Low Water Crossing Indicator

Design Document

Team Number: sddec22-10
Client: Lee Harker
Advisers: Lee Harker
Team Members/Roles:
Tyler Rebischke: Team Lead/Solar
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Brandon Choy: Communications
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Executive Summary

Development Standards & Practices Used

Software Practices: Agile Programming methodology

IEEE /ISO/IEC 17464-2021. This standard is relevant because it lays out guidance for software life cycle processes and maintenance. Because we will be using some open source software for our project we need to be comfortable with maintaining that software along with the software that we write .

Hardware Standards and practices:

IEEE 802.15.4-2003. This standard is relevant because it lays out guidelines for low power low data rate RF Communications. We plan on using low power and low data rate communications so this standard will help us to develop our strategy.

IP 67. This standard pertains to weatherproofing for electronics components that are to be used outside. This standard is extremely important to us as all of our components are to be kept outside for four seasons. We will be able to design the housings for our devices based on the requirements laid out in these standards.

Summary of Requirements

Functional Requirements:

- Read water level and display level appropriately
- Operating remotely with no power source, so it needs to be solar
- Minimal maintenance
- Weatherproof
- Dependable/sturdy
- Visibility/testing of visibility

Environmental:

- Low environmental impact on the stream and surrounding natural features
- Use of renewable energy sources to power the components of our project

Aesthetics:

- Weatherproof

- Display to be easy to understand, but not distracting

Economic

- Stay within $500 budget

Applicable Courses from Iowa State University Curriculum

EE 224 (Signals and Systems), CprE 288 (Embedded Systems), EE 201 (Electric Circuits), EE 230 (Electronic Circuits and Systems), ComS 309 (Software Development Practices), EE 303 (Energy Systems and Power Electronics)

New Skills/Knowledge acquired that was not taught in courses

- Water level sensing
- Solar panel configuration
- Road signage
- Wireless Communications
- Power storage
- Advanced hardware/software integration

Table of Contents

List of figures/tables/symbols/definitions (This should be the similar to the project plan)

Team

1.1 Team Members

Tyler Rebischke- Computer Engineering- Team Lead, Solar Lead

Dylan Blattner- Electrical Engineering- Sensor Lead

Nithin Sebastian- Software Engineering- Signage/Alerting Lead

Brandon Choy- Electrical Engineering- Communications Lead

Jacob Ross- Electrical Engineering- Power Systems Lead

1.2 Required Skill Sets for Your Project

-Communications, Embedded Systems, Power Systems, Programming, Road Signage, Sensors, Arduino Programming, Solar Power

1.3 Skill Sets covered by the Team

-Communications- Brandon

-Embedded Systems- Dylan and Tyler

-Power Systems- Jacob and Brandon

-Road Signage- Nithin

-Sensors- Dylan

-Arduino Programming- Dylan and Nithin

-Solar Power- Tyler

1.4 Project Management Style Adopted by the team

- Agile

1.5 Initial Project Management Roles

Tyler Rebischke- Team Lead, Solar Lead

Dylan Blattner- Sensor Lead

Nithin Sebastian- Signage/Alerting Lead

Brandon Choy- Communications Lead

Jacob Ross- Power Systems Lead

2 Introduction

2.1 Problem Statement

In thousands of places in the country including a few hundred in Iowa, there are minimum service roads interrupted by small creeks or rivers. On many of these roads, a low water crossing is created at a fraction of the cost of an actual bridge. These roads are used by farmers and residents in the area on a basis limited by the recent rainfall and drainage. When the flow is low, a regular vehicle can drive through the stream. When the flow is higher, it may only be crossed by a high clearance vehicle or tractor and sometimes it is impassable. If the water is too high, the driver would need to make a u-turn on a generally narrow minimally maintained road. Other than signs warning of possible high water, there is no way for the driver to know the actual condition except by driving within a few yards where they can see the water. Drivers usually have an option to take an alternate route but it may be many miles longer. The goal of this project would be to create a water level device and one or more remote annunciation devices so that drivers could see the level of the upcoming low water crossing before driving the length of the road and then possibly needing to turn around and backtrack.

2.2 Requirements & Constraints

List all requirements for your project . This includes functional requirements (specification), resource requirements, qualitative aesthetics requirements, economic/market requirements, environmental requirements, UI requirements, and any others relevant to your project. When a requirement is also a quantitative constraint, either separate it into a list of constraints, or annotate at the end of requirement as "**(constraint)**". Other requirements can be a single list or can be broken out into multiple lists based on the category.

Functional Requirements:

- Read water level and display level appropriately
- Operating remotely with no power source, so it needs to be solar (constraint)
- Minimal maintenance
- Weatherproof

- Dependable/sturdy
- Visibility/testing of visibility (constraint)

Environmental:

- Low environmental impact on the stream and surrounding natural features
- Use of renewable energy sources to power the components of our project

Aesthetics:

- Weatherproof
- Display to be easy to understand, but not distracting

Economic

- Stay within $500 budget if possible (constraint)

2.3 Engineering Standards

What Engineering standards are likely to apply to your project? Some standards might be built into your requirements (Use 802.11 ac wifi standard) and many others might fall out of design. For each standard listed, also provide a brief justification.

IEEE 802.15.4-2003. This standard is relevant because it lays out guidelines for low power low data rate RF Communications. We plan on using low power and low data rate communications so this standard will help us to develop our strategy.

IEEE /ISO/IEC 17464-2021. This standard is relevant because it lays out guidance for software life cycle processes and maintenance. Because we will be using some open source software for our project we need to be comfortable with maintaining that software along with the software that we write.

IP 67. This standard pertains to weatherproofing for electronics components that are to be used outside. This standard is extremely important to us as all of our components are to be kept outside for four seasons. We will be able to design the housings for our devices based on the requirements laid out in these standards.

