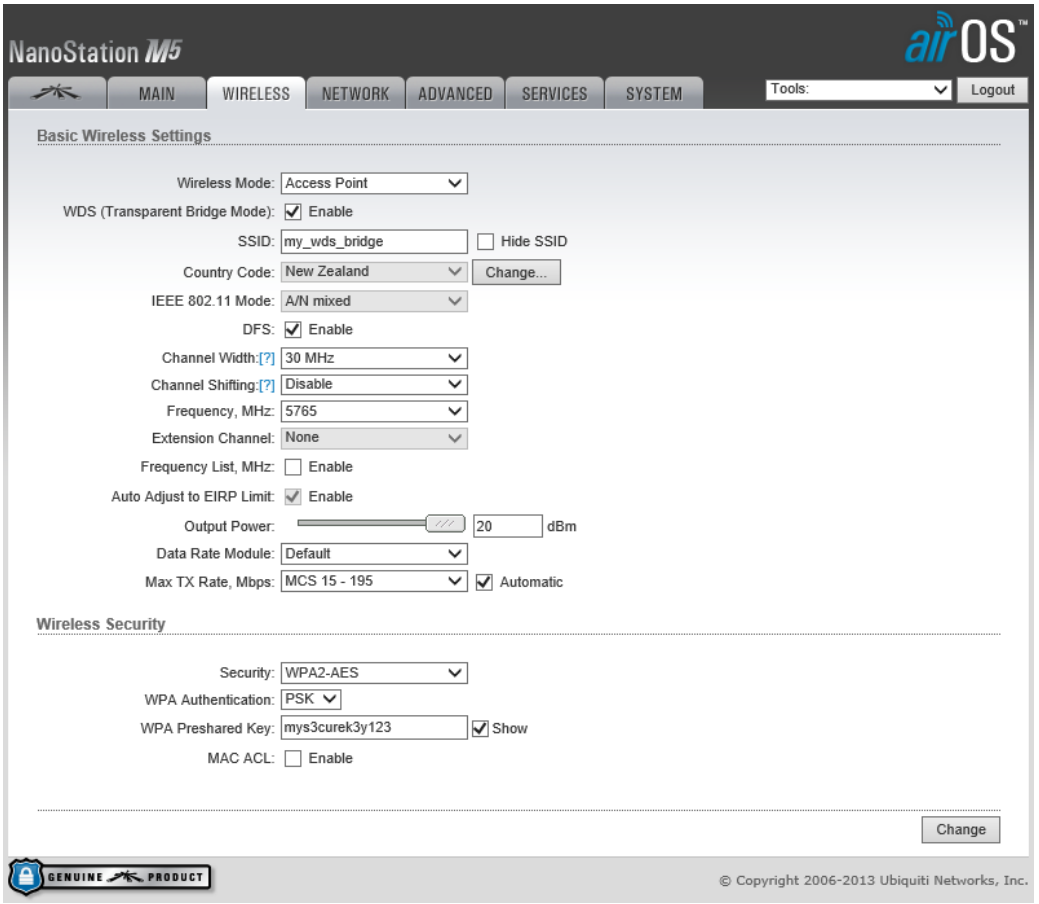
Example interface:



Antenne 1	Vlan 23	192.168.2.57	255.255.255.240
Antenne 2	Vlan 23	192.168.2.58	255.255.255.240
Antenne 3	Vlan 23	192.168.2.59	255.255.255.240
Antenne 4	Vlan 23	192.168.2.60	255.255.255.240

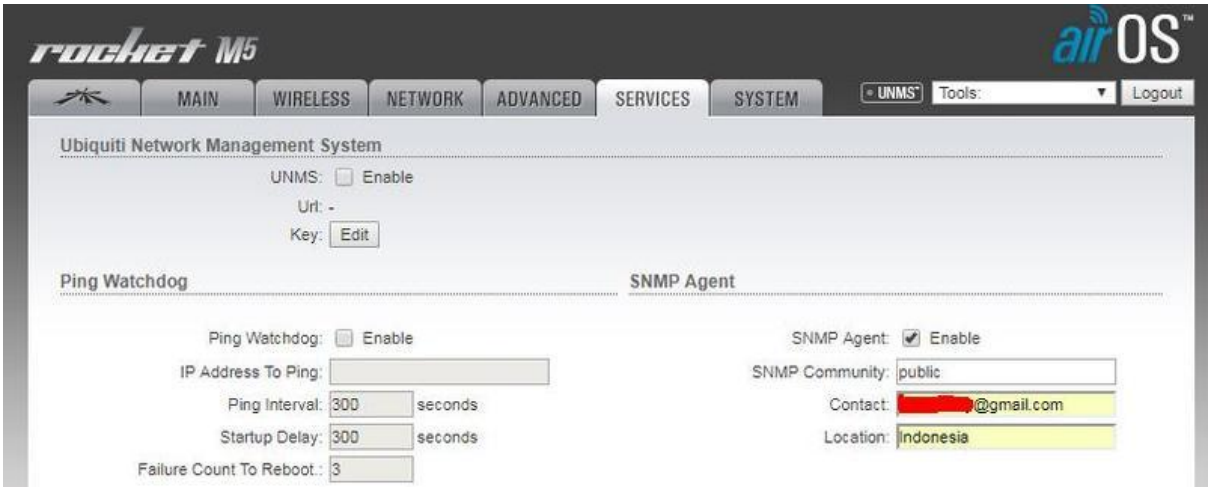
It is necessary to activate the WDS (Transparent Bridge Mode) so as not to change the packets which pass through the antennas, this means that you do not need to manage the vlans and the trunk on the antennas.

Example interface:



The snmp configuration is quite simple, you just have to activate the snmp, write the community string which is Equipe2 and fill in the contact and the location with the desired information.

Example interface:



ANNEX

https://www.tdk-electronics.tdk.com/inf/50/db/ntc/NTC_Mini_sensors_S863.pdf
https://sensing.honeywell.com/honeywell-sensing-hih4010-4020-4021-series-product-sheets-009020-1-en.pdf
https://www.infineon.com/dgdl/Infineon-KP215F1701-DS-v01_00-en.pdf?fileId=db3a30432ad629a6012af6a900a30b34

https://dl.ubnt.com/guides/nanobridge/NanoBridge_M2_M5_QSG.pdf

https://dl.ubnt.com/datasheets/nanobridgem/nbm_ds_web.pdf