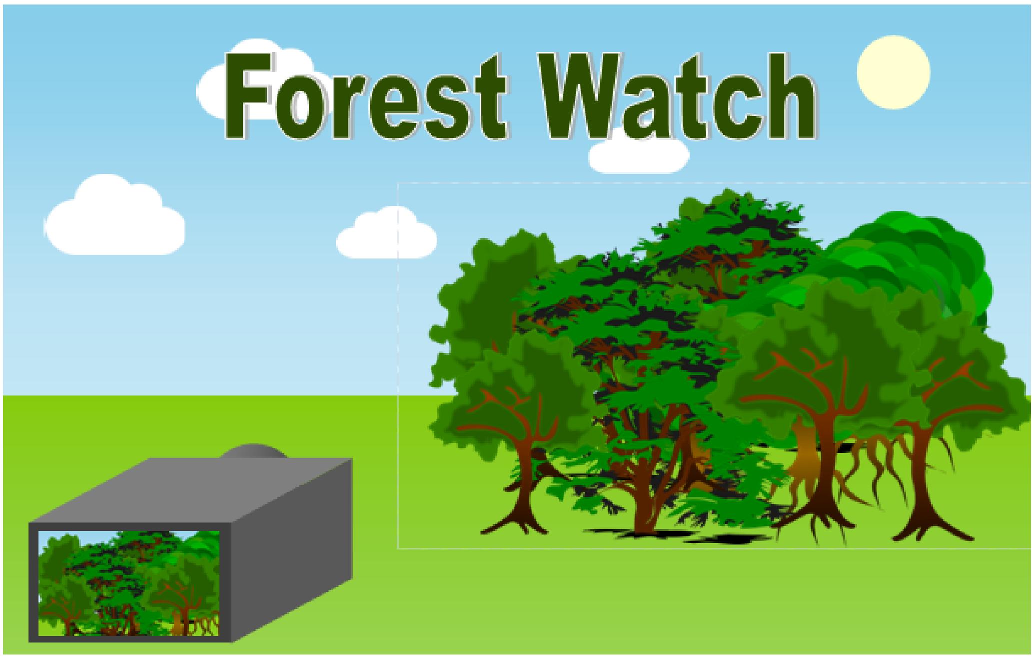


Technical Specifications

Darrys ABDELKRIM
Raimundo Vitor DE SOUSA CARDOSO
Florian KRASULJA
Alexandre MAILLET
Engineering student, 4A GPSE

Rodolphe WEBER
Teacher in Embedded Systems
Jury chairman

May 11, 2023

Summary

Acknowledgements

We would like to thank Robotek for lending us the tools to complete this project. We would also like to thank Rodolphe Weber, our tutor on this project, for his guidance, expertise and support throughout the duration of this project. Finally, we would like to thank Kamel Ladrouze for providing us with the components we needed for this project.

1. Project description

1.1. Analysis and expression of needs

Researchers from the University of Liège are studying trees in a tropical forest in Gabon to understand how seasonal drought affects the functioning of trees. To achieve their goals, they need a system capable of taking photos twice a day in order to analyze these images later on. Our objective, as designers of this system, is to create a device that meets the specific requirements of the researchers. The system must be capable of operating in a hot and humid environment, as it will be installed on a pole in a tropical forest. It must also be self-sufficient in terms of energy and storage, as the researchers will only be able to access the system every two or three months. Furthermore, the system must be able to communicate over long distances to provide researchers with information regarding the sensor data collected. Given that there is no conventional mobile network in the Gabonese forest, this must be done via a decentralized, low-energy, and long-range protocol. However, it will not be possible to send the images directly due to these communication constraints.

Figure 1: Example of a picture took by researchers in Gabon

1.2. Use case

The use case would be as following: The researchers come once to install the system on a pole on a hill, in front of the group of trees they want to observe. The system would then be placed in the desired location within the forest. The system would be sending data to researchers to ensure that it is functioning properly and that the pictures being taken are of high quality. After 3 months, the researchers would return to the forest to retrieve the system, the stored pictures, and logs about the system state. Then, the researchers would be able to analyse the images.

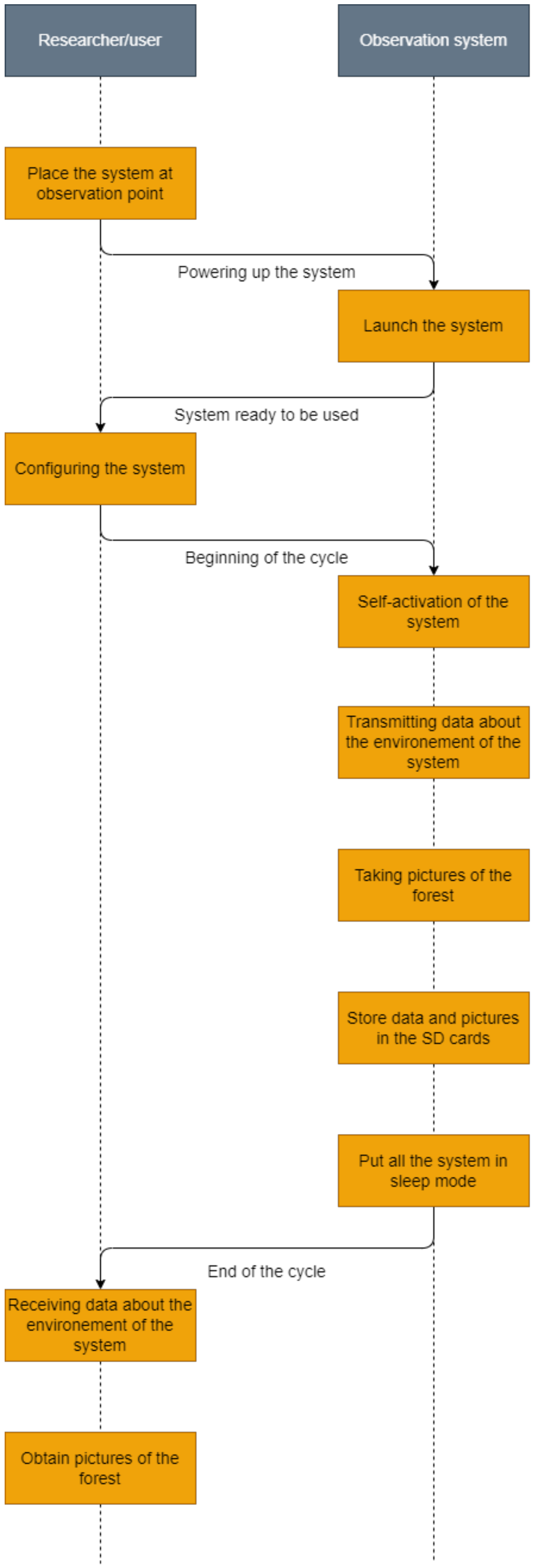


Figure 2: Picture representing the intended usage scenario for the system.

1.3. Functional specifications

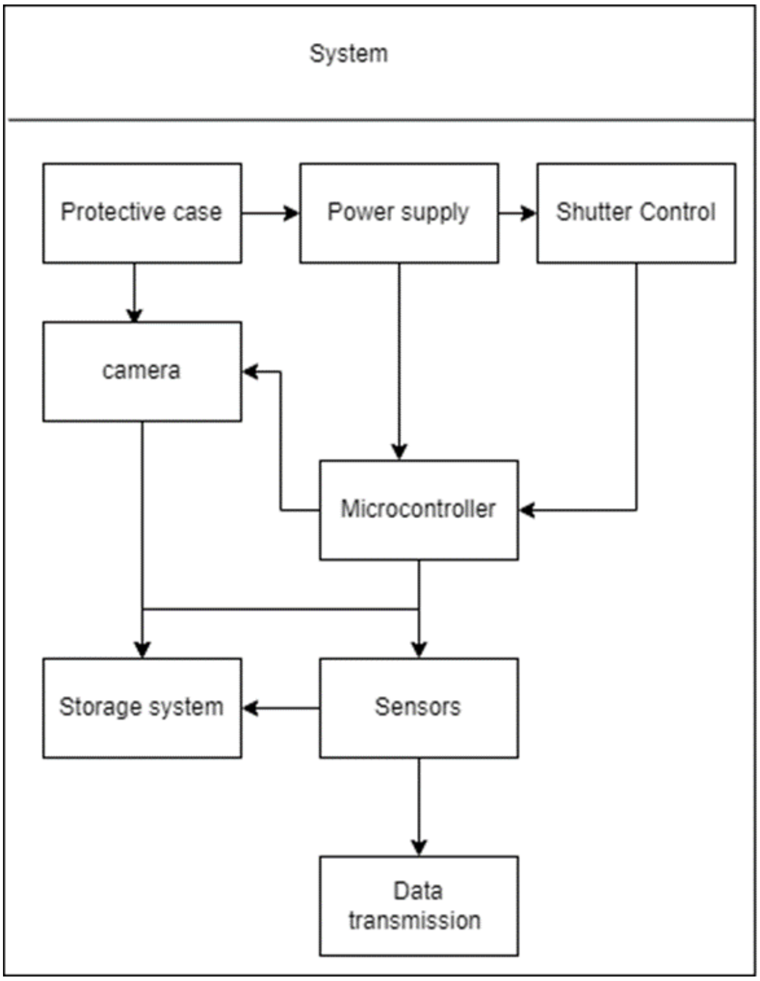


Figure 3: Schematic showing different functions interacting inside of the system

The diagram illustrates the interconnectivity of these functions, highlighting the relationships and data flow between them. To create a functional system, it is important to ensure that these components are properly integrated and configured to meet the specified technical requirements.

x	Function	Sub-function	Criterion	Value	Flexibility
F1	Take photos				
F1.1		Internal camera settings			
C1.1.1			Frequency	Once	2
F1.2		Taking photos regularly			
C1.2.1			Frequency	2 times a day	0
F1.3		Taking high-quality photos			
C1.3.1			Resolution	1920x1080	0
C1.3.2			Distance	300 meters	0
C1.3.3			Fields of view	32.4°	1
F2	Possessing an extended battery life				
F2.1		Possessing an extended battery life			
C2.1.1			Desired uptime	$\approx$ 1 year	1
F3	Storing data				
F3.1		Store photos			
C3.1.1			Picture-dedicated storage space	>16 Go	1
F3.2		Storing information on the device state			
C3.2.1			Information-dedicated storage space	16 Mo	3
C3.2.2			Logging period	$\approx$ 1 months	3
F4	Conveying system status information				
F4.1		Collecting information			
C4.1.1			Remaining battery charge percentage	Error margin of 10%	2

