

Concept Development:

1. Generate Subsystem Concepts:

- Each team member creates at least one concept for each required subsystem.
- There should be at least **three subsystems** for the final solution.
- Clearly define the boundaries of each subsystem and identify which team member created each concept.

2. Team Discussion and Refinement:

- As a team, review and discuss all concepts.
- **Categorize, refine, or combine** concepts for each subsystem.
- Document each subsystem with **sketches and descriptions**. Highlight the **benefits and drawbacks** of each.

3. Combine Subsystems into Functional Solutions:

- Mix and match subsystems to create at least **three full design solutions**.
- **Analyze and evaluate** these global concepts using a **selection matrix**, similar to what was done in class.

4. Select the Best Concept:

- Choose the best global concept based on your analysis.
- Justify why this concept was chosen over the others, with notes on benefits and drawbacks.

Documentation:

5. Document Top 3 Concepts:

- Record your **top three ideas** in the deliverable, and keep a record of any other generated ideas (recommended for the appendix).
- Prepare the deliverable in a **technical report format**, following the given template for structure (including Title Page, Abstract, Introduction, etc.).

Client Meeting:

6. Prepare for Client Meeting 2:

- Create slides to **present multiple concepts** to your client for feedback.
- Prepare questions to **validate the problem statement** and clarify project specifications.

Task Plan Update:

7. Update Trello Board:

- Modify your task board with any changes to task durations, responsibilities, or progress.
- Include more detailed sub-tasks and ensure all tasks are reasonable and assigned based on each member's availability.
- Verify task start and end dates, and account for any personal limitations (exams, travel, etc.).

8. Discuss Group Issues:

- Address any team conflicts or issues with the help of the Project Manager (PM) or TA.
- Keep the PM/TA informed about team progress throughout the term.

Submission:

9. Submit Deliverable:

- One team member submits the final **PDF deliverable** to BrightSpace.

This breakdown should guide you through each task in a clear, manageable way!

Concept 1(Ryan Ekong): Eco-Friendly Solar-Powered Bat Box with Integrated Ultrasonic Sensors

1.Subsystem 1: Bat Habitat and Structure

- **Material:** Use **sustainably sourced, weather-resistant plywood** to build the bat box, ensuring durability and eco-friendliness. Some examples of said materials include, [FSC certified plywood](#), [bamboo plywood](#), [Recycled composite plywood](#).
- **Design Features:** The box will include ¾-inch slats for roosting space and proper airflow. It will be compact, about 2 feet tall with 14-inch width chambers, and will feature a single entry/exit point with a landing area below the entrance to make it easy for bats to enter and exit.
- **Benefit:** Provides a **safe and suitable habitat** for bats while being eco-friendly.
- **Drawback:** Might need periodic re-treatment of materials to ensure longevity.

2. Subsystem 2: Sensor System for Tracking Bats

- **Sensors:** Integrate **ultrasonic sensors** to count bat entries and exits, with an accuracy goal of 95%.
- **Data Collection:** The system will also include the option for **time stamped data** to record the exact time of bat movements.
- **Benefit:** Consistent, reliable data collection of bat activity throughout the year.
- **Drawback:** Sensors could be sensitive to environmental factors like dust.

3. Subsystem 3: Solar-Powered Temperature Monitoring

- **Power Source:** Install **small solar panels** on the box to power the sensors and internal temperature monitoring system. The system will maintain an internal temperature below 40°C and collect data at 5-minute intervals.
- **Benefit:** Solar power ensures **energy efficiency** and reduces the environmental impact.
- **Drawback:** Solar panels may require occasional cleaning and maintenance to ensure proper function.

4. Combination and Global Solution

- These three subsystems will be integrated into a single bat box design that is:
 - *Eco-friendly* with minimal environmental impact.
 - *Energy-efficient* through the use of solar power.
 - Capable of providing *consistent data collection* on bat activity and temperature.
- **Maintenance** will be minimal (under 30 minutes every 6 months), ensuring ease of use.

5. Evaluation Against Design Criteria:

- **Safe Environment:** Provides optimal roosting space and keeps temperatures below 40°C.
- **Data Collection:** Ultrasonic sensors ensure high accuracy and reliability.
- **Eco-friendliness:** Sustainably sourced materials and solar panels minimize the environmental footprint.
- **Ease of Maintenance:** Maintenance can be completed within the 30-minute goal.
- **Cost:** Estimated total cost between \$100 - \$130, fitting within the budget constraint.