2.4 Intended Users and Uses

Who benefits from the results of your project? Who cares that it exists? How will they use it? Enumerating as many "use cases" as possible also helps you make sure that your requirements are complete (each use case may give rise to its own set of requirements).

Tractor Driver: They will use it to determine if they can cross the stream in their tractor.

Tanker truck driver: They will determine if they can cross the river. Our product is especially important since turning around on a one lane dirt road is very difficult

Average driver: They will use it to see if they can safely cross the river, potentially with their families.

Maintenance Workers: Need an easy way to maintain the system, potentially with low technical experience.

3 Project Plan

3.1 Project Management/Tracking Procedures

Which of agile, waterfall or waterfall+agile project management style are you adopting. Justify it with respect to the project goals.

We are mainly going to be using a waterfall+agile project management style. We are going to be going step by step, but also focusing on working in short sprints and having well established milestones. Each of our project modules have certain steps that need to be followed, and we want to make sure that we are following those steps while also adhering to larger project goals.

What will your group use to track progress throughout the course of this and the next semester. This could include Git, Github, Trello, Slack or any other tools helpful in project management.

We plan on using Git to track progress in regards to coding. We plan on using Slack/Discord to track progress for the other portions of our project.

3.2 Task Decomposition

In order to solve the problem at hand, it helps to decompose it into multiple tasks and subtasks and to understand interdependence among tasks. This step might be useful even if you adopt agile methodology. If you are agile, you can also provide a linear progression of completed requirements aligned with your sprints for the entire project.

<u>In parallel</u>

1. RF Communication
    a. Selecting appropriate communication standard
    b. Testing boundary conditions and limits
    c. Implementing needed technology
2. Water Depth Sensing
    a. Choosing sensor type
    b. Testing in real world conditions
    c. Integrating with Arduino
3. Solar
    a. Choosing solar panel
    b. Making sure it meets power requirements
    c. Real world testing
4. Signage/Lettering

    a. LED types
    b. Researching drivers needs for signage
    c. Easy to read and understand
5. Power Storage
    a. Choosing an appropriately sized battery for non ideal sun conditions
    b. Test storage and capacity during both peak and non ideal times
    c. Integrating with solar panel
6. Processor
    a. Choosing a power efficient microcontroller
    b. Ensuring proper GPIO pins are available for the modules we need
    c. Integrate with the other systems in the project

Final Steps (in order)

1. Testing the system as a whole
2. Choosing an appropriate weather resistant container
3. Deploying device and testing it in real world conditions

3.3 Project Proposed Milestones, Metrics, and Evaluation Criteria

What are some key milestones in your proposed project? It may be helpful to develop these milestones for each task and subtask from 2.2. How do you measure progress on a given task? These metrics, preferably quantifiable, should be developed for each task. The milestones should be stated in terms of these metrics: Machine learning algorithm XYZ will classify with 80% accuracy; the pattern recognition logic on FPGA will recognize a pattern every 1 ms (at 1K patterns/sec throughput). ML accuracy target might go up to 90% from 80%.

In an agile development process, these milestones can be refined with successive iterations/sprints (perhaps a subset of your requirements applicable to those sprint).

1. Designate each members Lead area for the categories above
2. Get first test of water sensor and signage together with Arduino
    a. Ability to see signage from 0.5 miles away
    b. Sensor is accurate to within an inch
3. Find a solar panel and battery storage combo
    a. Provides enough power for sensor in any environment
    b. Also provides enough power for the signage to continuously flash the sensor readings

3.4 Project Timeline/Schedule

• **A realistic, well-planned schedule is an essential component of every well-planned project**

• Most scheduling errors occur as the result of either not properly identifying all of the necessary activities (tasks and/or subtasks) or not properly estimating the amount of effort required to correctly complete the activity

• A detailed schedule is needed as a part of the plan:

– Start with a Gantt chart showing the tasks (that you developed in 2.2) and associated subtasks versus the proposed project calendar. The Gantt chart shall be referenced and summarized in the text.

– Annotate the Gantt chart with when each project deliverable will be delivered

• Project schedule/Gantt chart can be adapted to Agile or Waterfall development model. For agile, a sprint schedule with specific technical milestones/requirements/targets will work.

This is our schedule from the first , and half of the second, half of the semester(1/19/22-3/11/22)

Iteration 1(Research and gethering equipment)	38d	01/19/22	03/11/22
Selecting appropriate communication standard	38d	01/19/22	03/11/22
Choosing sensor type	38d	01/19/22	03/11/22
Choosing solar panel	38d	01/19/22	03/11/22
Selecting LED types	38d	01/19/22	03/11/22
Choosing an appropriately sized battery for non ideal sun conditions	38d	01/19/22	03/11/22
Choosing a power efficient microcontroller	38d	01/19/22	03/11/22
Researching drivers needs for signage	38d	01/19/22	03/11/22
Iteration 2(Building prototype)	20d	03/11/22	04/07/22
Integrating with Arduino	20d	03/11/22	04/07/22
Integrate basic RF communication	20d	03/11/22	04/07/22
Implementing needed technology	20d	03/11/22	04/07/22