C4.1.2			Temperature	0°C to 50°C	2
				Precision of 1°C	0
C4.1.3			Humidity	80 to 100%	2
C4.1.4			Remaining storage space	Warning at 90%	2
C4.1.5			Device motion	Precision : $\pm$ 1cm $\mid$ $\pm$ 1°	1
F4.2		Transmitting data remotely			
C4.2.1			Range	$\geq$ 10km	1
F5	Working in a specific environment				
F5.1		Resisting Central African climate			
C5.1.1			Humidity and fog	>90% of humidity	0
C5.1.2			Temperature	20°C to 35°C	0
C5.1.3			Rain	equivalent to IPX4	0
F5.2		Size			
C5.2.1			Dimensions	200x300x150 mm	2
F5.3		Weight			
C5.3.1			Mass	4 kg	1
F5.4		Installation			
C5.4.1			Relevant stand or platform	???	1

2. Compliance Matrix

Name	Criterion	Value	Test method	Conform: Yes/No/Partially
C1.2.1	Photo acquisition frequency	2 times a day	Let the system run and see if the system can take pictures at various pre-configured hours	
C1.3.1	Photo resolution	1 branch/pixel at 300m	Outdoor tests	
C1.3.2	Device uptime	1 year	Let the system run during a period to measure the consumption during this period	
C2.1.1	Logging effectiveness	*	Let the system run and verify in the SD card if the logs are effectively written	
C3.1.1	Remaining uptime on battery	±10%	Let the system run and verify if the calculus realized by the device are correct	
C4.1.1	Temperature measures	1°C	Tests with appropriated equipment	
C4.1.4	Device motion warning	2 cm/1°	Manual movement input	
C4.1.5	Distance de transmission	10 km	Long distance tests	Partially
C4.2.1	Humidity resistance	>90%	To be determined	
C5.1.1	Temperature resistance	20 - 40°C	Exposing the temperature sensors to known temperatures and read the value read by the microcontroller	
C5.1.2	Rain resistance	IP X4 equivalent	Leaving the box under the shower for 10 minutes	
C5.1.3	Small dimensions	212 x 149 x 93 mm	Measurements	
C5.2.1	Overall mass	4 kg	"	

The compliance matrix is a table with outlines various criteria or specifications that a device or system must meet, along with their corresponding values and test methods.

3. System Architecture

The system functions are all represented here. The main one is "Taking pictures of the forest", which is the main purpose of the system. All the other functions are made to serve this function.
The system can be divided in sub-systems, which are:

- The protective case
- The power supply system
- The camera
- The microcontroller
- The shutter
- The storage system
- The sensors

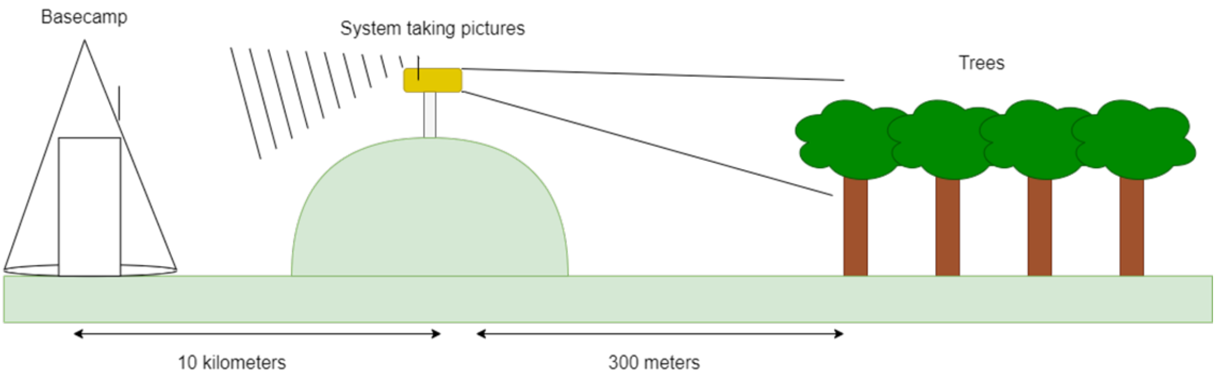


Figure 4: Schematic showing the global system installed in the forest

3.1. The camera

The camera is a Lumix DMC-G5. This model has been used in a similar project called micrObs to take pictures of penguins in Antarctica. In this project, the camera has successfully been retro engineered in order to control it automatically. The system to control the camera is explained in the 3.5. part.

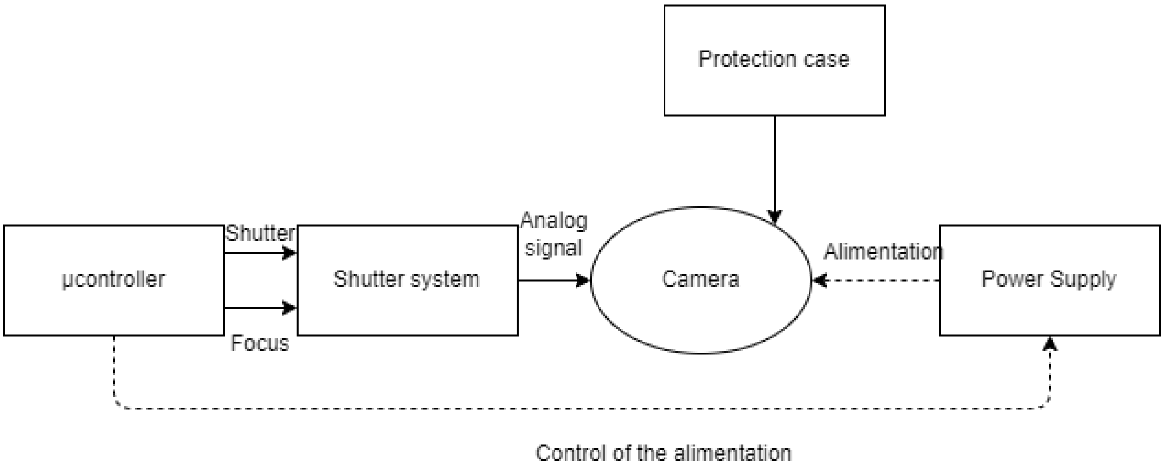


Figure 5: Architecture of the system surrounding the camera

The camera need a lens to be mounted on it in order to make it work properly. The calculations realized show the lens should be a lens with a focal length between 45 and 150 mm.

Here is the calculation:

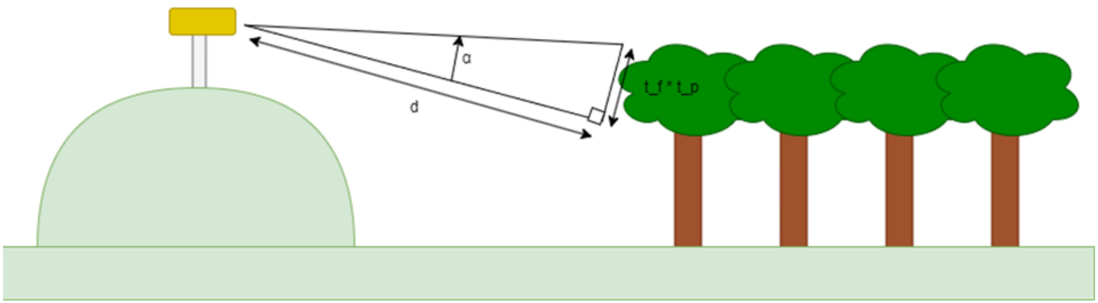


Figure 6: Schematic to calculate the focal length for the camera.

α: lens angle of the field of a (to calculate)
d: distance between our system and trees (equal to 300 metres)
t_f: size of a leaf, estimated to be 5,5 centimetres.
t_p: height of the image, which corresponds to 1024 pixels.

According to the trigonometric formulas: $\alpha = arctan\left(\frac{t_f * t_p}{d}\right) = 32,4$

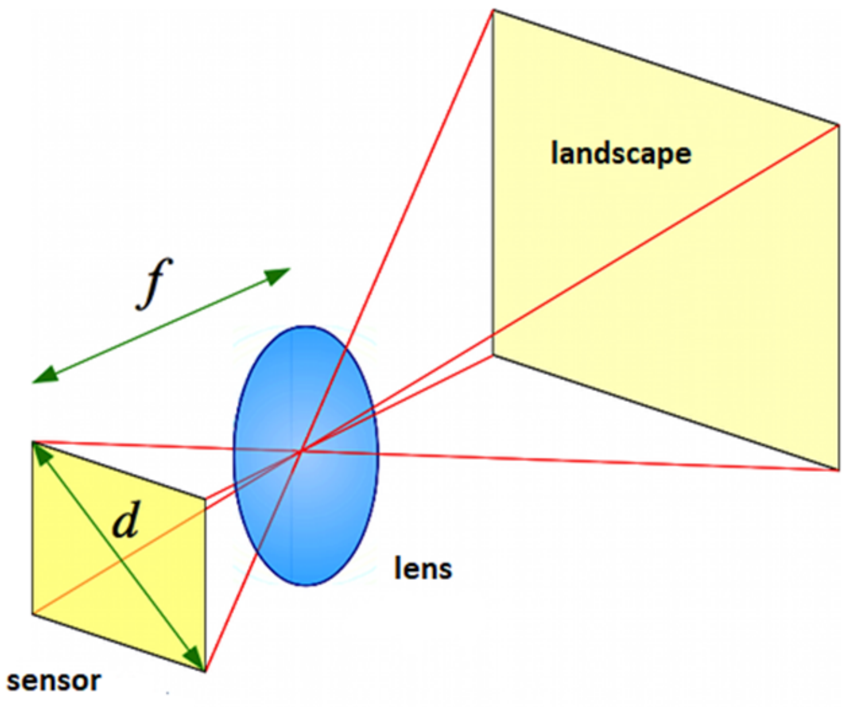


Figure 7: Link between angle of view and focal length
La focale d'un objectif : définition, angle de champ, focale équivalente. . . N.d.

The field of view angle (α) horizontally, corresponding to the length (L) of the sensor, is given by the following formula:

$$f = \frac{L}{2 * tan\left(\frac{\alpha}{2}\right)} \tag{1}$$

Where:
L: length of the sensor in mm
f: focal distance of the lens in mm
α: lens angle of the field of view
It is obtained: f = 117 mm

The equivalent focal length of a Micro 4/3 lens with a field of view of 32.4 degrees is approximately 117 mm.

