BirdBox

Technology in the service of nature

Project Name	Connected nesting box
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A.1 Context

A.1.1 What is the origin of the project ?

The origin of this project comes from the decline of these species. It is often due to the loss of their natural housing, the scarcity of their food and the disruption of their breeding cycles by increasing urbanisation. The design of an intelligent nesting box makes it possible to alleviate some of these problems by providing a safe shelter while collecting precise data on their habits and behaviour.

A.1.2 Which need does it respond ?

The connected nesting box is a project initiated as part of the Icam 4 Technical Project, in partnership with the Ligue de Protection des Oiseaux d'Alsace LPO. It responds to the monitoring and preservation of bird species in urban and peri-urban environments. The aim is to help preserve two particular species: the great-tit “Parus major” and the black redstart “Phoenicurus ochruros”.

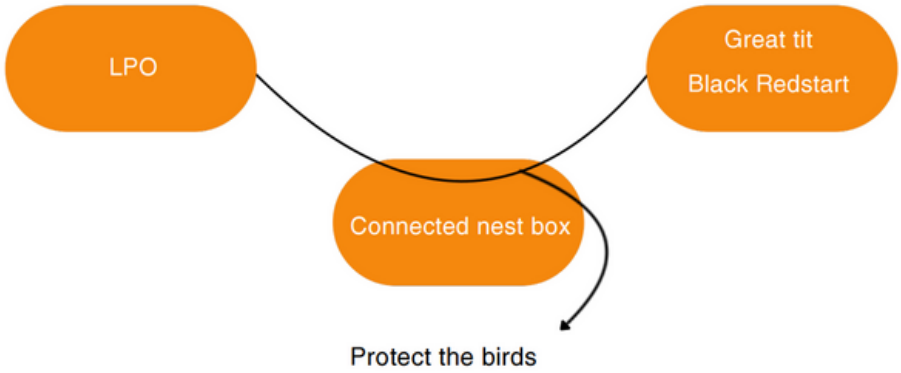


Figure 1: Horned beast-Connected nesting box

Figure 2: Ishikawa diagram

A.1.3 What are technological challenges that it seeks to overcome ?

The instrumentation system must be able to:

• Measure the temperature inside the nest from -25°C to 45°C with a tolerance of ±5°C, and humidity from 10% to 100% with a tolerance of ±5%.
• Count the number of birds in the nesting box with an accuracy of ±2, up to a maximum of 4 birds simultaneously.
• Identify the bird species to determine whether they are great tits, black redstarts, or neither, with a maximum margin of error of 30% by the end of each day.
• Be energy autonomous for at least one year, with a tolerance of ±2 months.
• Show no signs of degradation due to sun or rain for at least 8 months, and withstand winds up to 40 km/h (excluding storms, hail, or human accidents).
• Measure weight variations of the nesting box up to a maximum of 5kg, with a tolerance of ±5g.
• Transmit data to a user-friendly interface suitable for children as young as 4 years old to seniors, displaying hourly data.
• Transmit encrypted data with zero tolerance for data leakage.
• Limit emitted noise to 5 dB with a tolerance of ±2 dB.

The nesting box must be able to:

• Be adapted to different tree diameters ranging from 10 to 40 cm, with a tolerance of ±5 cm, and be mountable on a building wall at a height of 3 m with a tolerance of ±1 m.
• Show no signs of degradation due to sun or rain for at least 3 months (excluding storms, hail, or human accidents).

The project must respect a budget of 300€ and be completed safely without causing harm to anyone, with zero tolerance for safety violations.

A.2 State of the art

<u>Existing technology for a connected nest box:</u>

There are many types of connected nest boxes currently on the market. There are nest boxes equipped with these different elements:

1. CONCEPTION

Natural design and ecological materials:

Today's smart nest boxes favour environmentally friendly materials, such as FSC-certified wood and recycled plastic. For example, Nestera models use recycled plastic that is 10% more insulating than standard wood, contributing to better thermal protection for birds. Another model, Vivara, uses a mix of wood and concrete (WoodStone®), ensuring superior durability and weather resistance for up to 10 years.

Integrated drainage system:

Some nest boxes, such as those offered by Vivara, are equipped with an integrated drainage system that allows the humidity inside to be maintained below 5%, even after bad weather. This feature ensures a dry and comfortable habitat, essential for the reproduction of birds.

2. RECOGNITION AND NOTIFICATIONS

Identification of bird species:
Connected birdhouses like Birdfy's use artificial intelligence algorithms that can identify more than 6,000 bird species around the world. The accuracy of this system is 93% according to a study published in Nature Communications in 2023. Users receive instant notifications when a new bird is detected via the mobile application, allowing activity to be tracked in real time.