Fig. 1

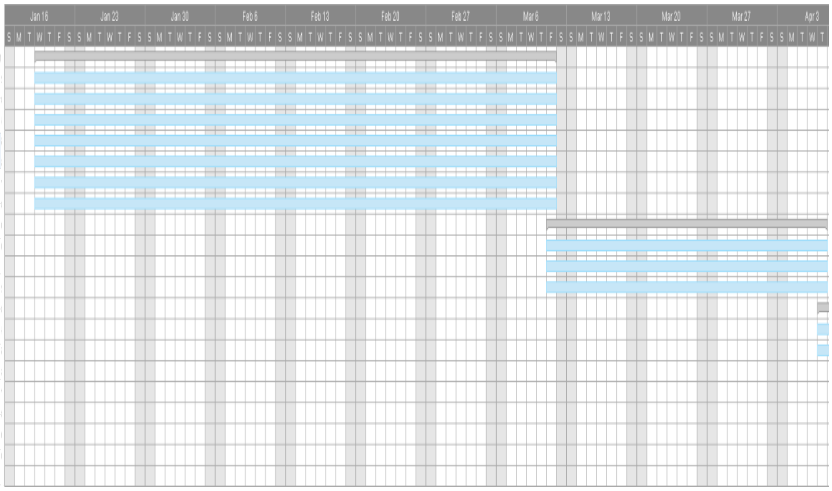

Fig. 2

This is our schedule from the second half of the semester(1/19/22-3/11/22)

Iteration 3 (Testing Protoype and making required changes)	11d	04/07/22	04/21/22
Test that sensor can detect water level of water in contained volume	11d	04/07/22	04/21/22
Test that communication to LED signage works	11d	04/07/22	04/21/22
Iteration 4(Further prototype additions)	17d	04/21/22	05/13/22
Create optimal signage(Easy to read and understand)	17d	04/21/22	05/13/22
Integrating with solar panel	17d	04/21/22	05/13/22
Integrate advanced RF communication	17d	04/21/22	05/13/22
Integrate with the other systems in the project	17d	04/21/22	05/13/22
Ensuring proper GPIO pins are available for the modules we need	17d	04/21/22	05/13/22

Fig. 3

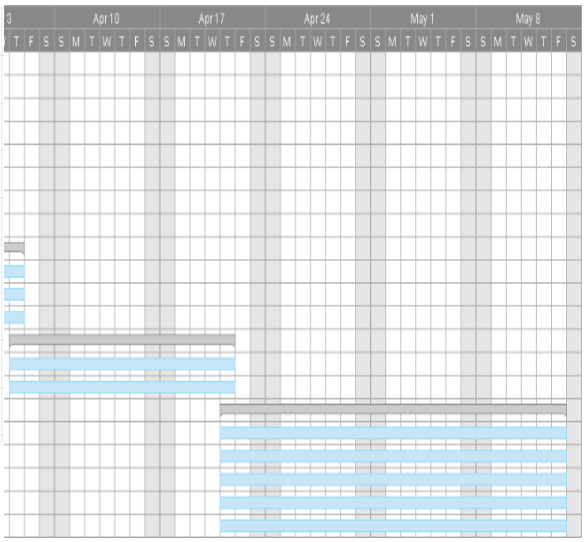

Fig. 4

3.5 Risks And Risk Management/Mitigation

Consider for each task what risks exist (certain performance target may not be met; certain tool may not work as expected) and assign an educated guess of probability for that risk. For any risk factor with a probability exceeding 0.5, develop a risk mitigation plan. Can you eliminate that task and add another task or set of tasks that might cost more? Can you buy something off-the-shelf from the market to achieve that functionality? Can you try an alternative tool, technology, algorithm, or board?

Agile projects can associate risks and risk mitigation with each sprint.

RF Communication system doesn't have enough range/can't get through obstacles- .5- we plan on using cellular communication as a backup system if our planned RF System doesn't work

Solar power system cannot deliver enough power- .2

Battery system can't store enough power- .1

Microprocessor doesn't meet requirements- .15

Since we will be using an iterative design process we can address different risks in each sprint.

3.6 Personnel Effort Requirements

Include a detailed estimate in the form of a table accompanied by a textual reference and explanation. This estimate shall be done on a task-by-task basis and should be the projected effort in total number of person-hours required to perform the task.

Task	Person Hours	Explanation
Select RF Comm. Standard	2	Choosing the correct form of RF communication for the project
Test RF boundary and limits	4	Do various testing with different ranges and obstacles present to test the limitations of our system
Implementing RF System	6	Setting up system on Arduino board and figuring out how to do communication with multiple nodes
Choosing water depth sensor	2	Researching various water depth sensors on the market and choosing one to prototype with
Testing the sensor	2	Testing to ensure the sensor works on local streams
Integrating with Arduino	4	Integrating the sensor into the rest of our system so that the data can be broadcasted
Choosing solar panel	2	Selecting solar panel based on power requirements and cost
Make sure it meets power requirements	1	Reading the data sheet to ensure that we can get necessary power
Real world testing	4	Test the panel on both sunny and cloudy days to see power output
Research LEDs	2	Look at different addressable LED technologies
Research driver needs	4	Figure out what we need to communicate the signals to drivers
Make sign easy to understand	2	Make the sign intuitive for drivers to read and understand
Choose appropriate battery	2	Research battery technologies

		to figure out what our system needs
Test storage capacity	3	Test how much energy it stores during different times hooked up to the solar panel
Integrate with solar panel	3	Come up with a weatherproofed integration of the solar system
Choosing a power efficient microcontroller	1	Find a proper microcontroller with proper power requirements
Ensure GPIO pins are available	3	Make sure that there are enough GPIO pins for the modules we need
Integration with other systems	2	Integrate all of the separate modules with the primary microcontroller

Fig. 5

3.7 Other Resource Requirements

Identify the other resources aside from financial (such as parts and materials) required to complete the project.

Expertise from our project mentor/other experts in the department

-Project components

-solar panels

-batteries

-water/temperature sensors

-Arduino controllers

-signage

-Addressable LED Strips

-Project management tools (Github, slack, etc.)

4 Design

4.1 Design Context

4.1.1 Broader Context

Describe the broader context in which your design problem is situated. What communities are you designing for? What communities are affected by your design? What societal needs does your project address?