According to the graph above, we should choose a lens between 100 and 200 mm. The smaller the angle of view (high focal length), the greater the magnification (long focal lengths will give the impression of being closer to the scene captured).
Our goal is not to visualize each leaf but each branch so a lens with a focal length of 175 mm will be sufficient for our project.
We have therefore selected this objective: `https://www.m43lenses.com/panasonic-45-175mm-f4-5.6/`

3.2. Diagram of the interior layout

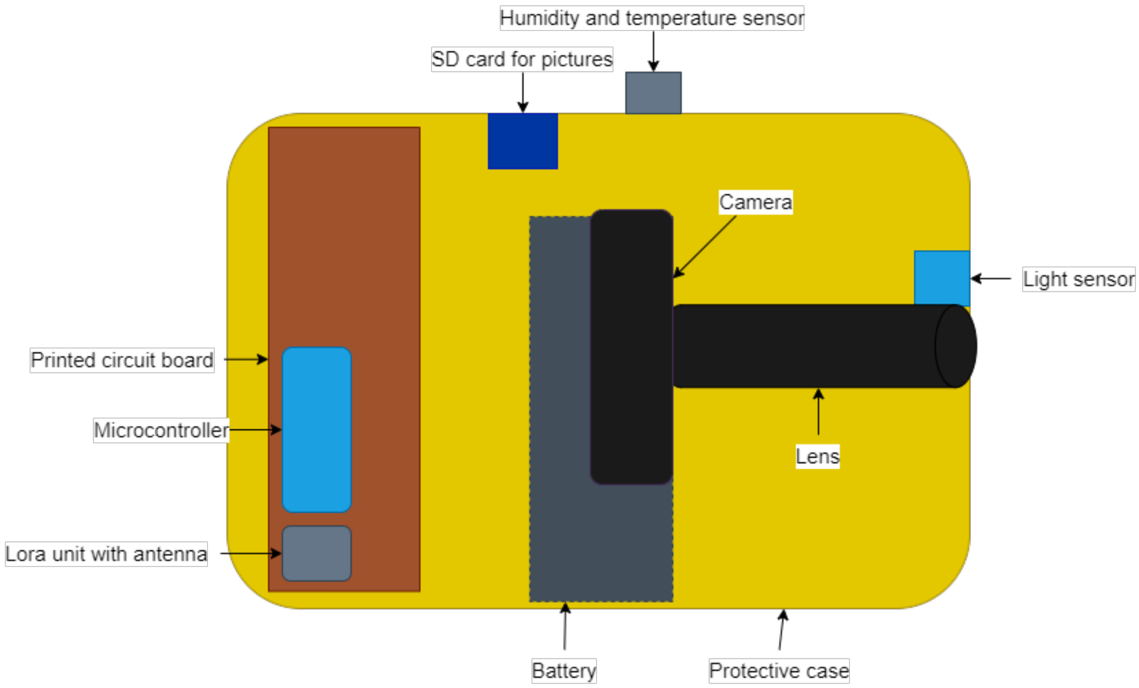


Figure 8: Schematic of the system inside the box (upper view)

This diagram shows the arrangement of the components inside the box. These components work together to create a functional unit that can capture and storing images.
The microcontroller is the brain of the system, responsible for processing the input data from the sensors and controlling the camera, as well as other functions such as power management and communication.
The lens and camera work together to capture high-quality images, which can be stored on the SD card for researcher.
The protective case ensures that the system is safe from damage and can withstand harsh environmental conditions.
The LoRa unit with its antenna enables the system to communicate wirelessly over long distances, making it ideal for remote monitoring and surveillance applications.
The printed circuit board serves as the backbone of the system, connecting all the components together and providing the necessary power and signals for their operation. The motion sensor on the PCB is responsible for detecting any movement of the system and transmitting this information to the base camp where the researchers are located.

3.3. The protective case

Figure 9: Valise Peli™ 1150
Valise Peli™ 1150 vide, noire n.d.

The protective case has a role of protecting the whole system from the outside elements. The housing of the recording system needs to withstand extreme weather conditions, such as high temperatures (which can reach up to 35°C in Gabon), high humidity (up to 90%), rain, and potential animal interference. To reduce wind-induced vibrations, a small plastic housing with a rubber seal was chosen (Protector 1150, Peli) to hold the camera, control unit, and GPS receiver.

3.4. The protective battery case

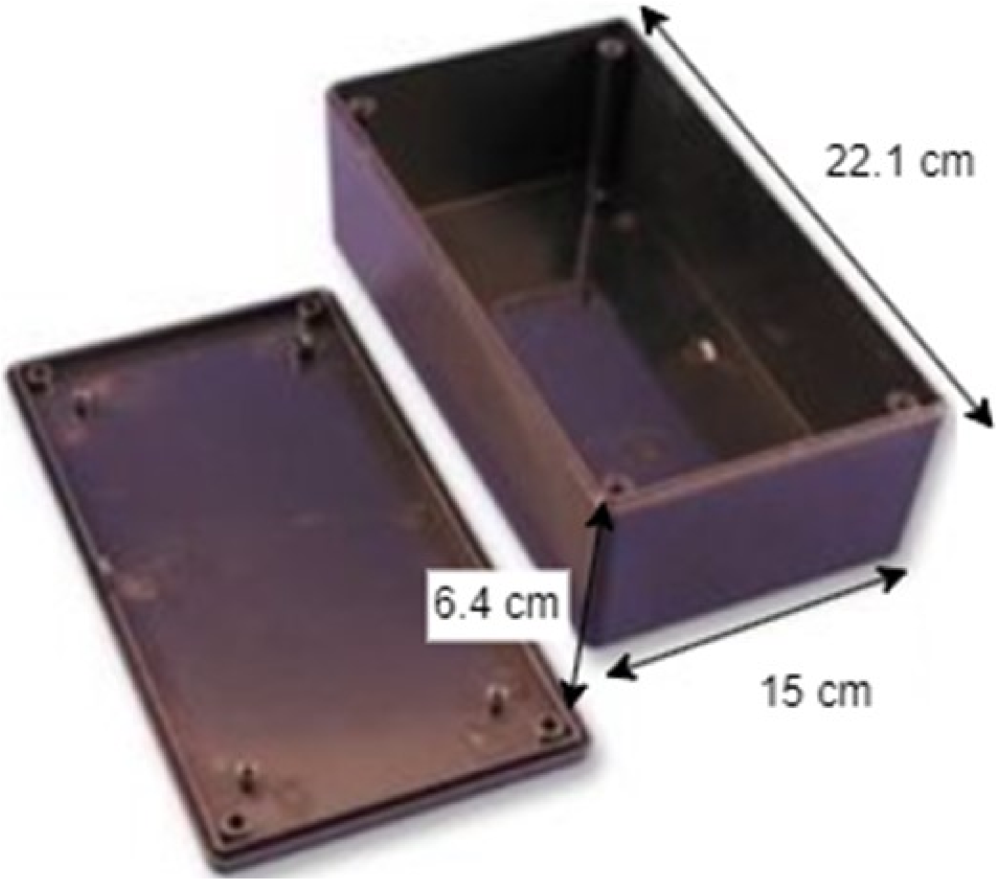


Figure 10: Battery box

When exposed to direct sunlight, batteries can overheat and degrade, shortening their lifespan and reducing their efficiency. By placing the battery inside the box, the battery is shielded from the sun's direct heat and is able to maintain a cooler operating temperature. This protection helps to extend the lifespan of the battery and ensure that it functions optimally in the harsh environmental conditions of the tropical forest. To protect the battery from direct sunlight and heat, a secondary battery box will be incorporated into the design of the system. This box will be located underneath the main box and will be designed specifically to shield the battery from the sun's direct heat, which can cause the battery to overheat and degrade.

3.5. The power supply system

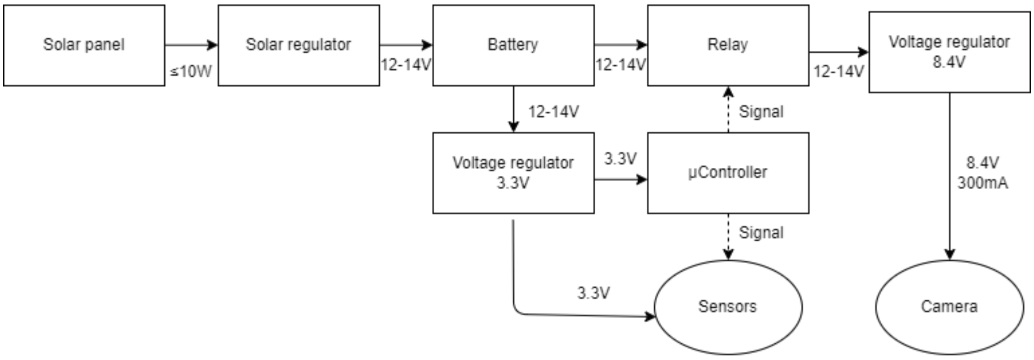


Figure 11: Power supply architecture

3.5.1. Camera and relay

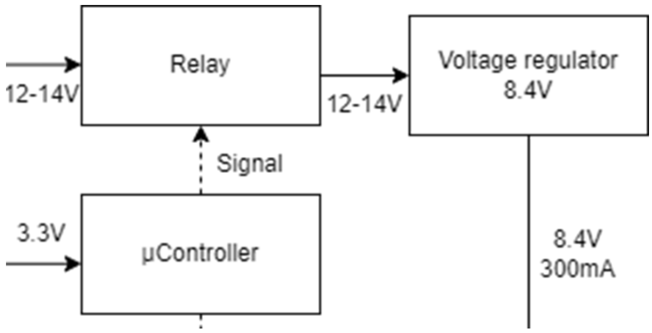


Figure 12: Schematic showing the architecture of the camera and relay

The camera necessitates an 8.4V power supply and a current draw of 300mA for optimal operation. The system connects to the camera through a dummy battery featuring wired connections to the board. A relay, managed by the microcontroller, controls the camera's power supply. This approach is energy-efficient and offers low-power consumption. The relay consumes only 20mA of current when activated and no power when deactivated. Any relay with low power consumption operating at 3.3V is suitable for use.

To ensure voltage stability from the battery to the camera at 8.4V, a voltage regulator is placed after the relay. Installing the relay before the regulator helps avoid current loss within the regulator, enhancing the system's overall efficiency.