Motion detection:
Nest boxes like Nestera's are equipped with PIR (Passive Infrared Sensor) sensors that can detect movement at a distance of 2 meters, with 90% accuracy. The system automatically activates video recording as soon as movement is detected, ensuring that you don't miss any important moments.

3. CAMERA AND VIDEO

High Definition (HD) Camera and Night Vision:
Connected models, such as those from Vivara, are equipped with Full HD cameras offering a resolution of 1920x1080 pixels, with a refresh rate of 30 frames per second. These cameras have a viewing angle of 120 degrees, allowing a wide area around the nest box to be captured. For night monitoring, invisible 850 nm infrared LEDs guarantee effective night vision up to 10 meters, without disturbing the birds.

Video recording and storage:
The Nestera birdhouse includes a 32GB microSD card, capable of storing up to 80 hours of video. Videos can be saved or shared via the Nestera app, allowing users to track bird activity or share key moments on social media.

4. ADDITIONAL FEATURES

Autonomy and solar power supply:
Models equipped with solar panels, such as those from Nestera, have an internal 5,200 mAh battery and a solar panel with a 15,600 mAh lithium-ion battery. This configuration allows the nest box to operate throughout the breeding season without requiring connection to an external power source. Recharging is done directly via the integrated solar panel or, in case of low sunlight, via a Micro USB socket. The autonomy is estimated at 4 weeks per recharge cycle.

5. CONNECTIVITY AND RANGE

Wi-Fi and long range connection:
Connected birdhouses like those from Birdfy and Nestera use 2.4 GHz Wi-Fi connectivity, ensuring stable transmission over a range of 30 meters outdoors. For remote or poorly served environments, some models, such as those equipped with LoRa (Long Range) technology, can extend the connection range up to 300 meters. This connectivity allows live streaming of video and the sending of instant notifications as soon as movement is detected.

Numerical references

1. *Nestera – Solar camera technology and technical specifications of connected nest boxes.*
2. *Vivara – WoodStone® nest box features and durability (10 years).*
3. *Birdfy – Species recognition systems (6,000 species, 93% accuracy) and long-range connectivity features (300 m).*
4. *Study published in Nature Communications (2023) – Accuracy of artificial intelligence algorithms for bird species classification.*

ANALYSIS OF EXISTING TECHNOLOGIES ON THE MARKET

In the connected birdhouse market, several products offer interesting features for monitoring and protecting birds. Brands such as Vivara, Nestera, and Green-Backward offer birdhouses that integrate various technologies, such as motion sensors, high-definition (HD) cameras, and species recognition systems via mobile applications. These products allow users to observe and document bird behavior remotely, while ensuring protection of the immediate environment of the birdhouse.

Product examples:

- Nestera offers a birdhouse with a built-in Wi-Fi camera, capable of streaming 1080p HD images and capturing videos using motion sensors. This model, which also includes a solar panel for power, is sold for around €250.
- Vivara offers a model equipped with WoodStone® technology, a mixture of wood and concrete ensuring better durability and thermal insulation. This nest box, mainly focused on protecting birds from predators, is sold at around €120.
- Birdfy has a birdhouse with species recognition via artificial intelligence, capable of identifying more than 6,000 species of birds. The model, which also integrates an HD camera and a microphone, sells for around €300.

These products are therefore positioned in a price range from €100 to €300, depending on the features offered and the materials used.

LIMITATIONS OF CURRENT TECHNOLOGIES

Although these products offer a wide range of features, none of them manage to combine all the criteria necessary to fully meet the specific needs of the LPO in the context of our project. Indeed, existing models often lack certain essential features, such as real-time measurement of environmental parameters (temperature, humidity) or the collection of more precise behavioral data, such as counting the entries and exits of birds in the nest box.

To fill these gaps, we have identified several technological elements to add:

- **Integrated scale sensor (€40 - €80):** to measure weight and detect subtle movements of birds.
- **Thermal sensor (€10 - €30):** to record the interior temperature of the nest box.
- **Hygrometric sensor (€5 - €20):** to monitor the humidity level inside the nest box, crucial for the comfort of the birds.
- **Microphone (€10 - €50):** to capture the sounds and vocal activities of birds.
- **Passage counter (€20 - €60):** based on an ultrasonic or infrared sensor, to detect the entry and exit of birds in the nest box.
- **User interface:** via a mobile application, allowing both a fun experience and expert monitoring of the data collected.

By integrating these components, we aim to offer a complete solution that not only improves bird monitoring, but also enables detailed and accurate data collection.

