APS111 Engineering Strategies and Practice

Instructors: Susan McCahan, Tome Kosteski, Ben Kinsella, Ted Nolan, Rubaina Khan

Final Examination

CASE STUDY BOOKLET – Booklet 3

December 8, 2023

9:30 am – 12:00 pm (2.5 hours)

Instructions

Below are **THREE** case studies.

1. Case Study #1: Team Case Study
2. Case Study #2: AquaEye Shallow Water Monitoring System
3. Case Study #3: Removing Leaves from a Laneway

Case Study #1: Team Case Study is to be used **ONLY** when answering Multiple-Choice questions specifically linked to this case study. **DO NOT** use Case Study #1 to answer Long Answer questions.

Case Study #2: AquaEye Shallow Water Monitoring System is to be used **ONLY** when answering Multiple-Choice questions specifically linked to this case study. **DO NOT** use Case Study #2 to answer the Long Answer questions.

Case Study #3: Removing Leaves from a Laneway is to be used **ONLY** when answering the Long Answer questions. **DO NOT** use Case Study #3 to answer the Multiple-Choice questions.

There are no questions in this booklet. You may write on or separate the pages in this booklet. Nothing you write in this booklet will be graded.

Case Study #1 – Multiple Choice
Team Case Study

---

*Case study #1 is to be used **ONLY** for the Teams Multiple Choice questions. **DO NOT** use this case study for the Long Answer questions.*

Four days before the PR assignment was due, Jen (research specialist) received a personal text from one of their team members, Randy, saying he has been quite ill for a few days and would not be able to contribute any further to the PR document. Randy also mentioned that he received a doctor's note recommending that he rest because of the severity of his illness. Jen shared this information with the rest of the team members on the team chat the next day. All team members wished Randy a speedy recovery on the team chat. Two days before the submission, Laura (project manager) opened the group's PR document to start writing her sections when she noticed Randy had not written or contributed to his assigned sections. She also noticed others were quite behind with their own writing. Laura decided to write her own sections and in addition did the work necessary for Randy's sections including writing up a first draft of every section Randy was supposed to complete. Laura was able to complete the sections right before the deadline. The team submitted their assignment without having a chance to read through the entire document.

Case Study #2 – Multiple Choice
AquaEye Shallow Water Monitoring System

---

*Case study #2 is to be used **ONLY** for the Multiple-Choice questions. **DO NOT** use this case study for the Long Answer questions.*

Design Brief (Client Statement) for AquaEye Shallow Water Monitoring System

Background:
AquaEye is interested in advancing its lifesaving technology by developing a new version of its product specifically designed for use by lifeguards at beaches. Unlike the current handheld model, which is primarily used by search and rescue for recovery operations, this new system will be deployed by a lifeguard to continuously monitor swimmers during the lifeguard's shift and enhance their capability to detect and respond to individuals in distress.

Project goals:
The primary goal of this project is to create an automated, non-intrusive, and reliable water monitoring system that extends the capabilities of lifeguards by providing an additional layer of safety for beachgoers. The system must be able to:

- Detect human bodies in water with high accuracy and speed.
- Function continuously and autonomously in various beach environments.
- Withstand harsh beach conditions including saltwater exposure, turbidity, sand, wave action, and temperature extremes.
- Interface seamlessly with lifeguard protocols and provide intuitive alerts and actionable information, such as the location of a swimmer in distress.

1. Design and Engineering:
    - Be able to differentiate between an active swimmer, and one who is in distress/unconscious.
    - Create a semi-mobile platform that integrates with the beach environment – such as an anchored buoy system that will hold the device in place.
    - Ensure that the system is robust, with a focus on corrosion resistance, waterproofing, and stability.
    - Specifically
        - Must work reliably when the device is submerged at 5m or less, and ideally would be waterproof to 10m depth.
        - Is light enough for a lifeguard to carry from a charging station and deploy; ideally less than 10kg.
        - Should be easy to deploy at the beginning of a lifeguard's shift, and easy to extricate to bring in for recharging or maintenance during off hours.

2. Power and Sustainability:
    - Develop a power system that maximizes uptime and reduces maintenance, considering solar options for sustainability.
    - Include backup power solutions to ensure continuous operation for a minimum of 8 hours.