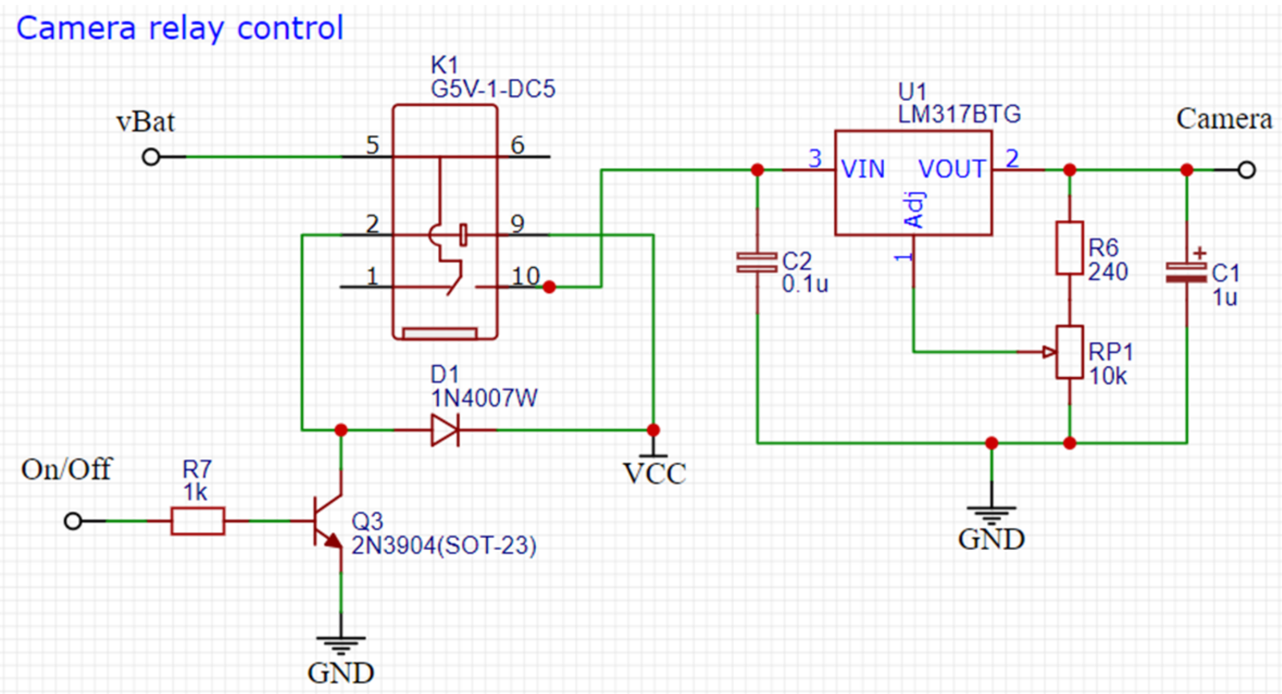
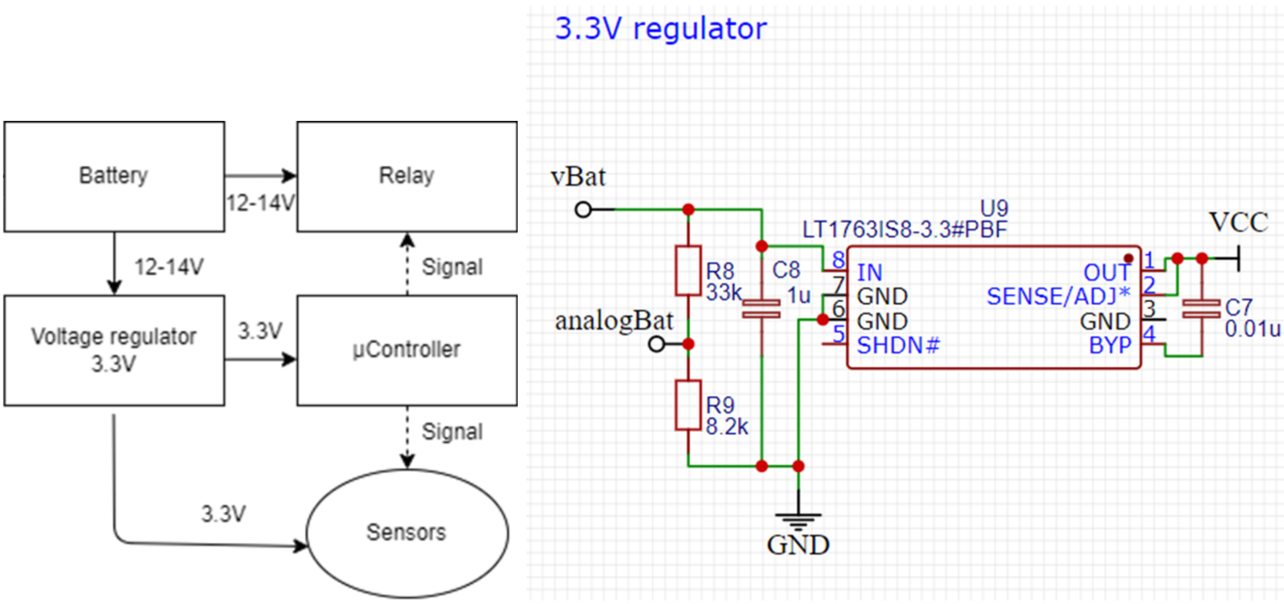


Figure 13: Camera-relay control

3.5.2. Battery and voltage regulator



(a) Schematic showing the architecture of the regulator (b) MT1763IS8 regulator

The LT1763IS8 is a voltage regulator designed to provide a stable 3.3V output while accepting an input voltage of up to 20V. It boasts a low quiescent current of 30µA, ensuring minimal power loss when supplying high output current, with less than 1mA lost to ground. Capable of delivering a maximum output current of 500mA, the LT1763IS8 is an efficient and reliable choice for regulating voltage in our application.

3.5.3. Sensors

The system incorporates an array of low-power sensors, powered by a 3.3V voltage supply from the regulator, to ensure accurate and reliable measurements while maintaining low power consumption. These sensors are scheduled to collect data every 30 minutes and transmit the information through LoRa, with the exception of the motion sensor, which is read upon detecting an interruption. All data is also stored locally in a CSV format on a microSD card.
- Motion Sensor: The ICM-20602 motion sensor operates in low power mode, consuming 1.33mA of current, and in Low-Noise mode, consuming 2.79mA. The primary purpose of the motion sensor is to detect when the container has been moved, which may cause the photos not to be aligned enough. When an interruption is detected, the motion sensor data, including rotation and acceleration, is read and transmitted through LoRa. The data format for motion is "date;gyro;acceleration".
- Humidity/Temperature Sensor: The AM2320 sensor measures both humidity and external temperature, consuming 50µA in sleep mode and 1mA in active mode. The sensor reads data every 30 minutes and sends it through LoRa. The data format is "date;internal temperature;external temperature;humidity;light".
- Internal Case Temperature Sensors: The LM35DZ sensors monitor the internal case temperature with a power consumption of less than 60µA. These sensors provide real-time data to the microcontroller.
- Light Sensor: The TSL2561 light sensor operates with a power consumption of 2µA when turned down and a typical current of 0.24mA when active. This sensor measures ambient light levels every 30 minutes, and the light data is used to determine the lighting conditions when a photo is taken. If the light level at the scheduled photo-taking time is insufficient, the system will delay the photo-taking event until adequate lighting is available. The data format for this sensor is included in the combined format for the humidity/temperature sensor.
By using these low-power sensors, the system effectively minimizes energy consumption while still providing accurate and reliable measurements. All data, including sensor readings and motion events, is stored in a CSV format on a microSD card, ensuring that the information is readily available for analysis and review.

3.5.4. Micro-controller

The microcontroller used in the system is an STM32 Nucleo F303K8, which is powered at 3.3V directly from the voltage regulator. When active, with all peripherals disabled, it draws a current of 13mA. In sleep mode, with the Real-Time Clock (RTC) enabled, the microcontroller consumes only 3mA. It can be activated either by the interrupt signal from the motion detector or by the RTC at a predefined time, ensuring efficient power management and prolonging battery life while maintaining the responsiveness of the system. The STM32 Nucleo F303K8 offers flexible power options and low-power modes, making it suitable for energy-conscious applications that require optimal performance.

3.5.5. Solar panel and regulator

The primary power source for the system is a 12V 2.3Ah (27.6Wh) lead battery, chosen for its high capacity, its ability to retain charge over extended periods and its ability to resist to high temperatures. With an average power consumption of 127mAh a day, the battery can supply power up to 18 days.

	Time where the system is on per day(s)	Current	Average consumption per days (mAh)
Camera	20	330	1,8333
Sensors	480	50	6,6666
Sleep mode	85900	5	119,30
Total consumption per days			127,81

A 10W solar panel with 23% efficiency is employed in this system to provide a significant safety margin, considering the intermittent nature of solar energy that can sometimes generate no power during the day. The solar panel is responsible for charging the lead battery during sunlight hours. A solar voltage regulator ensures that the voltage from the solar panel is within the appropriate range for charging the lead battery. The battery can be fully recharged with 2 days of sunshine.

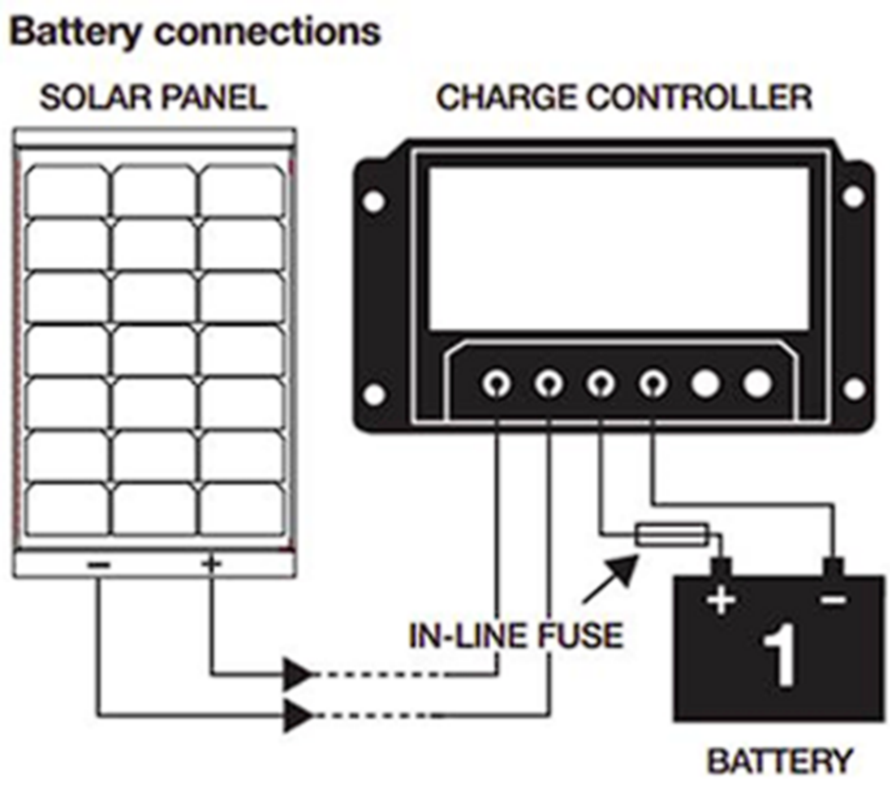


Figure 14: Battery connection
RS PRO 12 V, 24 V 10A Solar Charge Controller | RS n.d.

The solar panel and the battery are directly connected to the charge controller. The charge controller uses PWM to charge the battery with the good power.

