Project Proposal for Preventing Wrong Way Driving Through Intelligent Transportation Systems

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Team: Right-Way Drivers

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS AND INITIALISMS

AASHTO - American Association of State Highway and Transportation Officials

ADOT – Arizona Department of Transportation

ITS – *Intelligent Transportation Systems*

O&M – Operations and Maintenance Manual

WWD – *wrong-way driving*

1.0 PROJECT UNDERSTANDING

1.1 Introduction

The intent of this project is to develop a system that can detect and alert a wrong-way driver, warn oncoming right-way drivers, and alert the Arizona Department of Transportation about the wrong-way driving incident in hopes to correct or stop the wrong-way driver within the rural areas of interstates. Additionally, this system will be able to be implemented anywhere wrong-way driving incidents occur. The WWD detection system will utilize Intelligent Transportation Systems (ITS) to provide feedback to the Arizona Department of Transportation while warning the wrong-way driver and right-way drivers.

Wrong-way drivers are an ongoing problem in Arizona and nationwide. Most wrong-way driving comes from drivers who are impaired, distracted, or confused posing a serious threat to the safety of all motorists involved due to the potential for fatal collisions [1]. Per the National Highway Traffic Safety Administration from 2004 to 2011, an annual average of 350 people dies in 270 crashes per year from wrong-way driving [1].

Wrong-way driving is a difficult issue to solve with no solution at the national level [1]. Solutions currently in place are conducted at the state level, with just 10 state departments of transportation working on options to reduce the number of incidents of wrong-way driving since 2000 [1]. The use of ITS to solve wrong-way driving is being considered and tested throughout the nation and is at the forefront of solving this issue [1].

1.2 Project Background

The proposed project will start on January 22nd of 2018 and will use as a reference for designing the exit ramp number 333 of Interstate-17 with Mountainaire Rd. in the Kachina Village area. No testing will be performed on the roadway itself. The area represents typical low light conditions it is 3 miles away from the nearest exit ramp, it is close to the city of Flagstaff. Also, it has a very common roadway geometric design and it is located in a rural area. Furthermore, the area it is within the so-called "Dark-Sky Oasis" which means that the light pollution regulations must be met.