Concept 2 (Anna Walsh): Solar Powered Bat Box with Motion Sensors

1. Subsystem 1: Bat Box

- **Material:** Weather-resistant plywood, or similar lightweight wood-based material. Potentially a soft, natural wood to simulate the organic environment of the bats. For example, [Northern oak](#), or [Scot's Pine](#).
- **Design Features:** While the box can vary in width/length/height, to accommodate the different species of bats and colony sizes, the inside will largely be the same from box to box. It will have several ridged slats, spaced $\sim\frac{3}{4}$ inch apart, so that the bats have space, and are relatively secure.
- **Benefit:** Provides a safe habitat that simulates the natural environment of the bats.
- **Drawback:** May not be altogether eco-friendly, as the box would be made of wood.

2. Subsystem 2: Detection

- **Method:** A motion sensor installed near the base of the bat box to detect and record movement in and out of the bat box. If possible, the timestamps of each trigger of the sensor should be recorded. Shooting for an accuracy of 95%.
- **Data Storage:** The data will be stored by the sensor, with timestamps if there are any, and collected once a month.
- **Benefit:** Allows for consistent tracking of bat movement throughout their active season.
- **Drawback:** If several bats move past the sensor at once, it may read as one entry.

3. Subsystem 3: Solar Power

- **Energy:** Install small, durable, solar panels on the roof/sides of the bat box to power the motion sensor.
- **Benefit:** Keeps the detector running, in a sustainable manner.
- **Drawback:** If it breaks, the detector may not be able to function until the next maintenance time.

4. Combination and Global Solution

The three subsystems form a the backbone of a design that is:

- *Natural* to the bats, and may attract them better
- *Eco friendly* with the use of a sustainable resource like solar power
- *Dependable* when it comes to data on the bats, and their movements

5. Evaluation Against Design Constraints

- **Environment:** Provides a natural environment for the bats to roost
- **Data:** Collects data on the bats' movements
- **Maintenance:** Requires low maintenance (less than 30 minutes, every 1~2 months)
- **Cost:** Estimated cost between \$75-\$125, within budget constraints

Concept 3 (Keith Karuna) Solar Powered Bat Box Using Thermal Sensors

1. Subsystem 1: Bat Habitat

- **Material:** Use wood panels with potential insulation between multiple layers of wood to ensure temperature remains stable even in fluctuating weather conditions, while also ensuring durability in harsher weather.
- **Design Features:** Adjustable ventilation feature to be used when drastic weather changes occur such as in the winter months to ensure stable temperatures.
- **Benefit:** Provides stable and comfortable living environment for the bats during any weather conditions
- **Drawback:** Adjustable ventilation requires manual adjustment, unless more electronics are utilized, however, this will add to the overall cost of the design,

2. Subsystem 2: Bat Monitoring using a thermal camera

- **Sensor:** Utilize a thermal camera to track the bats instead of ultrasonic sensors, tracking their body heat instead.
- **Data Collection:** Captures temperature data of the bat box, along with being able to monitor the number of bats entering and exiting the bat box.
- **Benefit:** Avoids the potential disturbance that the bats might face if ultrasonic sensors are used as bats are capable of hearing ultrasonic sound. Furthermore, a thermal camera can allow for tracking the number of bats present in the bat box at a certain time.
- **Drawback:** Thermal Cameras would be far more expensive compared to ultrasonic sensors and would require specialized software.

3. Subsystem 3: Solar Power

- **Power Source:** Small and Efficient solar panels that would be used to power the thermal monitoring system, along with a battery to ensure that the monitoring system remains working even during periods without sun.

- **Benefits:** Eco-Friendly and keeps the bat box running continuously.
- **Drawback:** May require a lot of solar panels to power a thermal imaging system, furthermore will require maintenance such as cleaning

4. **Combination and Global Solution**

The three form a bat box that is:

- Insulated to ensure temperature stability and a comfortable environment for roosting
- Advanced monitoring using a thermal imaging camera to track number of entries, exits, and bats currently present
- Powered using solar energy to ensure an eco friendly design and low maintenance.

5. **Evaluation Against Design Criteria**

- **Environment:** Provides a warm, safe, and stable environments for the bats
- **Data Collection:** Thermal sensors offer a non invasive and accurate way to monitor the bats
- **Eco-Friendliness:** Solar energy ensures that the environmental impact of the bat box is minor, while also ensuring ease of maintenance
- **Cost:** Estimated to be around 150\$ which aligns with the budget.

Chosen Concept:

Subsystem 1: Concept 1 (Ryan)

Subsystem 2: Concept 2 (Anna)

Subsystem 3: Concept 2 (Anna)