3.6. The microcontroller

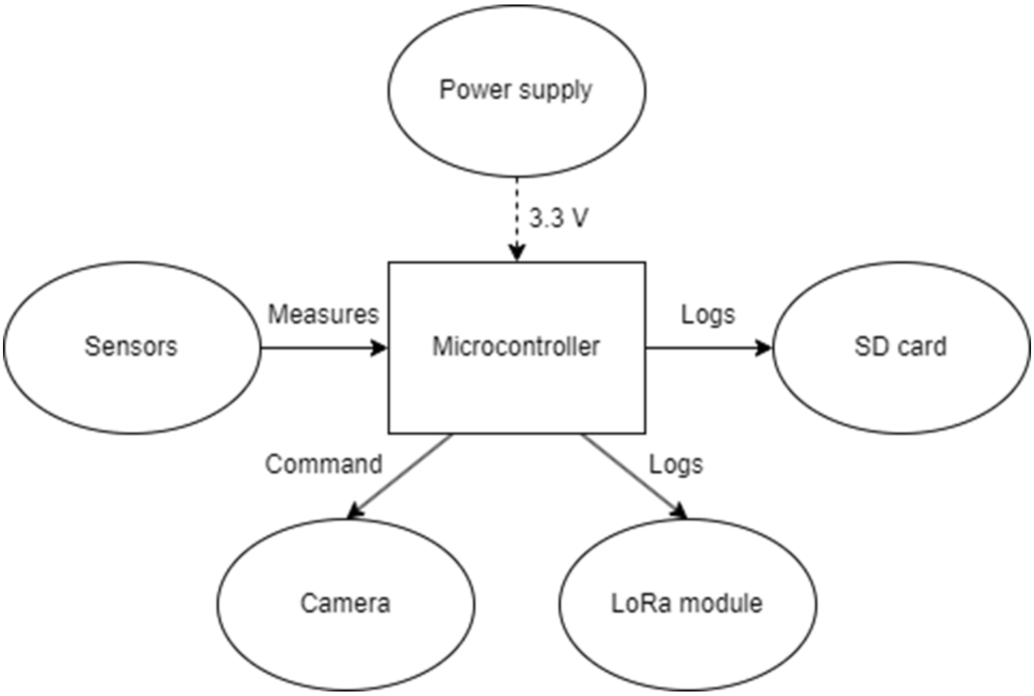


Figure 15: Schematic of the microcontroller and its relationships with other elements

The microcontroller is the core of the device. It is responsible to command the whole system. The STM32 Nucleo F303K8 microcontroller was chosen for this project due to several key features that make it suitable for our application. Firstly, it has very low power consumption, with only 3mA in sleep mode and 13mA during operation. Secondly, it includes a built-in Real-Time Clock (RTC), eliminating the need for an external RTC module, thereby saving cost and board space. Furthermore, one was readily available, which saved time and reduced the overall project cost.
The microcontroller operates on a 3.3V power supply, a common voltage level for many electronic devices, simplifying integration into our project without the need for additional voltage regulation or level shifting circuits. This compatibility allows for seamless connections with the various sensors in our system, such as the ICM-20602 motion sensor, the AM2320 humidity and temperature sensor, the LM35DZ internal case temperature sensors, and the TSL2561 light sensor. The microcontroller receives data from these sensors and processes it to make decisions and execute predefined actions, ensuring the proper functioning of the system.
Lastly, the STM32 Nucleo F303K8 microcontroller offers multiple communication interfaces, such as I2C, SPI, and UART, providing flexibility in connecting and communicating with the sensors and other peripherals, like the LoRa module, in our project. These interfaces facilitate the efficient transmission of sensor data to the microcontroller for real-time monitoring, analysis, and response.
The microcontroller is being programmed in order to use the temperature and humidity sensor, and the SD card in order to create logs.

3.7. The shutter system

The shutter system is a sub-system allowing the microcontroller to command the camera. This system was developed with the help of video tutorials dismantling commercial remote shutters, showing that they were mainly made of resistances.

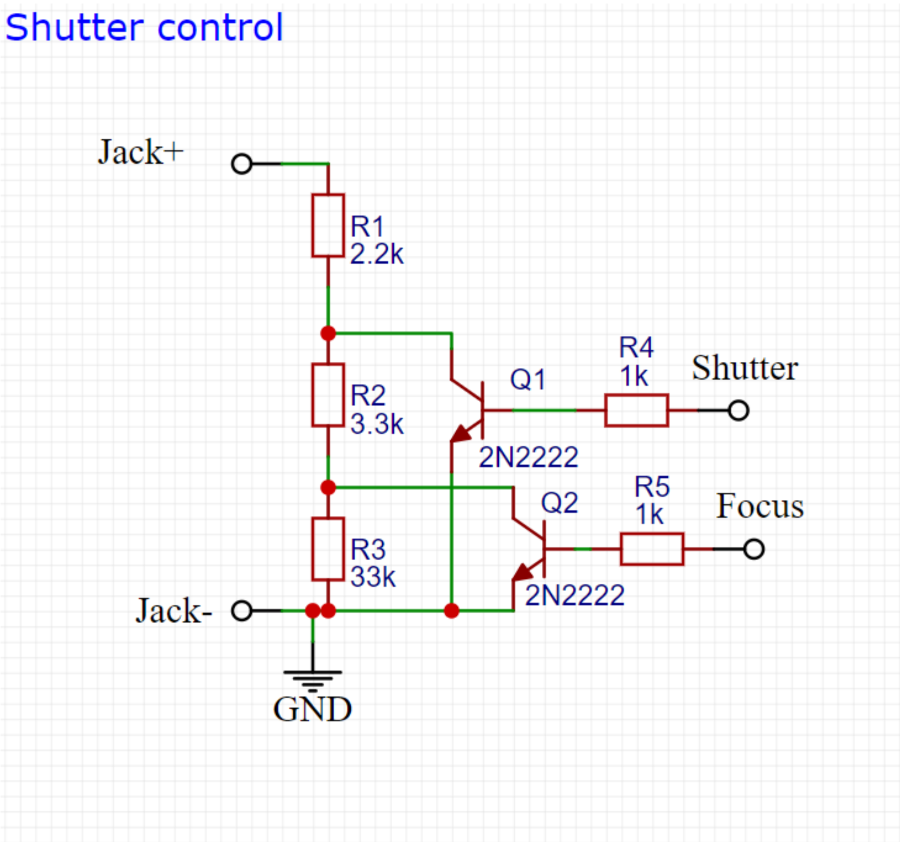


Figure 16: Schematic of the shutter system
LT1763 n.d.

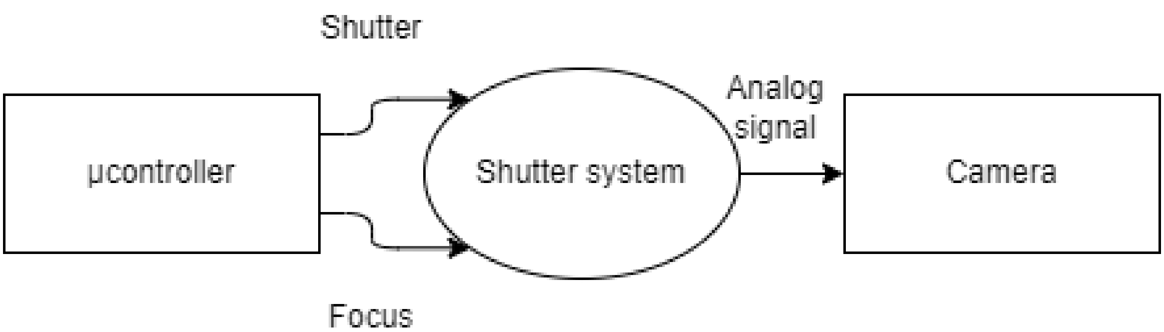


Figure 17: Shutter system

The system is made of a jack socket, connected to resistances. The shutter and the focus pin are linked to the microcontroller. The microcontroller can then be programmed to put the pins at a high or a low state to trigger the shutter or the focus of the camera. By controlling transistor, the camera sees a change in the resistor and trigger the associated actions.

3.8. LoRa

LoRa is a wireless communication protocol that is designed for long-range, low-power, and low-data-rate applications. LoRa is based on chirp spread spectrum modulation (CSS) technology, which enables long-range communication with low power consumption, making it suitable for IoT devices that need to transmit data over long distances while consuming minimal power.

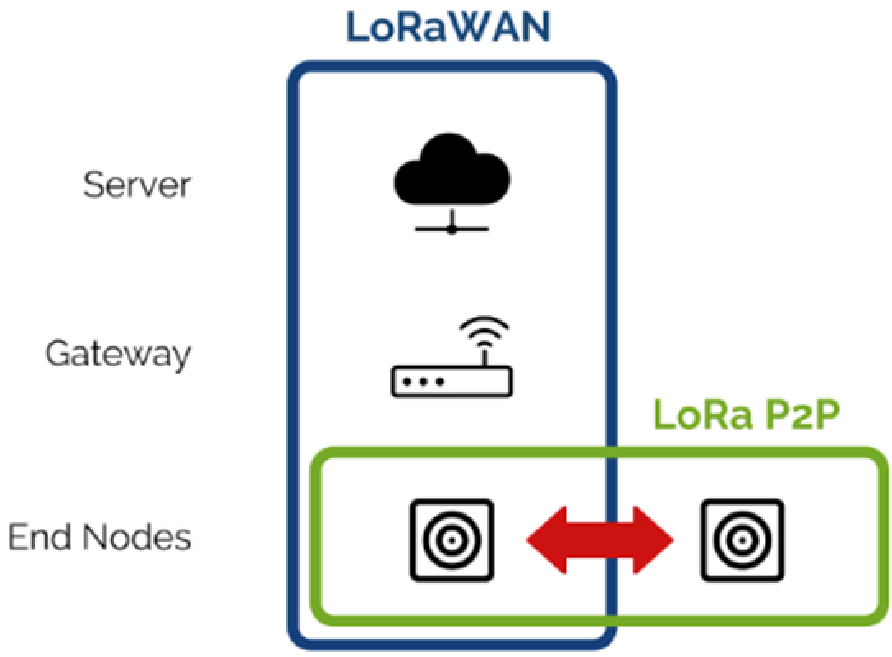


Figure 18: LoRa WAN and LoRa P2P scheme

LoRa is primarily designed for long-range communication between IoT devices and gateways using a star network topology. However, it is possible to use LoRa for peer-to-peer (P2P) communication between two LoRa devices without the need for a gateway or network server. This type of communication becomes important and applicable because the remote monitoring system, to which the LoRa protocol will be applied, is located in a forest. Where there is no internet connection.