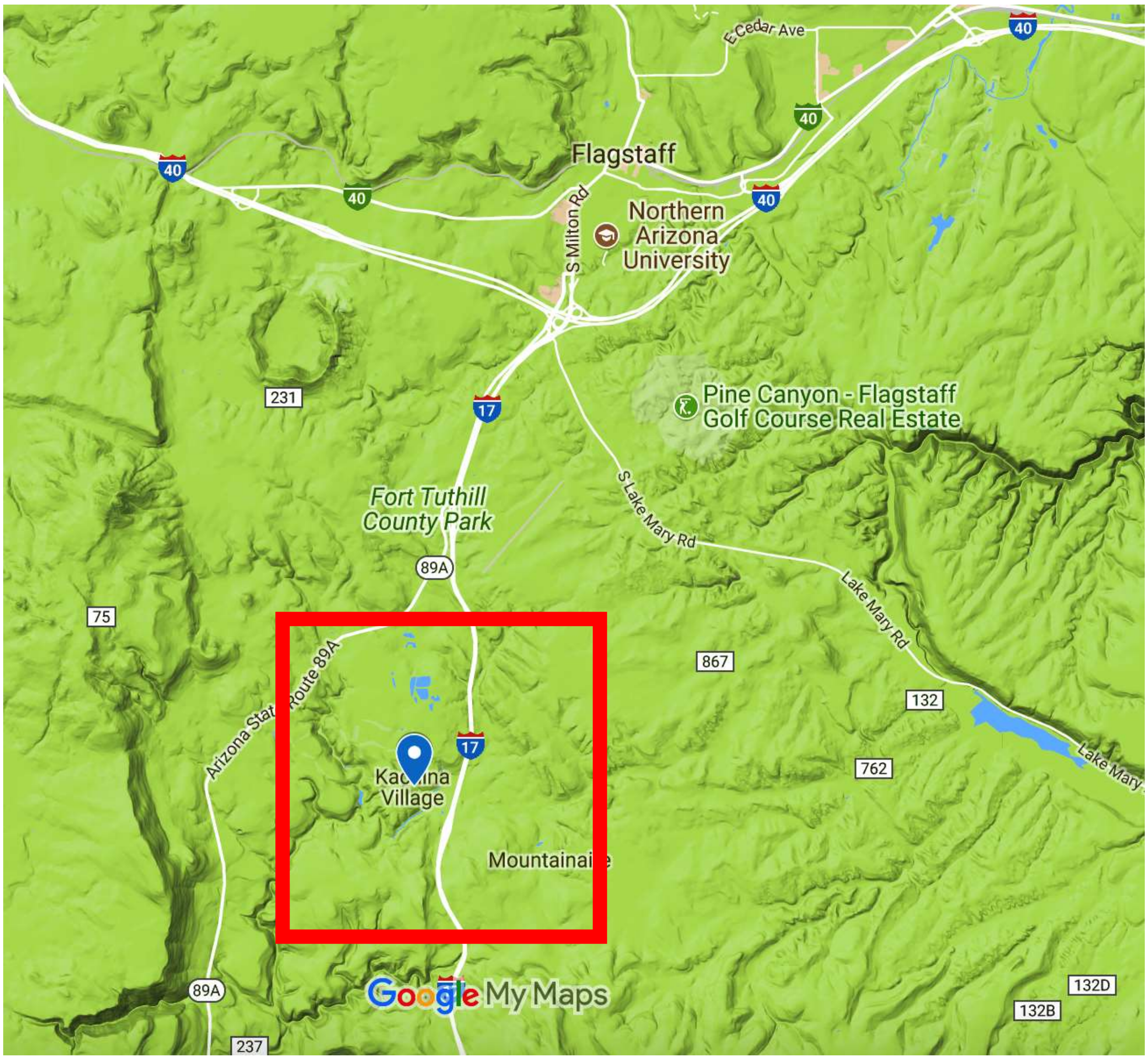

Figure 1-1: Site area highlighted within Flagstaff area in the state of Arizona.