Sources of components : Gotronik, Kubii, Conrad.

Matrice SWOT :

Figure 3: Matrice SWOT

B. Functional analysis

Main functions:

Category	Function	Validation criteria	Tolerance	Flexibility
FP1	Measure the temperature	From -25°C to 45°C	+-5°C	F0
FP2	Measure the humidity	Form 10% to 100%	+-5%	F0
FP3	Identify bird species	Three cases : Great-tit , Red-start or neither	30% error max on all the identification at the end of the day	F0
FP4	Count bird	Count until 4 birds at the same time in the nest	+-2	F0
FP5	Measure variation of weight	Can measure a variation of weight until 5kg	+-5g	F0
FP6	Visualize data	user friendly	user 4 years and more	F0

Constrained functions:

Categories	Function	Validation criteria	Tolerance	Flexibility
FC1	Adaptability of the nest	Nest can be attached to a tree with a diameter between 10 and 40 cm or to a building wall at a height of 3m	+-5 cm for diameter +- 1m for a building wall	FC
FC2	Resistance to all kind of weather	No degradation in winds up to 40 km/h or from sun/rain for 8 months for the instrumentation system and 3 months for the nesting box	Storm, hail and human accident not take into account	FC
FC3	Data security	Make sure that all data are encrypted	0 data leakage	FC
FC4	Minimise birds annoyment	Limit emitted noise until 5 dB	+-2 dB	FC
FC5	Easy installation	Can be assembled in less than 30min	+- 10 min	FC
FC6	Be autonomous in energy	Energy autonomy of at least 1 year	+-2 months	FC
FC7	Budget	300 €	Tolerance 0	FC
FC8	Security	Nobody gets hurt	Tolerance 0	FC

C. Environmental approach

The project aims not only to protect birds, but also to minimise their ecological impact.
To ensure that these commitments will be met, we have integrated these constraints into our functional analysis.

1. Eco-responsible design

- **Reuse of components:** We will integrate into the specifications the obligation to reuse electronic components from previous projects when technically possible. An inventory of recoverable components will be carried out at the start of the project to maximize their use.

2. Manufacturing and assembly

- **Waste Reduction:** Manufacturing processes will be optimized using methods that minimize material waste. Waste tracking will be implemented to measure and reduce losses.
- **Use of renewable energy:** The electronic system of the nest boxes will be powered by solar panels connected to a battery. This constraint will be integrated into the choice of components, ensuring that the sizing of the energy system is sufficient for total autonomy via renewable energy.

3. Product life

- **Optimization of the service life:** The design of the nest boxes will be carried out using robust materials. Resistance and waterproofing tests will be carried out before installation to ensure an optimal service life.

4. End of life

- **Recyclable materials:** All materials used will be selected based on their ability to be recycled. A disassembly manual will be provided to facilitate end-of-life waste management. We will not use glue to allow easy disassembly and better recycling management.
- **Disassembly:** The modular design will allow the nest boxes to be easily disassembled. This will facilitate the separation of the different materials for recycling.

5. Societal impact

- **Awareness and education:** The project will include an educational component aimed at the general public. The data collected will be used to create educational materials accessible to local schools and communities, in partnership with the Ligue de Protection des Oiseaux d'Alsace.

D. Users Stories et backlog

User Story	Validation criteria	Priority	Sprint	Stain
As an ornithologist, I want to be able to track the temperature and humidity inside the nest boxes in order to monitor nesting conditions.	Temperature and humidity sensors are installed and the data is available on an interface.	High	1	Selection and installation of sensors. Development of the data visualization interface.
As an ornithologist, I want to be able to identify and count the number of birds present in the nest boxes in order to monitor the evolution of bird populations.	The system is able to detect the presence of birds and count them in real time.	High		Implementation of motion detection sensors. Real-time counting algorithm.
As a user, I want to view an event log (bird entries/exits) to visualize key moments of bird activity.	The interface allows you to display a time-stamped event log, including bird entries and exits.	Average		Development of the logging module. Display test on the interface.
As a user, I want the nest box to be dismountable and recyclable to promote sustainable resource management and minimize waste.	The nest box is designed without glue, its components are easily disassembled and can be sorted for recycling.	Average		Design and manufacture of the removable nest box. Selection of recyclable materials. Prototyping and disassembly validation

Table 4 : User story et Backlog

E. Budget Envelope

1. Materials and Supplies

- **Sensors (Temperature, Humidity, Motion):** These elements are essential for the basic functionality of the connected nest box.
- **Electronic Components (Boards, cables, etc.):** Required for the assembly and connection of the various sensors and modules.
- **Construction Materials (Wood, screws, etc.):** For the physical construction of the nest box.
- **Battery or Solar Panel:** For the autonomous energy supply of the system.