3.8.1. Analysis and expressions of needs for LoRa

The analysis and expression of needs would involve identifying the specific requirements for LoRa. For this, it is considered two main needs. The first is to establish communication between the transmitter and the receiver. The second is to cover a distance greater than or equal to 10 km. The goal is to send data via LoRa protocol, obtained by the sensors connected to the remote monitoring system, directly to the site where researchers will be able to analyse the information about its operation.

3.8.2. Use case for LoRa

The system would then be placed in the desired location within the forest. For this reason, LoRa peer-to-peer communication will be used, as there is no internet connection in the location mentioned. All operating data obtained by the monitoring system will be passed to the LoRa transmitter via the microcontroller. With this, the data sent should reach the receiver located at a distance of 10 km or more. Finally, with the communication effected, the researchers will be able to analyze the operating conditions of the system. In our case, the architecture is organized like this:

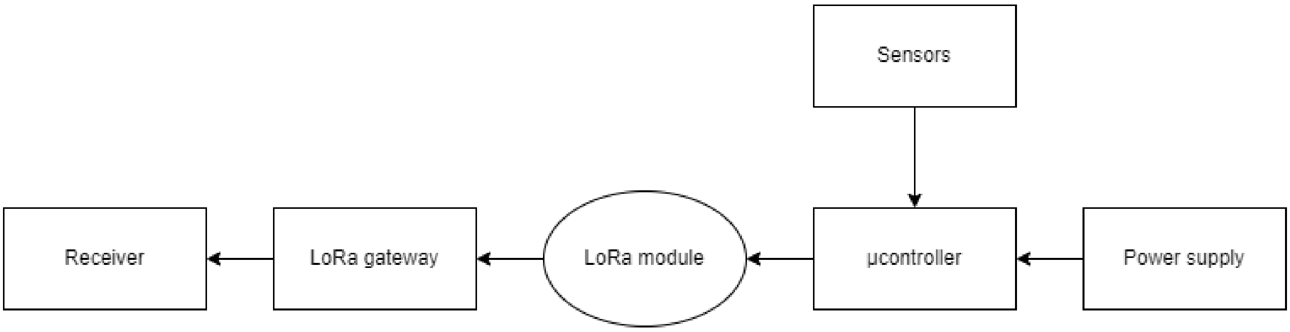


Figure 19: LoRa architecture diagram

3.8.3. Technical constraints

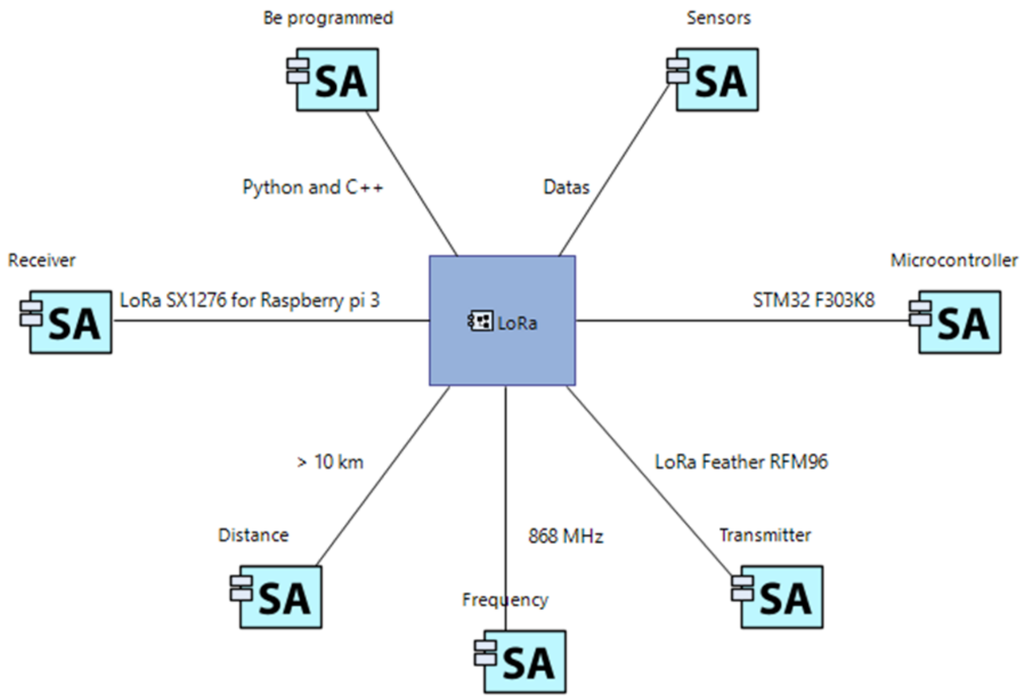


Figure 20: Graph presenting the different elements exercising constraints on the LoRa

Sensors: The sensors will be the source of the monitoring system's operational data, which will be sent for transmission via LoRa protocol.

Microcontroller: The microcontroller STM32 F303K8 will pass the data obtained from the sensors to the LoRa transmitter, so that this information can be sent to the receiver.

Transmitter: As a transmitter, the LoRa Feather RFM96 will be used, which will send the obtained data to the receiver.

Frequency: The frequency on which the LoRa communication will take place is 868 MHz.

Distance: Sending data must pass over a distance of 10 km or more.

Receiver: The Lora SX1276 connected to the raspberry pi 3 will be used as a receiver, which will act as a gateway allowing researchers to retrieve data from the monitoring system.

Be programmed : In order for communication to take place, a code for sending data, in C++ language will be written in the LoRa transmitter connected to the microcontroller. For the receiver, a code in python will be written for retrieving the sent data.

3.8.4. LoRa transmitter

As transmitter the LoRa RFM95W module is used, which is connected to the STM32. The RFM95W module is based on the Semtech SX1276 chip, which is a high-performance, low-power LoRa transceiver. It operates in the 868 MHz and 915 MHz frequency bands, and provides a range of up to 5-10 km in open areas, depending on the transmit power and other environmental factors.

Figure 21: LoRa RFM95W
RFM95W - Low Power Long Range Transceiver Module n.d.

Before configuring the LoRa module to act as a transmitter, it was necessary to connect a wire to the component in order to obtain an antenna. The size of the wire varies according to the transmission frequency. In this case for a frequency of 868 MHz, according to the manufacturer's website, the wire size is 8.2 cm. Because of this it was used.
Next, the Arduino IDE was used to configure and implement the C++ code, available for analysis in the appendix, for sending data via LoRa. The code was written with the help of existing Arduino libraries and forums on the subject available on the internet.

3.8.5. LoRa receiver

As receiver, the LoRa SX1276/ GPS Hat for Raspberry will be used. In this sense, the Raspberry pi 3 connected to the LoRa will have access to the received information. The currently available module for the project already has an uFL antenna.

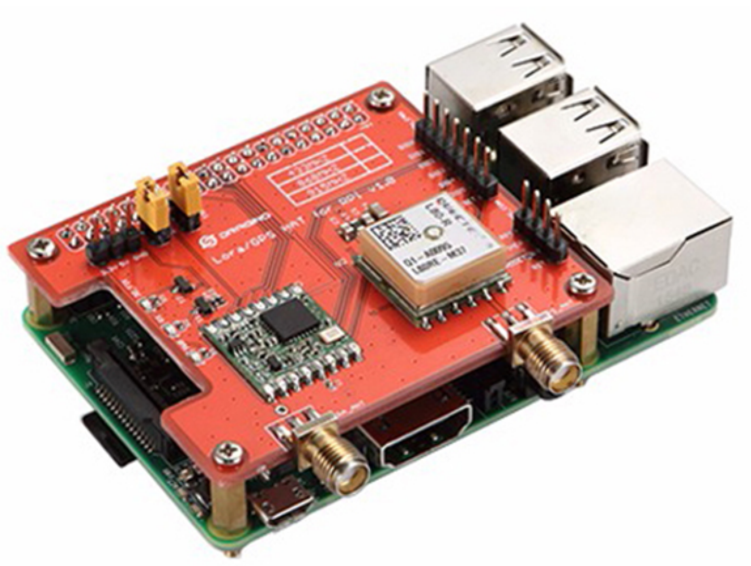
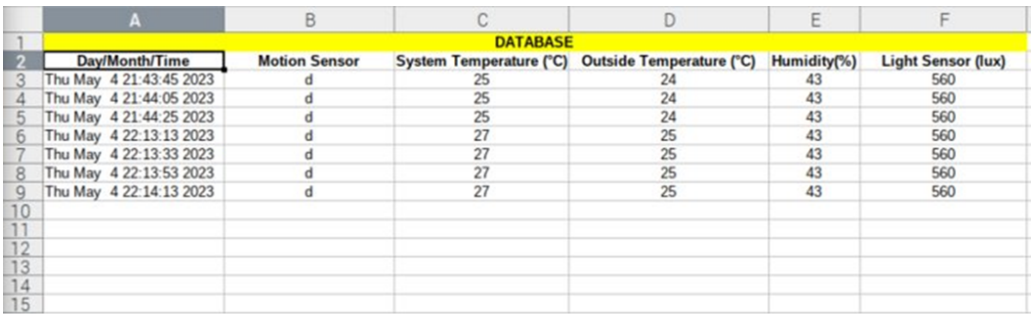


Figure 22: LoRa/GPS HAT for Raspberry
Lora Hat for Raspberry Pi n.d.

The data received by Raspberry is automatically stored in a database available in a libre office Calc folder. This way, the user can have easy access to the system state. For the Raspberry to work as a data receiver, it was necessary to configure it to enable some functions and update and download specific libraries for the LoRa SX1276. With this done, a program was written in python, available for analysis in the appendix, to receive the data. The data received by Raspberry is automatically stored in a database available in a libre office Calc folder. This way, the user can have easy access to the system state.

The database records the date and time each information is received. For the motion sensor, the letter "d" means that there is receiving data, if the system eventually moves, data about the movement will be sent, and letter "m" will appear in the database, indicating movement.