List relevant considerations related to your project in each of the following areas:

Area	Description	Examples
Public health, safety, and welfare	Our solution provides public safety and welfare by alerting the public to when water conditions are safe for them to attempt a crossing at a low water crossing	-reducing the likelihood that a car is swept away by high water -saving the public time by alerting them if they need to take an alternate route due to unsafe water conditions
Global, cultural, and social	Our project reflects the major values of safety that exist in rural America. Because there is very little consideration by government entities given to rural areas, our project provides safety to these areas.	-Implementation provides value to community members
Environmental	Our project will have very little impact. We plan on using low profile devices to reduce our footprint and use solar panels to sustainably power the project.	-increasing use of solar panels -increasing use of renewable/recycled materials
Economic	We aim to keep a low cost of implementation so that our project can be deployed at low water crossings across rural Iowa.	-using low cost readily available materials -keeping development costs under budget

Fig. 6

4.1.2 User Needs

List each of your user groups. For each user group, list a needs statement in the form of:

User group needs (a way to) do something (i.e., a task to accomplish, a practice to implement, a way to be) because some insight or detail about the user group.

- Rural drivers need a way to identify if low water crossings are safe to drive through because during times of flooding they can be dangerous to cross.
- Farmers need a way to know if they can cross the stream because they can suffer significant financial loss if their tractors are lost in the streams

- Tanker truck drivers need a way to ascertain stream levels because turning around a large truck on a narrow dirt road is very difficult and dangerous.
- Maintenance workers need a way to maintain these devices in a straightforward way because it can't be assumed they will have sufficient technical knowledge to fix everything.

4.1.3 Prior Work/Solutions

Include relevant background/literature review for the project

– If similar products exist in the market, describe what has already been done

– If you are following previous work, cite that and discuss the advantages/shortcomings

– Note that while you are not expected to "compete" with other existing products / research groups, you should be able to differentiate your project from what is available. Thus, provide a list of pros and cons of your target solution compared to all other related products/systems.

Detail any similar products or research done on this topic previously. Please cite your sources and include them in your references. All figures must be captioned and referenced in your text.

1. One similar product we found is made by Radio Bridge Inc. described as a Armored Ultrasonic Level Sensor. This product features a built in radio that communicates with the LoRaWAN wireless network, ultrasonic sensor used for tank level monitoring and measurements, and a 10 year battery depending on usage. This product has the advantage of being an all in one system, but is not weather proof and doesn't allow as much flexibility.
2. During our research we found a project very similar to ours to measure water levels. This project was built from the ground up and mirrors our requirements almost exactly.

4.1.4 Technical Complexity

Provide evidence that your project is of sufficient technical complexity. Use the following metric or argue for one of your own. Justify your statements (e.g., list the components/subsystems and describe the applicable scientific, mathematical, or engineering principles)

1. **The design consists of multiple components/subsystems that each utilize distinct scientific, mathematical, or engineering principles –AND–**
2. **The problem scope contains multiple challenging requirements that match or exceed current solutions or industry standards.**

1. Our project is made up of 6 major subsystems, each consisting of multiple components. The subsystems and their components are:

- RF communication
    - LoRa transmitter and receiver, in terms of scientific principles, this requires signal processing

- Water Depth Sensing
    - Ultrasonic water sensor, in terms of scientific principles, this requires signal processing and data collection
- Solar
    - Solar panels that lie at adjusted angles to maximize power capabilities
- Signage/Alerting
    - Sign, and addressable LEDs to display water levels, in terms of engineering principles, this requires the use of data processing
- Power Storage/Batteries
    - Battery storage units to hold power
- Processing
    - Arduino microcontrollers to process signals/data

2. Our project scope consists of items that exceed current solutions for the problem we are seeking to address. Current solutions for this problem are very static, only offering a sign to make drivers weary of a potential rise in water levels for a low-water crossing. Our problem-scope exceeds this current solution, because we are seeking to dynamically alert drivers about the water levels of a low-water crossing. For our system to operate as intended, we are required to have a working water depth sensor that is solar powered, and has a radio frequency component to it so that the sensor can relay signals to our sign, so that the sign can display water levels on the LED strip attached to it.

4.2 Design Exploration

4.2.1 Design Decisions

List key design decisions (at least three) that you have made or will need to make in relation to your proposed solution. These can include, but are not limited to, materials, subsystems, physical components, sensors/chips/devices, physical layout, features, etc.

In regards to our project, some of the potential points that we might potentially change or add due to the solution not meeting our or client's expectation would be the following:

Components:

- Changes in antenna of Radio Frequency Transceiver (LoRa) or the entire module due to the range that it can send signals.
- Changes in the LED's for alertage due to the brightness capabilities.
- The addition of more components

Design/Layout:

- Changes in Solar Panel angle or position due environmental obstacles and sun position
- Positioning of water sensor in the stream
- Positioning/frequency of alertage sign on the roadway
- Frequency at which the sensor collects/sends data

Features:

- Ability to check status of the water levels via a mobile application or website

- Wireless communication module connecting via cellular services (4g,5g, etc.)

4.2.2 Ideation

For one design decision, describe how you ideated or identified potential options (e.g., lotus blossom technique). List at least five options that you considered.

-For our wireless communication module we considered the 5 following options:

- LoRa

-Cellular

-RFID

-LTM-E

-SigFox

We decided on LoRa because it offered the necessary distance of transmission that we needed at the lowest cost. Because our product will hopefully be produced in large quantities we need it to able to be built at a low cost.

4.2.3 Decision-Making and Trade-Off

Demonstrate the process you used to identify the pros and cons or trade-offs between each of your ideated options. You may wish you include a weighted decision matrix or other relevant tool. Describe the option you chose and why you chose it.

- For each wireless communication module considered we roughly weighted the following factors.
    - Cost (40%)
    - Transmission distance (30%)
    - Power consumptions (20%)
    - Ease of use (10%)
- With these factors we decided to go with LoRa because it offered our required transmission distance at the lowest cost. It also is a low power communication and can run off solar power.