2. Development and Services

- **Software development:** Creation of the user interface and data processing algorithms.
- **Installation and Testing:** Field work for installation of nest boxes and initial testing.

3. Miscellaneous costs

- **Transportation and Logistics:** Costs associated with transporting materials and deploying them to site.
- **Contingencies:** A small reserve to cover unforeseen events or cost overruns.

Estimated Budget Breakdown

Category	Planned allocation (€)	Percentage of Total Budget
Equipment and Supplies	150	50%
Development and Services	120	40%
Miscellaneous costs	30	10%
Total	**300**	**100%**

Figure 5: Budget distribution

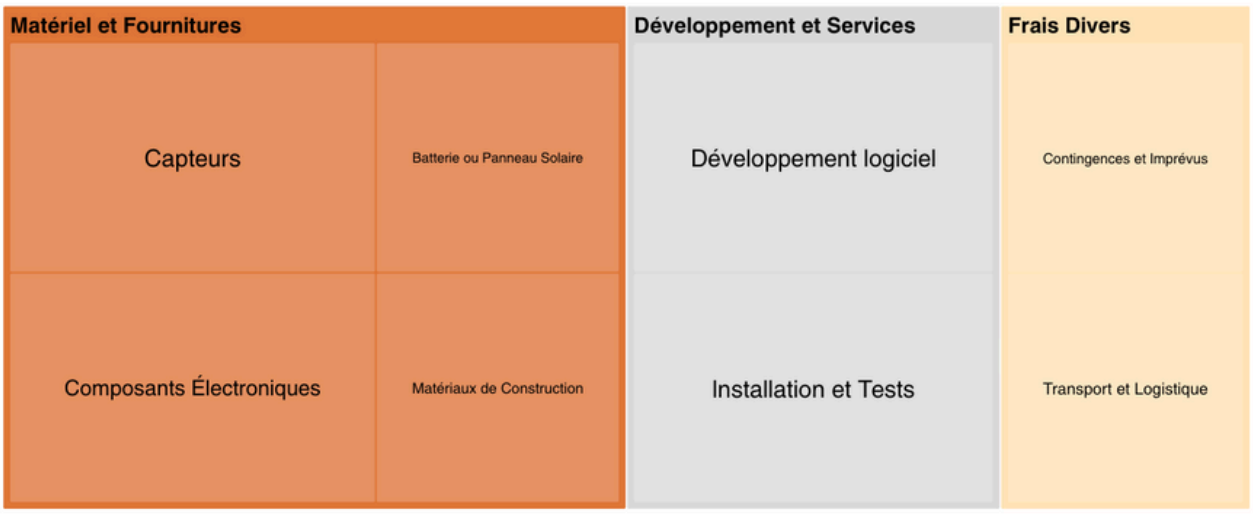


Figure 5: Budget distribution

Notes and Justifications of the budget distribution

- **Priority is given to sensors and construction materials, as these are the essential elements to ensure the functionality of the nest box.**
- **Software development has a significant share of the budget because the platform must be reliable and well designed for the project to be successful.**
- **A small contingency reserve is included to manage project risks.**

Conclusion

This forecast budget should be revised regularly as the project progresses. This will allow expenditures to be adjusted based on achievements and discoveries made during the project.

F. Planning

In our project to develop a connected birdhouse, we use Notion as our central project management tool. It allows us to centralize all information and activities related to the project, providing a convenient side for documentation, task planning, and progress tracking.