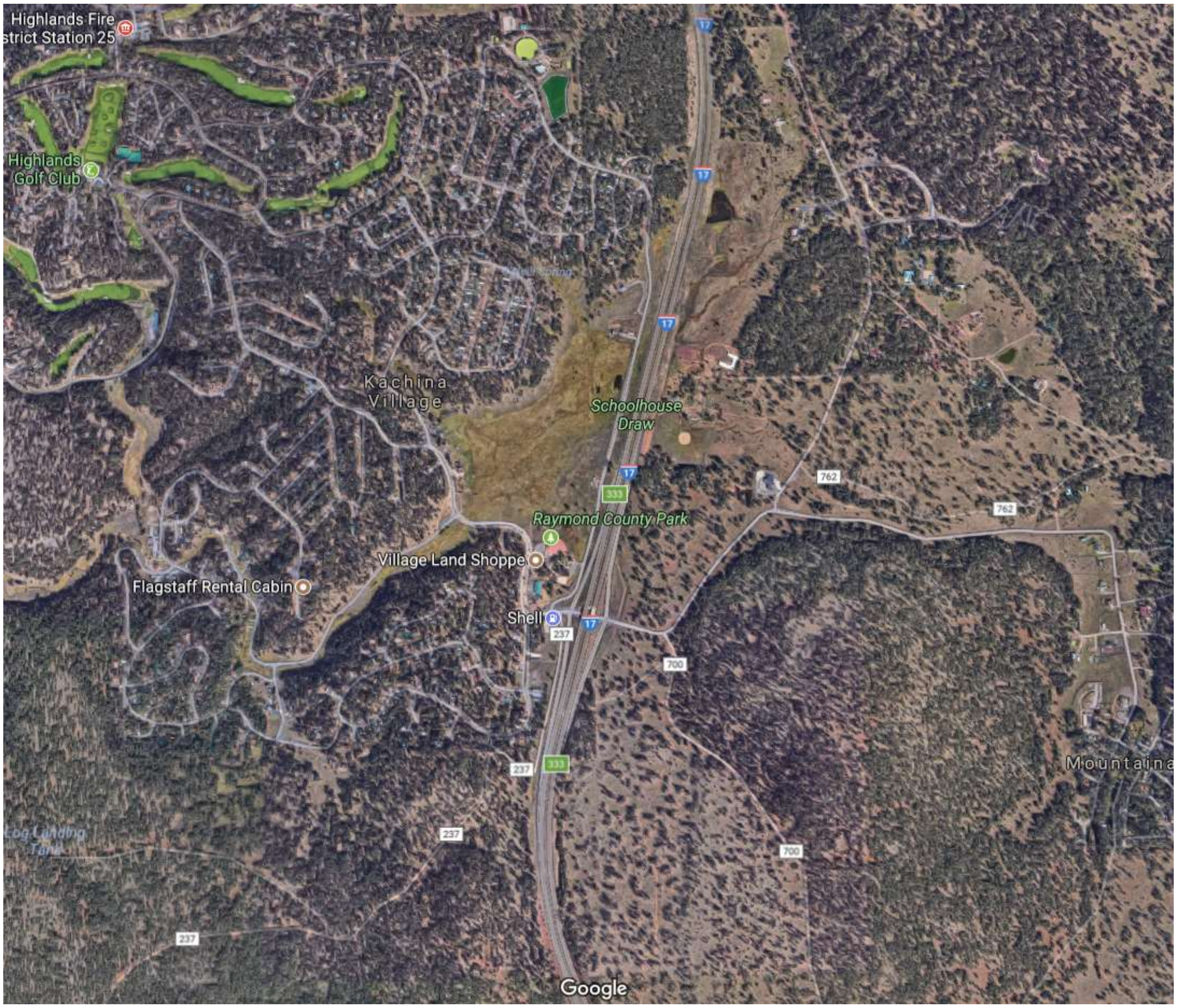

Figure 1-2: Site Area

Functionality within a rural area with no power grid is a challenge that the team has accepted to deal with. The location of this systems constrains the source of power into renewable energy that either depends on solar or wind

1.3 Study Objectives

Key objectives of this project include:

- Identifying a solution which meets the needs of all freeway and interstate users, such as; passenger vehicles, busses and trucks, and their governing bodies, such as; the state department of transportation, traffic control centers, law enforcement, and the state itself.
- Identification of regulations and codes that must be met
- Develop a detection system that can be installed on rural freeway exit ramps
- Develop warnings systems to be installed on the roadway to alert the wrong-way driver
- Develop a warning system to inform ADOT about the occurrence of wrong-way driving
- Target rural sections of Interstates

- Comply with the Dark Sky cities propositions for Flagstaff
- Adapt the detection system to be placed on segments of the roadway to track the wrong way driver and inform ADOT
- Research a communication interface between the remote device and ADOT

1.4 Technical Considerations

1.4.1 Plan of Action

The team will identify and prototype a solution that will effectively detect and alert a wrong-way driver, warn oncoming right-way drivers, and alert the Arizona Department of Transportation (ADOT) when the wrong-way driving occurs.

This project will comply with all the applicable codes such as the Manual on Uniform Traffic Control Devices (MUTCD), the American Association of State Highway and Transportation Officials (AASHTO), and those provided by the local municipality.

1.4.2 Potential Challenges

The main challenges regard the team's safety, the abundance of materials, and powering the system. Night visits with low light conditions is challenging and hazardous. The team will wear reflective safety vests class II at all times when performing site visits, have a safety plan in place detailing the areas that will be visited and how the walk-through will be performed including safety recommendations, and by having flashing lights on the vests and any vehicle used for the site visit. The safety plan must be approved by the course instructor.

Obtaining of full or small-scaled detectors and warning systems is another possible challenge that the team will face. The necessary vendors will be contacted to make sure that the devices utilized in the technical matrix are available for testing in a small-scale environment.

Outfitting the system to operate in a rural area off the power grid is another challenge. Finding a reliable source of energy to power the WWD detection system outside of the convention will require some ingenuity. The location of this system constrains the possible source of power to renewable energy. Alerting the authorities is another challenge the team will overcome in this project due to the lack of a grid system. The detection system itself will have integrated circuit systems that involve various types of sensors and alerting tools that will operate in harmony.

Constraints such as those which would be provided by following design code will need to be accounted for and taken into consideration throughout the entire design as to prevent a non-working solution. Political challenges could arise if our wrong-way driver deterrence system emits light or sound, as it could disturb residents. Currently, unknown challenges will likely occur and must be accounted for when creating the schedule, allowing for plenty of leeways should a challenge arise.

Table 1-1: Project challenges and their mitigation options

CHALLANGES	MITIGATION
Night Site Visit	Safety Plan; Safety Vest; Blinking Lights
Acquisition of Parts	Order in Advance
Lack of Power Grid	Renewable Source of Energy
Disturbance of Residents	Following code and area requirements

1.4.3 Stakeholders

A consensus between the client, state department of transportation, residents, taxpayers, and any additional stakeholders must be met on the scope of the project, cost, feasibility, and schedule. The state department of transportation will be tasked with the implementation and regulation of the project. The residents and taxpayers will be the users of the WWD system and primarily provide project funding.