4.3 Proposed Design

Discuss what you have done so far – what have you tried/implemented/tested?

- Basic Design Decisions
    - Solar Powered
    - LED Signage
    - Waterproof Container for Sensor
    - Battery Storage
- Components bought
    - LoRa RF Communication

- Arduino Microcontroller
- LED Strips
- Ultrasonic Water Sensor

- Testing of each component separately and together will be done this and next we ek

4.3.1 Design Visual and Description

Include a visual depiction of your current design. Different visual types may be relevant to different types of projects. You may include: a block diagram of individual components or subsystems and their interconnections, a circuit diagram, a sketch of physical components and their operation, etc.

Describe your current design, referencing the visual. This design description should be in sufficient detail that another team of engineers can look through it and implement it.

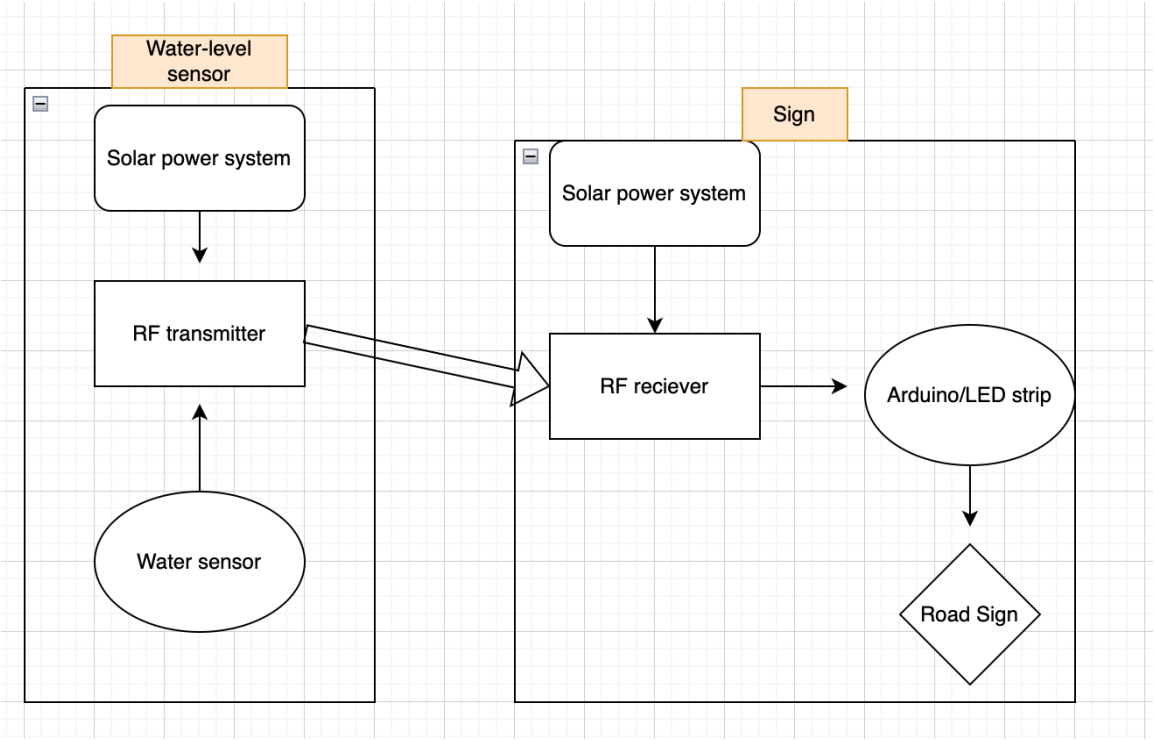

Fig. 7

Our current design for our solution consists of two major halves, the water-level sensor, and its subcomponents, and the sign and its subcomponents. In the water-level sensor, our water-level sensor will gauge water levels in the stream periodically, and use the RF transmitter to send signals to our sign half about current water levels. Within our sign half,the RF receiver will receive periodic signals from the sensor transmitter, and the arduino will process the signal to accurately display water levels on the sign's LED strip. Both of these halves are powered by solar panels.

4.3.2 Functionality

Describe how your design is intended to operate in its user and/or real-world context. This description can be supplemented by a visual, such as a timeline, storyboard, or sketch.

How well does the current design satisfy functional and non-functional requirements?

- Our design is intended to be set up in an optimal spot to read the most accurate water level near the crossing. Additionally we have to consider the location for the solar panel to achieve optimal power generation to ensure all the components are powered. Finally we must consider any obstacles that would interfere with the radio communication to the signage near the road.
- Our current design seems to satisfy these functional requirements, once further testing has been conducted we can rework any of those requirements.

4.3.3 Areas of Concern and Development

Based on your current design, what are your primary concerns for delivering a product/system that addresses requirements and meets user and client needs?

-Our primary concern is that our power system may not be able to fully support the hardware systems that we are deploying for in terms of power production.

-Another concern is that our RF communication system will not be powerful enough to communicate through obstacles that may be present at a low water crossing

-One concern our advisor brought up was if the solar power system could provide power consistently 365 days a year since sunlight levels fluctuate heavily throughout the year in Iowa

What are your immediate plans for developing the solution to address those concerns? What questions do you have for clients, TAs, and faculty advisers?

-Our primary plan is developing a robust testing plan for the various components of our project and running those tests before we begin actually assembling a final project. If we have any of our concerns actually become realized, then we should have enough time to iterate a new design that accounts for the failures of the tests.

-Most of our relevant questions have been answered by our client already but we plan on keeping a running questions document so that we can ask our client/TA/advisor those questions when they arise.

4.4 Technology Considerations

Highlight the strengths, weakness, and trade-offs made in technology available.