Project Management with Notion

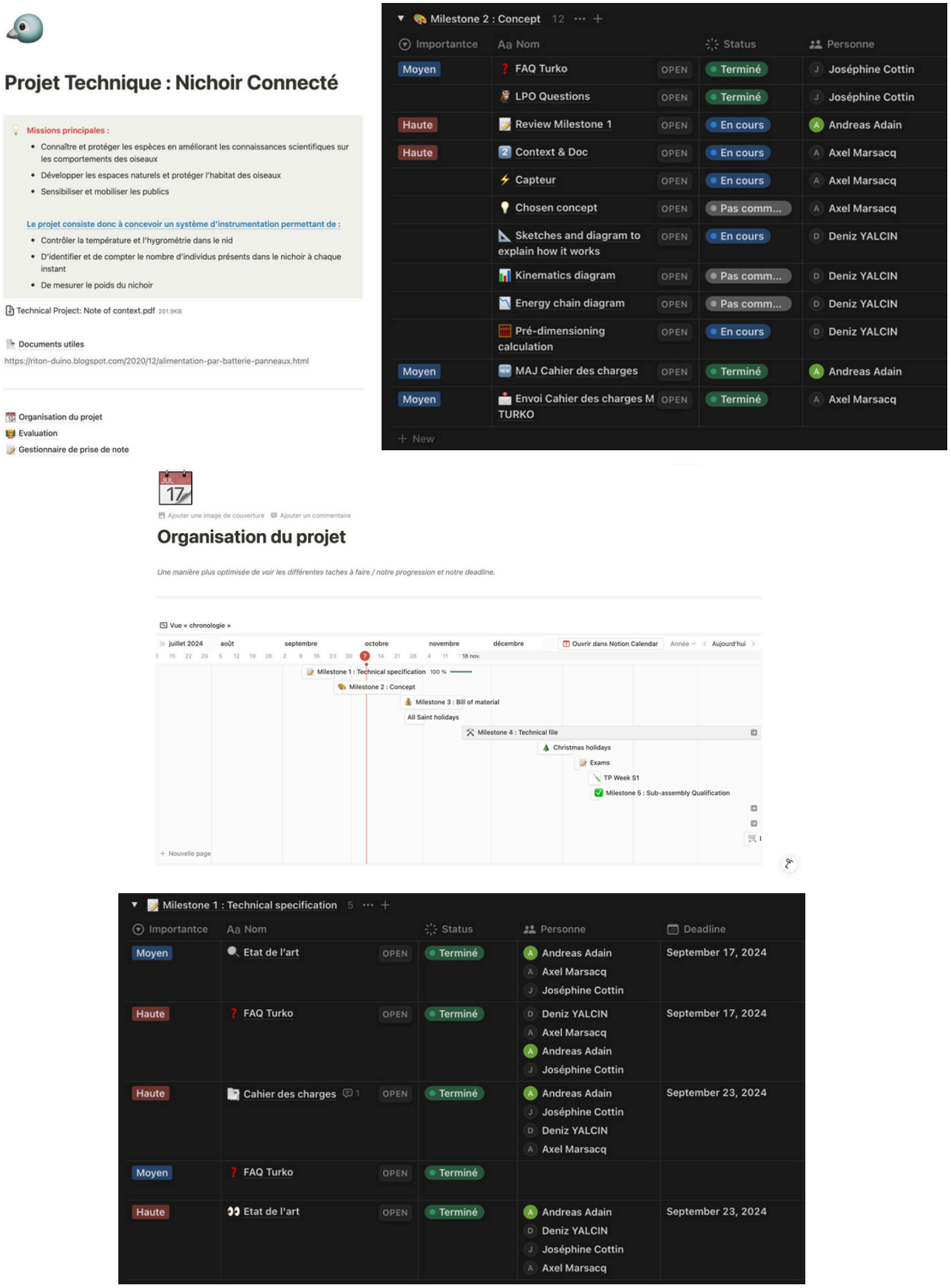
1. Documentation of Objectives and Missions: The missions of our project are clearly defined, such as the protection of bird species and public awareness.

2. Technical Features and Product Backlog: The technical features of our connected birdhouse are detailed directly in Notion. Each feature, such as temperature control and bird identification, is associated with specific user stories that are integrated into our product backlog. This organization allows us to precisely track development and prioritize tasks efficiently.

3. Visual Planning and Task Tracking: Notion's timeline views, similar to Gantt charts, help us plan and track our milestones. Each task is assigned to a specific sprint, making it easy to visualize our progress and manage deadlines.

4. Team Collaboration: Notion also serves as a collaboration platform for our team. Technical documents, project updates, and communications are all centralized. Every team member can access and contribute to this information in real-time, making our teamwork more cohesive and efficient.

5. Resource Management: All technical documents, including specifications, work orders, and educational resources, are stored and organized in Notion. This ensures that information is accessible at all times to all team members, facilitating quick references and necessary revisions.



Using Notion helps us maintain an organized structure, manage our project efficiently, and ensure that all stakeholders are constantly informed and involved. This allows us to remain agile and respond effectively to challenges as we move forward with our connected birdhouse project.

G. Conclusion

This project is an innovative solution for protecting and observing birds, while raising public awareness of biodiversity conservation. The connected nesting box project undertaken as part of Ecam 4's Technical Project stems from a request from the Ligue de le Protection des Oiseaux d'Alsace. After much research, such a nesting box does not yet exist.

Different technologies will be brought together to create a shelter and collect data on two specific species. The budget allocated by Ecam will be used entirely for components, transport costs and testing. Planning will be carried out on Notion so that all information is properly centralized and continually updated for the whole group