3. Operational Range:
    - Achieve a detection range suitable for the average size of designated swimming areas at beaches; at least 25 meters or more radius through 360° scanning, or 2000m^2.
    - Optimize depth sensitivity for shallow water (15m or less), considering variations in beach and underwater topography.

4. Data and Communication:
    - Implement a real-time data transmission system with high reliability, low latency, and resistance to environmental interference.
    - Develop a user interface that provides lifeguards with clear, immediate, and easy-to-understand alerts and actionable information; e.g., the location of a swimmer in possible distress.

5. Maintenance and Serviceability:
    - Design for ease of maintenance with modular components that can be easily replaced or serviced.
    - Establish a maintenance schedule that minimizes downtime and ensures operational reliability.

6. Compliance and Privacy:
    - Ensure the system meets all relevant regulatory and safety standards.
    - Address privacy concerns through design, ensuring that the system's operation respects individual privacy rights.

7. Cost-effectiveness:
    - Aim for a cost-effective design that does not compromise essential functionality.
    - Evaluate manufacturing materials and methods for economies of scale and sustainability.

8. Rescue Integration:
    - Ensure that the system's operation complements existing lifeguard rescue protocols.

Evaluation Criteria:

The success of the design will be evaluated based on its:

- **Accuracy in detecting human bodies in various water conditions.**
- **Reliability and uptime in real-world beach settings.**
- **Durability over an extended period of field use.**
- **User feedback from lifeguards and safety personnel.**
- **Cost relative to budget projections and financial targets.**

Conclusion:

This design brief will guide the development of the AquaEye shallow water monitoring system. Our commitment is to create a product that ensures higher safety standards on beaches and provides peace of mind for both swimmers and lifeguards. We anticipate close collaboration with all stakeholders to make this vision a reality.

Case Study #3 - Long Answer
Removing Leaves from a Laneway

---

*Case study #3 is to be used **ONLY** for the Long Answer questions. **DO NOT** use this case study for the Multiple-Choice questions.*

Client Statement: Removing Leaves from a Laneway

Figure 1: The tree canopy at Arkham City Cemetery

The Arkham City Cemetery is notable for its very old gravestones as well as its very old trees. It sits on 4 acres of land and its tree canopy is nearly 100% complete. In the height of summer, you can barely see the sky. Locals call it "the forest of the dead." The chief arborist (tree specialist) of the cemetery claims that some of the trees in the cemetery are over 400 years old, and that in many ways the cemetery acts as a healthy forest, with all the benefits that brings. Topmost among those benefits is that it acts as a carbon sink, pulling carbon dioxide out of the atmosphere, it cools the surrounding area in the hottest parts of the summer, and it provides habitat for a large number of animals, especially birds (both migratory and permanent). Therefore, the health of this small forest in the cemetery is important to safeguard.

A laneway separates the cemetery from a row of houses, with a wall separating the laneway from the cemetery. Many of the trees from the cemetery hang over the wall, and in the fall, leaves collect in vast amounts in the laneway.

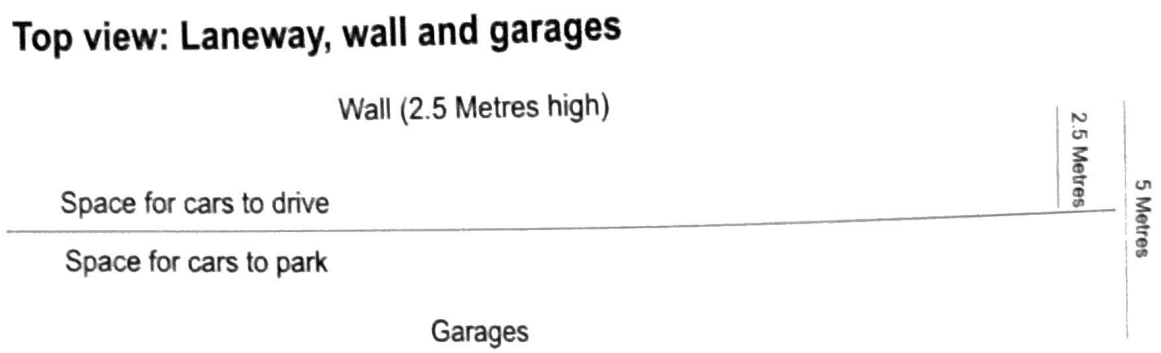

Figure 2: A top view of the laneway.