There isn't much current technology that does actual depth detection. Current technology only looks at measuring flow levels, so our product is very new at measuring stream levels.

4.5 Design Analysis

– Did your proposed design from 3.3 work? Why or why not?

We haven't yet fully created our proposed design, but early testing is promising.

– What are your observations, thoughts, and ideas to modify or iterate over the design?

Our design is currently holding up to our early module testing

5 Testing

Testing is an **extremely** important component of most projects, whether it involves a circuit, a process, power system, or software.

The testing plan should connect the requirements and the design to the adopting test strategy and instruments. In this overarching introduction, given an overview of the testing strategy. Emphasize any unique challenges to testing for your system/design.

4.1 Unit Testing

What units are being tested? How? Tools?

We will be testing each aspect of our device individually, and then test the device with the components together. For our purpose of testing we will be testing these units...

1. Ultrasonic sensor (water level sensing)
2. RF communication (LoRa system)
3. Solar power generation (solar panel)
4. Power storage (battery)
5. Signage (LED's)

By testing each component individually we can eliminate any errors that would be harder to diagnose when they are combined. While testing each device we will have to use different methods to evaluate the units. For the ultrasonic sensor we will be using the Arduino to gather the water depth level and compare that with physical measurements. While testing the RF communication the Arduino will again be useful to evaluate signal strength. By first creating a control situation, we can then add environmental challenges in (distance, obstacles, etc.) to get a sense for the boundaries of the unit. Solar power generation and storage will be evaluated using traditional electrical testing equipment (multimeter, oscilloscope, etc.) and critical conditions will be tested. Finally the LEDs will be tested by simulating real life conditions by driving at expected speeds and evaluating the effectiveness of the signage.

4.2 Interface Testing

What are the interfaces in your design? Discuss how the composition of two or more units (interfaces) are being tested. Tools?

The interfaces in our design are the interface for our water detection sensor, and the interface for our signage. Within our water detection interface, we are testing our water-level sensor and our rf transmitter. For the water-level sensor we will first test it out in a contained volume, so that we can validate initial accuracy of depth detection. As for the system as a whole, we will make sure to run tests to validate that correct water-levels are being sent by the rf transmitter. For the signage

interface, we will use a set of pre-set water levels, to make sure that first the RF receiver is receiving the proper values, and then we will use these tests to validate that the correct number of LEDs is being displayed to show water depth in real time.

4.3 Integration Testing

What are the critical integration paths in your design? Justification for criticality may come from your requirements. How will they be tested? Tools?

1. The first integration path is connecting our sensing and communication modules to the solar power system. This is critical because we will be testing the individual components on controlled power sources, so adding in the solar system will be a crucial part of our project. We will be testing this part of our system by leaving it outside and seeing if the battery system has enough power to safely power the system. We will be using a voltmeter to measure the amount of power in the battery after the system is left outside in sunny and cloudy conditions.
2. The second critical integration path will be connecting the display/signage module to the measurement module and make sure that they are properly connected and displaying the water depths correctly. We will be testing this by putting the measurement portion of our system in a river and testing the display module at various distances to ensure that the display portion correctly displays the depth. We won't need any specific tools to measure anything as this is more of a verification visually.

4.4 System Testing

Describe system level testing strategy. What set of unit tests, interface tests, and integration tests suffice for system level testing? This should be closely tied to the requirements. Tools?

System Testing: Complete end-to-end testing is done on the complete software to make sure the whole system works as expected.

To ensure the whole system is properly working we must conduct various levels of each part of the project. Once each part of the system is tested we can start piecing together the whole system. Couple of the main test strategies that we will be using in regards to unit, interface, and integration will still be using the oscilloscope/multi-meter to measure if the solar panels are correctly powering all components and if wireless signals are still as expected when hooked up along with other components. Also, we will utilize real time outputs and inputs to determine if components are functioning as expected.

4.5 Regression Testing

How are you ensuring that any new additions do not break the old functionality? What implemented critical features do you need to ensure do not break? Is it driven by requirements? Tools?

- Individual testing followed by group testing
- Water Sensor
- RF transmitter and receiver
- Solar Panels

4.6 Acceptance Testing

How will you demonstrate that the design requirements, both functional and non-functional are being met? How would you involve your client in the acceptance testing?

We will ensure that our design requirements are met by showing our client the final design before the end of the project and walk them through the features in our project. This will allow the client to offer guidance on features that they may like to see that aren't in the project so that we have time to iterate before the project ends. We also plan on giving weekly updates on the status of our project and major changes in the project design that are different from what we had originally discussed with the client. We also will make sure to put together a final summary document that lists out the requirements that we completed so that our client has an easy guide to understand the features on the project.

4.7 Security Testing (if applicable)

4.8 Results

What are the results of your testing? How do they ensure compliance with the requirements? Include figures and tables to explain your testing process better. A summary narrative concluding that your design is as intended is useful.

Our early testing is going well, but we plan on doing more testing of modules throughout the first semester.

6 Implementation

Describe any (preliminary) implementation plan for the next semester for your proposed design in 3.3. If your project has inseparable activities between design and implementation, you can list them either in the Design section or this section.

Our current plan for next semester is to begin combining each major system of our project to work together. This will involve continual testing of each major component to ensure that there are no underlying issues that might appear once components are combined. In ranking priority this is the steps we plan to take:

1. Stress test each major component of our system to a high level of certainty in a controlled, and non-controlled environment (outdoors).
2. Begin to combine each component and test in a controlled environment.
3. Deploy our design and try to simulate real world conditions as much as possible.