	A	B	C	D	E	F
1	DATABASE					
2	Day/Month/Time	Motion Sensor	System Temperature (°C)	Outside Temperature (°C)	Humidity(%)	Light Sensor (lux)
3	Thu May 4 21:43:45 2023	d	25	24	43	560
4	Thu May 4 21:44:05 2023	d	25	24	43	560
5	Thu May 4 21:44:25 2023	d	25	24	43	560
6	Thu May 4 22:13:13 2023	d	27	25	43	560
7	Thu May 4 22:13:33 2023	d	27	25	43	560
8	Thu May 4 22:13:53 2023	d	27	25	43	560
9	Thu May 4 22:14:13 2023	d	27	25	43	560
10						
11						
12						
13						
14						
15						

Figure 23: Sensors database

3.9. The storage system

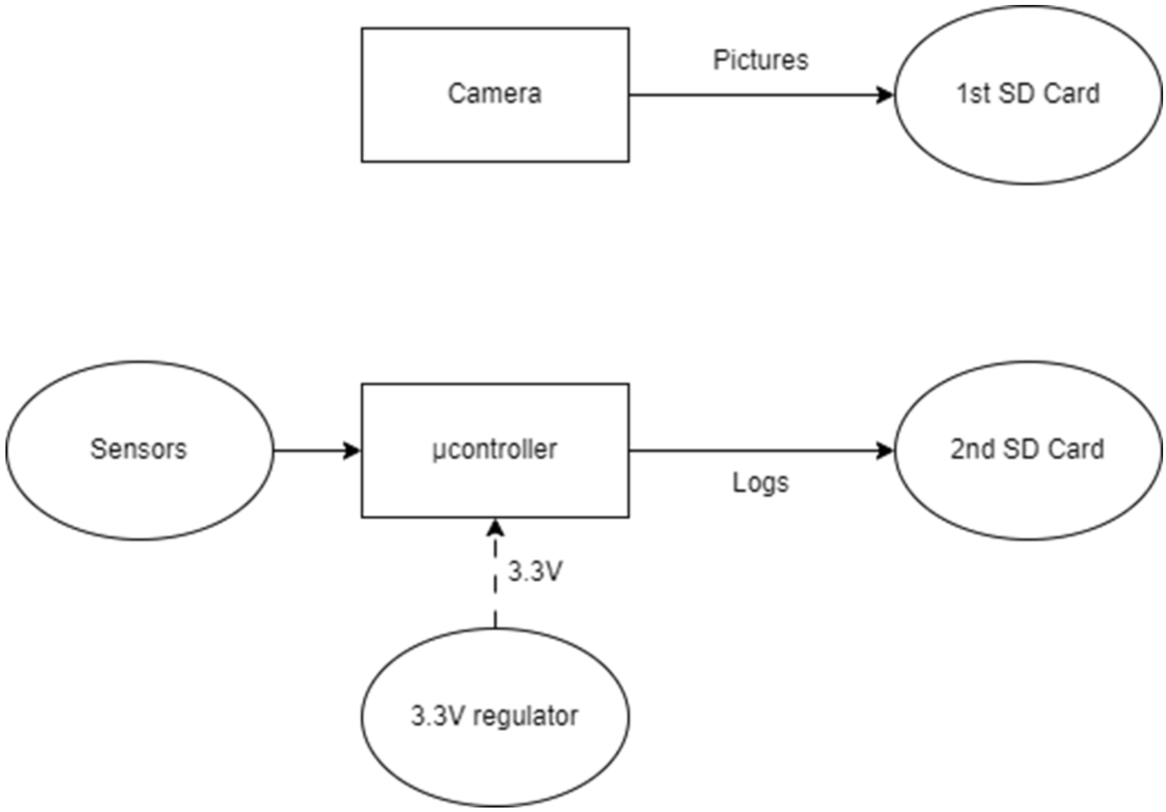


Figure 24: Storage system diagram

The storage system is made of a SD card linked to the camera and a second SD card linked to the microcontroller. The first SD card linked to the camera is used to store the pictures taken by the camera. The second one is used to store the logs emitted by the system. The measures gathered by the sensors are fetched by the microcontroller, which sends them via LoRa to the gateway and stores them at the same time in the 2nd SD card.

3.10. The sensors

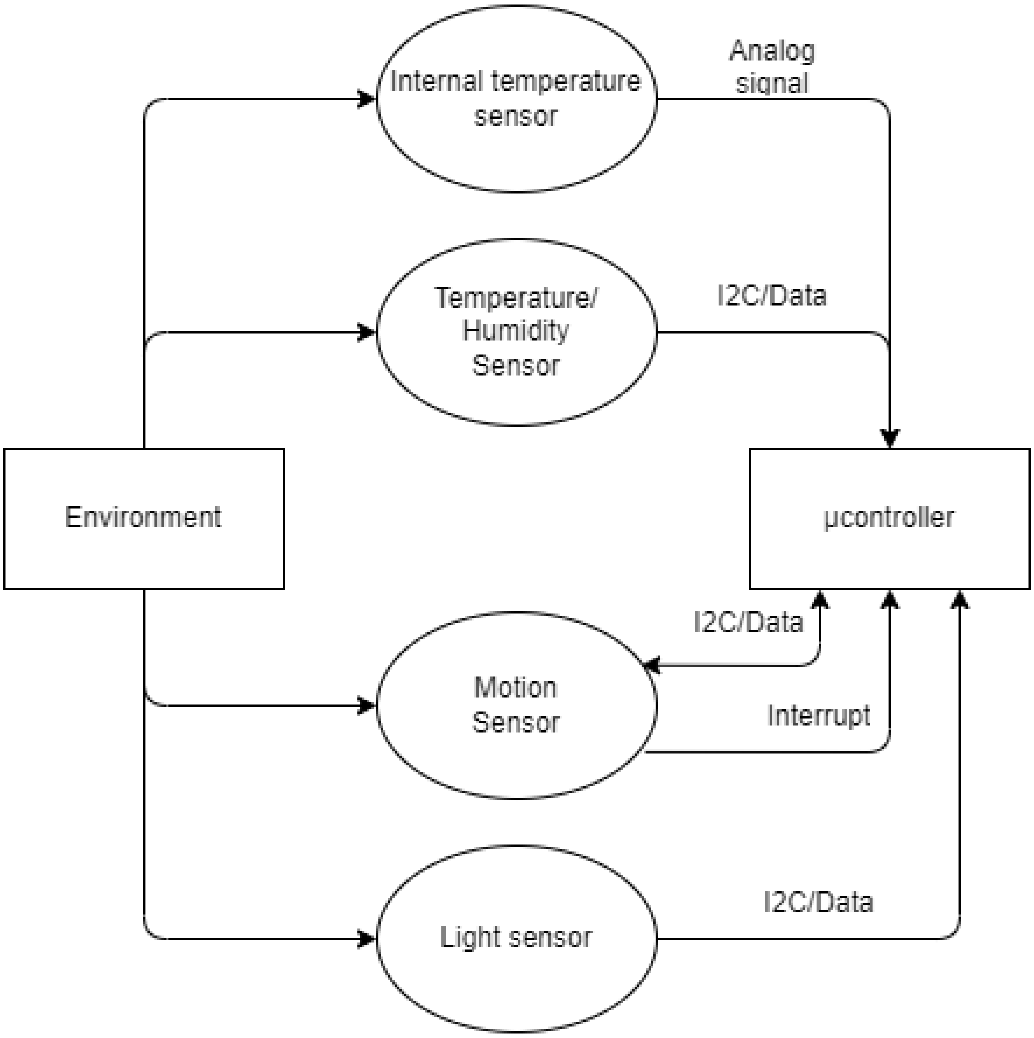


Figure 25: Architecture diagram of the sensors and their relationship to other components

Our aim was to ultimately add sensors to the system in order to send information about it with the LoRa communication protocol. The researchers can then know the state of the system in real time, in order to not lose days or even weeks of pictures collected if the system has a problem.
In fact, the environment could perturbate the environment in 2 different ways:
The system could move (because of wind or potentially animals), which would unbalance the system. The system could then fall on the ground or take pictures of the wrong place. The researchers not knowing it could let the system in place during months, which could lead to a loss of time in their work.
The system could also be damaged by bad weather conditions, such as humidity and temperature. For example, if the temperature rises too much, the battery and other components could be damaged. So, it is important to detect the problems to inform the researchers.
The sensors would collect data in the environment and send it to the microcontroller in order to process it and log it. Then, the data would be sent to the storage system.

3.10.1. Motion sensor

The motion sensor employed in this device is an ICM-20602. This motion tracking device was chosen for its low power consumption (1.33mA in low power mode and 2.79mA when in low noise mode). The ICM-20602 is also programmable, allowing users to define a threshold value to wake up the microcontroller. For communication, the ICM-20602 utilizes an I2C interface, as well as an interrupt pin to signal events such as data-ready or wake-on-motion. This makes it easy to interface with a microcontroller and manage the sensor's operation. The output data rate (ODR) for both the accelerometer and gyroscope can be configured based on your application requirements. When using interrupt-driven data collection, the interrupt pin can be set to trigger when new data is available, allowing the microcontroller to process the information.

Figure 26: Picture of the motion sensor ICM-20602
ICM-20602 - Module MEMS, Série MotionTracking, Gyroscope/Accéléromètre 3 axes, ±16g, 1,71V à 3,45V, LGA-16 n.d.

3.10.2. Humidity/Temperature sensor

The AM2320 has been selected as the humidity and temperature sensor for this project due to its affordability and low power consumption (maximum 1mA and 50µA in sleep mode). This sensor covers a wide temperature range from -40 to 80°C and is capable of measuring humidity from 0 to 99.9% relative humidity. The AM2320 is also equipped with an I2C connection, making it convenient for integration with a microcontroller. In this application, humidity and temperature will be measured every 30 minutes. The I2C interface of the AM2320 facilitates communication with the microcontroller, allowing for efficient and accurate data collection at regular intervals. This ensures that the project remains energy-efficient while providing reliable temperature and humidity measurements.

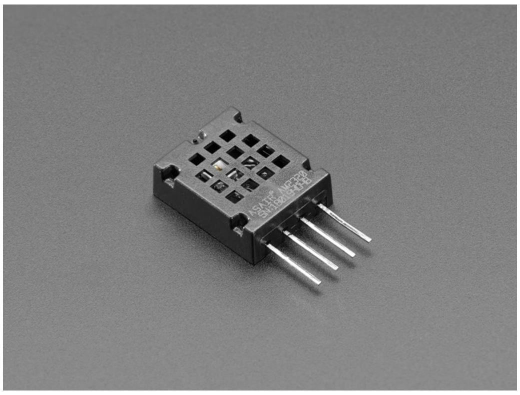


Figure 27: Picture of the temperature and humidity sensor AM2320
AM2320 Digital Temperature and Humidity Sensor n.d.

3.10.3. Temperature sensors

The LM35DZ temperature sensor is selected for internal case temperature monitoring due to its high accuracy, low power consumption (less than 60µA), and easy interfacing with a microcontroller. It provides a linear output (10mV/°C), operates in a -55 to 150°C range, and minimizes self-heating, which reduces measurement interference. Temperature measurements will be taken every 30 minutes, ensuring energy-efficient and reliable monitoring.

Figure 28: Temperature sensors LM35DZ
LM35DZ Temperature sensor n.d.