Figures 3 and 4: Trees hanging over the wall and laneway. Figure 3 is in early Fall, when the leaves are beginning to fall and accumulate in the laneway.

Many residents park their cars in the laneway, and the leaves collect under those. When it rains, the leaves get very hard to remove, as they are heavy and stick to the ground. Currently, the city requires that residents collect the leaves in large paper yard waste bags and drag them to the front of their houses for the city to collect. Many residents find this difficult, and the city offers assistance to some.

The cemetery and the city (the clients) think this is a waste of resources and a missed opportunity. It is difficult, slow, annoying and wasteful for residents to fill the bags and for the city to spend time and fuel picking up the bags and disposing of their contents. At the same time, the cemetery's arborist argues that the leaves could be used to safeguard the health of the cemetery's trees. In nature, leaves disintegrate and eventually turn into soil, helping nurture the trees by replenishing the soil they depend on. There is an opportunity, then, to fix a problem and improve the local environment.

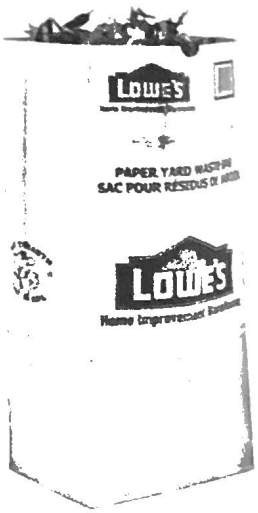

Figure 5 and 6: A yard waste bag full of leaves and wet leaves collected under a parked car

Therefore, the clients have joined forces to call for a solution that eliminates the waste in this situation, supports the trees and saves the residents time and effort. They want a solution that can be implemented by city workers. While the laneway is owned by the city of Arkham, residents are allowed to park there, and currently they are responsible for cleaning up the leaves. However, the city is open to having its workers clear the leaves, if the solution is effective and easy to implement.

Therefore, the clients are seeking solutions for city workers to remove the leaves from the laneway and deposit them over the cemetery wall into the cemetery where they can decompose into soil around the trees. One challenge in doing this is that the wall separating the laneway from the cemetery is 2.5 metres high. The narrowness of the laneway (two cars fit side-by-side, but not with a lot of space left) makes it difficult for the city to get heavy equipment in the laneway. Nothing bigger than a pickup truck can fit. It is also difficult to get the leaves out from under the parked cars, and this is made worse when rain or snow make the leaves wet, sticky and heavy.

The clients are seeking a solution that allows city workers to easily remove the leaves from the laneway and transfer them over the fence. After that point, cemetery groundskeepers will take care of spreading the leaves around the cemetery grounds such that they decompose and contribute to the health of the soil.

--See next page for more design considerations from the clients--

The clients ask you to adhere to the following additional design considerations:

1. In addition to cars, there are utility poles throughout the alley, on the garage side between garages, which interfere with efforts to pick up the leaves. Speed bumps, potholes and cracks in the laneway's cement will also interfere with leaf collection.

Figure 7: Utility pole (right) and cracks in the laneway concrete

2. The city currently has a fleet of small trucks, shovels and rakes they can use to collect leaves, but none of these suffice to move the leaves over the wall. They also have large leaf vacuum vehicles, but these are designed for street use and will not fit into the laneway. The city is open to using the existing equipment they have to partially solve this problem, but you must propose some new design elements to complete this task.

3. The entrance to the cemetery is on the opposite side of the laneway wall. It is possible to drive the leaves around to the entrance, but that will take more time than depositing them over the wall. The clients prefer an over-the-wall solution.

4. The clients request that solutions do not interfere with residents who are using the laneway for walking or driving. The solution should therefore take as little time as possible to complete its processes, or take up as little space as possible while in operation.

5. Children sometimes play in the laneway, and residents walk their dogs there, so you must ensure their safety.

6. Wildlife is abundant in the area, including in the laneway, and the design cannot cause any injury to the natural environment.