7 Professionalism

This discussion is with respect to the paper titled " Contextualizing Professionalism in Capstone Projects Using the IDEALS Professional Responsibility Assessment", *International Journal of Engineering Education* Vol. 28, No. 2, pp. 416–424, 2012

7.1 Areas of Responsibility

Pick one of IEEE, ACM, or SE code of ethics. Add a column to Table 1 from the paper corresponding to the society-specific code of ethics selected above. State how it addresses each of the areas of seven professional responsibilities in the table. Briefly describe each entry added to the table in your own words. How does the IEEE, ACM, or SE code of ethics differ from the NSPE version for each area?

Area of responsibility	**Definition**	**NSPE Canon**	**IEEE**
Work Competence	Perform work of high quality, integrity, timeliness, and professional competence.	Perform services only in areas of their competence; Avoid deceptive acts.	7. to seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others;
Financial Responsibility	Deliver products and services of realizable value and at reasonable costs.	Act for each employer or client as faithful agents or trustees.	9. to avoid injuring others, their property, reputation, or employment by false or malicious actions;
Communication Honesty	Report work truthfully, without deception, and understandable to stakeholders.	Issue public statements only in an objective and truthful manner; Avoid deceptive acts.	3. to be honest and realistic in stating claims or estimates based on available data; 4. to reject bribery in all its forms;
Health, Safety, Well-Being	Minimize risks to safety, health, and well-being of stakeholders.	Hold paramount the safety, health, and welfare of the public.	1. to accept responsibility in making decisions consistent with the safety, health, and welfare of the public, and to disclose promptly factors that might endanger the public or the environment;
Property Ownership	Respect property, ideas, and information of clients and others.	Act for each employer or client as faithful agents or trustees.	7. to seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others;

Sustainability	Protect environment and natural resources locally and globally.		
Social Responsibility	Produce products and services that benefit society and communities.	Conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession.	1. to accept responsibility in making decisions consistent with the safety, health, and welfare of the public, and to disclose promptly factors that might endanger the public or the environment;

Fig. 8

Describe each entry:

1. to accept responsibility in making decisions consistent with the safety, health, and welfare of the public, and to disclose promptly factors that might endanger the public or the environment;

- To act in the best interest of the public with regards to their safety, health, and overall welfare. If there are any factors that seem like they might endanger this idea, they will be disclosed promptly.

3. to be honest and realistic in stating claims or estimates based on available data;

- Be upfront and honest in claims/estimates based on evidence/data.

4. to reject bribery in all its forms;

- Reject bribery in all its forms.

7. to seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others;

- Seek to improve your own technical work and correct any errors that may be found with proper recognition.

9. to avoid injuring others, their property, reputation, or employment by false or malicious actions;

- Avoid any actions that may damage relations/property of others.

IEEE V.S NSPE

1. Work competence
    a. They are similar but the NSPE focuses on ability, whereas the IEEE focuses on improvement.

2. Financial Responsibility
    a. Very similar, just worded a bit differently.
3. Communication Honesty
    a. Both seek to be honest with the public/client and avoid deception.
4. Health, Safety, Well-Being
    a. Very similar want to keep the health, safety, and well-being of the public as a top priority.
5. Property Ownership
    a. Give credit where it is due is a similar idea in both.
6. Sustainability
    a. Neither code explicitly touches upon this issue.
7. Social Responsibility
    a. NSPE focuses on upholding the honor of the profession, while the IEEE focuses on the public's needs more.

The IEEE code of ethics differs from the NSPE Canon slightly. First, it splits up a couple of the different areas of responsibility from the original table and breaks them into more in depth ethical codes. For example, instead of just addressing work competence, the IEEE talks about improving understanding of technology and accepting criticism about your work. Also, the IEEE code has a larger emphasis on teamwork, as it encourages engineers to make sure that their coworkers and team members are also following the code while the NSPE Canon doesn't talk as much about holding others accountable.

7.2 Project Specific Professional Responsibility Areas

For each of the professional responsibility area in Table 1, discuss whether it applies in your project's professional context. Why yes or why not? How well is your team performing (High, Medium, Low, N/A) in each of the seven areas of professional responsibility, again in the context of your project. Justify.

1. Work competence (Medium)
    a. This applies to my projects because we are all trying to work together to produce a high-quality product. Currently we are researching semi-independently but fact checking each other and offering advice. Our team is also assigning work based on people's unique experiences and asking for help in areas where we may not have a lot of technical experience.
2. Financial Responsibility (Medium)

    a. We are working to produce a product that our advisor/client requested. To accomplish this, we must use resources well and make sure that we are honest with our spending. Our team is putting a lot of emphasis on creating the highest level of quality in our final project at the lowest possible cost to our client.

3. Communication Honesty (High)
    a. This applies but we are not making anything that would potentially put the public in danger. We are being honest though with what we can do. We make sure that we send weekly status updates to our client and have biweekly meetings to discuss progress with him.
4. Health, Safety, Well-Being (High)
    a. The whole point of our project is to create something that will help the public. Because of this we are prioritizing their safety and needs.
5. Property Ownership (High)
    a. We are creating something new and going along with advice offered by our advisor.
6. Sustainability (Medium)
    a. The parts we are using might not be the most sustainable to make, but we are incorporating solar power so it shouldn't have as high of an impact as other power sources.
7. Social Responsibility (High)
    a. Goes along with the reasoning stated for 4, we are producing a product for the public. We also ensure that all group members on our team have their voices heard, and make sure that our final product will help people and communities.

7.3 Most Applicable Professional Responsibility Area

One area of professional responsibility that is important to our team is Health, Safety, and Well-Being. For our project we want to create something that will have a minimal impact on the environment and serves to help others. One example of these priorities is our early decision to utilize solar power in our project. This helps to reduce the environmental impact of our project and serves to benefit the community more. Additionally, we also want to make sure that our project has the largest possible impact on community safety. To accomplish this task, we plan on speaking to the Iowa Department of Transportation in order to get their input on the best ways for us to communicate safety data on roadways. While it is still early in our project, prioritizing health, safety, and well-being should prove to help us develop the best possible final product.