3.10.4. Light sensor

For light sensing requirements, the chosen sensor is the TSL2561. This efficient and cost-effective sensor is known for its reliable light intensity measurements across a wide range of conditions. One of the key reasons for selecting the TSL2561 is its low power consumption, with a typical active current of 0.24mA and a power-down current of 2µA, which aligns with the project's focus on energy efficiency. Additionally, the sensor boasts a range of 0.1 to 40,000 lux, making it suitable for various lighting environments. The availability of the TSL2561 for quick delivery further contributed to this decision. Its I2C interface enables integration with the microcontroller, while the high-resolution 16-bit digital output ensures accurate and precise light readings. In this application, the TSL2561 operates with an I2C interface and takes light measurements every 30 minutes. Additionally, a measurement is taken before capturing a photo to ensure optimal lighting conditions. This approach guarantees energy-efficient and precise light readings, contributing to the overall effectiveness of the project.

Figure 29: TSL 2561
TSL 2561 Light sensor n.d.

List of Figures

References

Hervé (LuzPhotos). *La focale d'un objectif : définition, angle de champ et focale équivalente...* fr-FR. Jan. 2020. URL: https://www.luzphotos.com/materiel/objectif/focale-objectif-def-focale-equivalente.

AM2320 Digital Temperature and Humidity Sensor. URL: https://www.adafruit.com/product/3721.

Angle de champ. URL: https://media4.obspm.fr/public/ressources_lu/pages_instruments-photo/instru-ap-grand-angle-teleobjectif.html.

Hirudin. *Arduino Panasonic remote shutter release (DMW-RSL1 disassembly)*. Aug. 2013. URL: https://www.youtube.com/watch?v=DNj48nwUjxk.

ICM-20602 - Module MEMS, Série MotionTracking, Gyroscope/Accéléromètre 3 axes, ±16g, 1,71V à 3,45V, LGA-16. URL: https://fr.farnell.com/invensense/icm-20602/mod-mems-gyroscope-accelerometre/dp/2911496.

La focale d'un objectif : définition, angle de champ, focale équivalente... URL: https://www.luzphotos.com/materiel/objectif/focale-objectif-def-focale-equivalente.

LM317 - Adjustable Regulator. URL: https://www.ti.com/lit/ds/symlink/lm317.pdf.

LM35DZ Temperature sensor. URL: https://boutique.semageek.com/fr/index.php?controller=attachment&id_attachment=80.

Lora Hat for Raspberry Pi. URL: https://www.dragino.com/products/lora/item/106-lora-gps-hat.html.

LT1763. URL: https://www.mouser.fr/datasheet/2/609/1763fh-3123364.pdf.

LT1763. URL: https://www.doc-diy.net/photo/remote_pinout/#lumix.

Relay G5V-1. URL: https://www.mouser.fr/datasheet/2/307/en-g5v_1-1097070.pdf.

RFM95W - Low Power Long Range Transceiver Module. URL: https://www.hoperf.com/data/upload/portal/20190801/RFM95W-V2.0.pdf.

RS PRO 12 V, 24 V 10A Solar Charge Controller | RS. URL: https://uk.rs-online.com/web/p/solar-charge-controllers/9054532.

The Backoffice. *Camera Remote Shutter control for Lumix*. Mar. 2017. URL: https://www.youtube.com/watch?v=p38VHJZr6iE.

TSL 2561 Light sensor. URL: https://shop.mchobby.be/.

Valise Peli™ 1150 vide, noire. URL: https://shop.cpfrance.com/peli-cases/554-valise-peli-1150-vide-noire-0019428005313.html.

Alexander Winterl et al. "micrObs A customizable time-lapse camera for ecological studies". en. In: *HardwareX* 8 (Oct. 2020), e00134. ISSN: 24680672. DOI: 10.1016/j.ohx.2020.e00134. URL: https://linkinghub.elsevier.com/retrieve/pii/S2468067220300432.

www.doc-diy.net :: camera remote release pinout list. URL: https://www.doc-diy.net/photo/remote_pinout/#lumix.

Appendices

Github repository

Everything we used (code,documentation,schematic ...) is available on our GitHub repository on this link : `https://github.com/RedCoal27/4AGPSE-Forest-Watch`

Horned beast diagram of the system

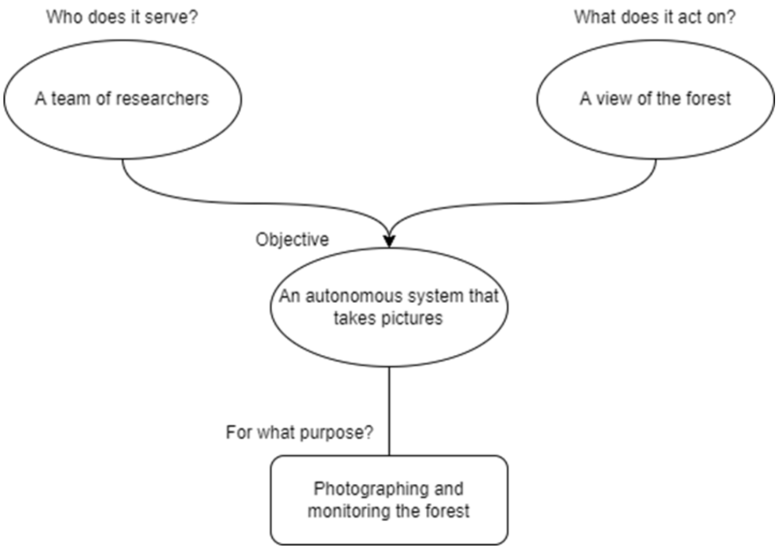


Figure 30: Horned beast diagram of the system

Horned beast diagram for Lora

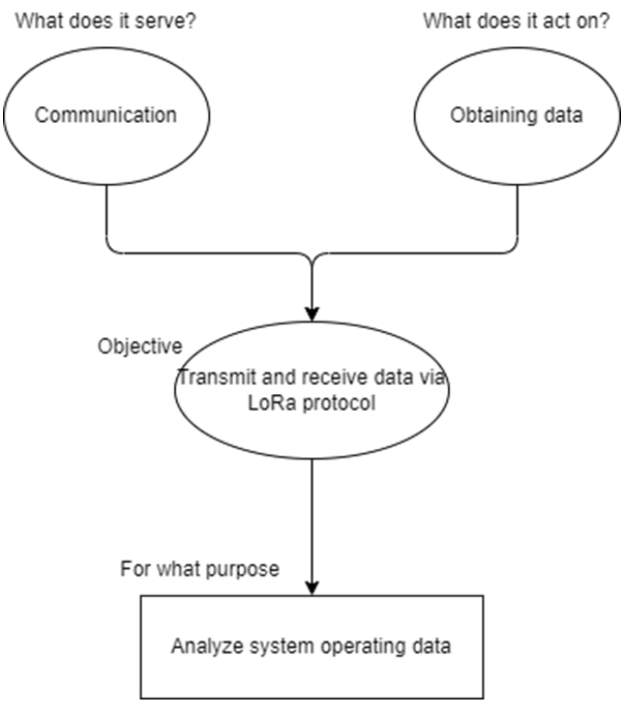


Figure 31: Horned beast diagram for Lora

Self-assessment:

Krasulja Florian

I was part of the team that worked on the design and implementation of an autonomous system for taking pictures of a tropical forest in Gabon for research purposes. As a member of the team, I was responsible for the following tasks:

- Product design: I have gained experience in designing a product that meets the specific requirements and constraints of the project, such as durability, waterproofing, ventilation, and ease of access.
- Technical drawing and 3D modeling: I have improved my skills in using technical drawing software and 3D modeling software to create detailed and accurate designs of the case.
- Project management: I have gained experience in working in a team and coordinating with other members to ensure that the design of the case is completed on schedule.
- Communication: I have improved my ability to communicate my ideas and designs effectively to the rest of the team, and to explain the reasoning behind my design choices.

Overall, I believe that my contribution to the design of the case has been significant, and I am proud of the final product. I believe that my experience in this project will be valuable in future projects, both in terms of technical skills and experience in project management.

Florian	
3D Drawing/Printing	Beginner → Intermediate +
Enclosure	0→ Intermediate
Imaging system	Beginner→ Intermediate
Teamwork	Beginner → Intermediate

Maillet Alexandre

As a member of the team responsible for the design and implementation of an autonomous system for taking pictures of a tropical forest in Gabon for research purposes, I was responsible for the alimentation part of the system. My role in the project included the following tasks:

- Alimentation system design: I have gained experience in designing an alimentation system that meets the specific requirements and constraints of the project, such as the use of a 12V 2,3Ah lead battery, a 10w solar panel, a sun voltage regulator, and a LM317 to regulate the voltage to approximately 8V.
- Voltage regulation: I have improved my skills in using LM317 and other regulators to ensure that the voltage supplied to the camera and microcontroller is within the proper range.
- Project management: I have gained experience in working in a team and coordinating with other members to ensure that the alimentation system is completed on schedule.
- Communication: I have improved my ability to communicate my ideas and designs effectively to the rest of the team, and to explain the reasoning behind my design choices.

Although my contribution to the project was significant, I believe that we could have worked harder on the project. I think that if we put more effort into it, we could have improved the final product even more. Nevertheless, I believe that my experience in this project will be valuable in future projects, both in terms of technical skills and experience in project management.

Alexandre	
Arduino/C++	Intermediate → Advanced
PCB Manufacturing	Intermediate+ → Intermediate+
Electronics	Intermediate+→ Advanced
Team Management	0 → Beginner
Teamwork	Beginner → Intermediate

DE SOUSA CARDOSO Raimundo Vitor

The first part of this project allowed me to learn and develop competencies in the areas in which I worked towards the development of the system. Especially those related to modelling and project planning, as well as the communication part via LoRa protocol. In the part involving planning, I could learn how to organize and detail a project before its execution. I was able to do different analyses, functional, risk, and process, some of them using the Cappella software. In the communication via LoRa protocol part, I could understand how the architecture of this technology works. I applied the knowledge obtained in classes to perform a communication via UART between the microcontroller and the LoRa/GPS HAT, also providing a learning and code development for programming this function. Finally, by working alongside a fantastic team, I was able to develop my teamwork skills, especially in an environment where I was communicating using a foreign language. I learned a lot by debating ideals, discussing problems, pointing out solutions, and presenting our project to teachers and students.

Raimundo	
LoRa	0 → Intermediate
Arduino/C++	Beginner → Intermediate
Raspbian	0 → Intermediate
Teamwork	Intermediate → Intermediate+

Abdelkrim Darrys

While working on this project, I contributed on many aspects:

- Research: In this project, I took part on research about components and methods. For example, I researched components to buy for the project alongside other team members. I also made research on how remote shutter systems work to reproduce it.
- Project management: This project permitted me to improve my skills in project management and communication with my colleagues.
- Documentation: While writing documentation for the project, it helped me to better understand what my colleagues were doing and to write technical documents. I also documented what we were doing each time we were working on the project.

Darrys	
Arduino/C++	Beginner → Intermediate
Electronics	Intermediate → Intermediate+
Imaging System	0 → Intermediate
Teamwork	Intermediate → Intermediate+