8 Closing Material

8.1 Discussion

At the end of the first semester, the early results of our planning and testing are very positive. We plan on doing the final integration of our parts early in the fall semester and iterating our design throughout the semester

8.2 Conclusion

Summarize the work you have done so far.

- We have completed the initial project design and market research
- We have ordered almost all of our project parts and are in the midst of testing those parts at the moment
- We have a plan for integrating these parts into our final design

Briefly re-iterate your goals. Then, re-iterate the best plan of action (or solution) to achieving your goals.

- Our primary goal this semester was to establish a solid plan of action to complete the project and identify which parts were needed to complete the project
- Our secondary goal was to begin most of the testing for our project parts and develop a plan to integrate them
- Our reach goal was to have a working prototype by the end of this semester

What constrained you from achieving these goals (if something did)? What could be done differently in a future design/implementation iteration to achieve these goals?

- Our main constraint with completing our reach goal was managing the workload of our other classes with work on our project. For the fall semester, we plan to do a lot of our work early in the semester (first 2-3 weeks), before our workload begins to really pick up.

8.3 References

List technical references and related work / market survey references. Do professional citation style (ex. IEEE).

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“Wireless Level Monitoring,” *Senix Ultrasonic Distance and Ultrasonic Level Sensors*. https://senix.com/wireless-level-monitoring/ (accessed Apr. 24, 2022).

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[7]

D. Workshop, “Waterproof Ultrasonic Distance Sensors with Arduino,” *DroneBot Workshop*, Oct. 05, 2021. https://dronebotworkshop.com/waterproof-ultrasonic/ (accessed Apr. 24, 2022).

[8]

“LoRa, SigFox, and LTE-M Technologies for long-range communications,” *VOLANSYS*, Nov. 14, 2019. https://volansys.com/selecting-right-low-power-wide-area-network-lpwan-technology/ (accessed Apr. 24, 2022).

8.4 Appendices

Any additional information that would be helpful to the evaluation of your design document.

If you have any large graphs, tables, or similar data that does not directly pertain to the problem but helps support it, include it here. This would also be a good area to include hardware/software manuals used. May include CAD files, circuit schematics, layout etc,. PCB testing issues etc., Software bugs etc.

8.4.1 Team Contract

Team Members:

1) Tyler Rebischke 2) Brandon Choy

3) Jacob Ross 4) Dylan Blattner

5) Nithin Sebastian

Team Procedures

1. Day, time, and location (face-to-face or virtual) for regular team meetings:

Friday's 12-1. Mix of in person and virtual depending on team needs. Sunday as needed to complete assignments

2. Preferred method of communication updates, reminders, issues, and scheduling (e.g., e-

mail, phone, app, face-to-face): Discord

3. Decision-making policy (e.g., consensus, majority vote): Majority

4. Procedures for record keeping (i.e., who will keep meeting minutes, how will minutes be

shared/archived): Dylan volunteered to keep meeting minutes. He will store notes in the shared Google Drive

Participation Expectations

1. Expected individual attendance, punctuality, and participation at all team meetings: Show up to the meetings on time and be present and participate in meetings, engage in conversations.

2. Expected level of responsibility for fulfilling team assignments, timelines, and deadlines: Just do your portion of the work that we have split up.

3. Expected level of communication with other team members: Respond to messages on Discord and attend the meetings.

4. Expected level of commitment to team decisions and tasks: Be committed and help out team members.

Leadership

1. Leadership roles for each team member (e.g., team organization, client interaction,

individual component design, testing, etc.): Each person will be experts in their area, decisions that will affect the whole team (ie major design decisions) will be handled by the whole team.

2. Strategies for supporting and guiding the work of all team members: Have a weekly plan and stick to it. Help out others if they need it.

3. Strategies for recognizing the contributions of all team members: Just thank people if they help you and don't be mean to teammates.

Collaboration and Inclusion

1. Describe the skills, expertise, and unique perspectives each team member brings to the

team.

Brandon: EE major. Circuit analysis. PCB Design. Signals/communications. CAD

Dylan: Physics Degree, also EE major. C coding. Signals/communications.

Jake: EE major. Circuit design. Specification of power.

Nithin: SE major. Coding in Python/Java. Agile/Scrum.

Tyler: CPRE major. Project management. Python/Java.

2. Strategies for encouraging and support contributions and ideas from all team members: Just be respectful of others and their ideas. Thank people for positive contributions.

3. Procedures for identifying and resolving collaboration or inclusion issues (e.g., how will

a team member inform the team that the team environment is obstructing their

opportunity or ability to contribute?): If you've got a problem with someone or their actions, just communicate it with them and talk out your differences and how you will overcome them so the team can be successful.

Goal-Setting, Planning, and Execution

1. Team goals for this semester: Conclude research. Have a solid plan for design and start prototyping.

2. Strategies for planning and assigning individual and team work: Just have a weekly plan and make sure that you follow the plan and get your work done every week.

3. Strategies for keeping on task: Reminders in the group chat, meetings every week to review work and talk about things when we were in class.

Consequences for Not Adhering to Team Contract

1. How will you handle infractions of any of the obligations of this team contract? Just talk to the person and see what's preventing them from completing their work and come up with a plan to get everything completed.

2. What will your team do if the infractions continue? Talk to the professor to help come up with a plan.

****

a) I participated in formulating the standards, roles, and procedures as stated in this contract.

b) I understand that I am obligated to abide by these terms and conditions.

c) I understand that if I do not abide by these terms and conditions, I will suffer the

consequences as stated in this contract.

1) Brandon Choy DATE 2/11/22

2) Dylan Blattner DATE 2/11/22

3) Nithin Sebastian DATE 2/11/22

4) Jacob Ross DATE 2/11/22

5) Tyler Rebischke DATE 2/11/22