2.0 SCOPE OF SERVICES

2.1 Task 1: Site Investigation

This project will utilize the exit ramp 333 of Interstate 17 as a reference for testing, criteria, and constraints applicable to the project. The intersection is in a rural area, in an environment of reduced lights and dark-sky compliance, 3 miles away from the nearest exit ramp and surrounded by the census-designated area Kachina Village. Two site visits will be performed to understand better the challenges of the site location.

2.1.1 Task 1.1: First Site Visit - Day Time

The first site visit will be performed during the day to understand the geometry of the road and characteristics of the field such signage and striping. Photos and videos of the area will be taken for record keeping and to identify signs, obstacles, road conditions, characteristics of the area and utilities available.

2.1.2 Task 1.2: Second Site Visit - Night Time

The second site visit will be performed during the night to understand better how the low light environment affects driving conditions. Photos and videos will also be taken to keep a record of the driving conditions, light conditions, and signage in place. This task requires special precautions given that stop and being close to an interstate ramp or roadway is dangerous. Special attention and wearing safety vests and lights are mandatory.

2.1.3 Task 1.3: Collecting Geometric Data

Satellite data will be used to measure road geometry (ramp length, lane width, shoulder width, length of interstate underpass roadway, etc.). The data will be acquired from the Google Maps platform. ADOT possibly will be able to provide as-built for the area making this task unnecessary.

2.2 Task 2: Detection Design

To accomplish the proposed project goals, it is necessary to investigate an effective way to detect wrong-way drivers. The team will test commercially available detection systems to evaluate the better option and propose an application for the chosen device.

2.2.1 Task 2.1: Research of Detection Types

Considering all the main detection methods commercially available, the team will identify their technical aspects, cost and performance data to develop a decision matrix. The matrix will be used to compare the available systems and choose one for further analysis. The search will be first performed online by checking products from different vendors. When a viable option is found, the team will contact the vendor by phone or email to get more specific information and check the availability and price of a small-scale device.

2.2.2 Task 2.2: Technical Specifications for Chosen Detection System

Considering all the main detection methods commercially available, the team will identify their technical aspects, cost and performance data to develop a decision matrix. The matrix will be used to compare the available systems and choose one for further analysis.

2.2.3 Task 2.3: Parts Acquisition

As soon as the evaluations are finalized, and funds are made available, the team will request a full or small-scale detector to perform tests in the laboratory, depending on the availability. The requested detector should be able to fully function as the full-scale detector and possess the same characteristics of operation. Parts will either be provided by government agencies or manufactured in the laboratory.

2.2.4 Task 2.4: Assembling and Testing

2.2.4.1 Task 2.4.1: Assembling

As soon as the parts arrive, the device will be assembled and tested in the laboratory for compliance with the criteria and constraints of this project. This phase will also comply with any Operation and Maintenance (O&M) manuals provided. The results of the tests performed will be incorporated in the 50% report.

2.2.4.2 Task 2.4.2: Driving Test

The device should be able to detect a vehicle with minimal error driving in both directions of traffic and identify the direction of the vehicle, in order to only alert the other systems for wrong-way drivers. The team will conduct tests by driving toy cars in different directions and logging the results.

2.2.4.3 Task 2.4.3: Multi-lane Driving Test

The device should be able to detect a vehicle with 98% of accuracy in detecting vehicles driving in two lanes at the same time or moving between lanes. This test has to comply with the previous driving test. Which means that the previous test will be performed once again with the added variables of this test.

The test will consist of a small-scale vehicle driving in multiple directions and using 2 lanes and changing lanes. The team will record all test results.

2.2.4.4 Task 2.4.4: Environment Tests

Depending on the detection system selected for the tests, it might be necessary to perform environmental tests with the detector. The detector will be exposed to hot weather, cold weather, dust, wind, rain, and ice/snow conditions. These tests will be necessary to identify when environmental variables affect the performance of the detection method. The need was determined by taking into consideration the technical characteristics of the intersection being analyzed.

Once the tests are finalized, a comprehensive test report will be made available, and incorporated to the deliverables, discussing the performance of the devices and describing how the chosen device will be applied as the solution for detecting wrong-way driving.

2.3 Task 3: Warning Systems

2.3.1 Task 3.1: Research Warning Systems

The team will conduct research on wrong-way driving warning and prevention systems currently being used by Arizona Department of Transportation (ADOT). Next, research will be conducted on warning systems for warning right-way drivers of a wrong-way driver currently being used by ADOT's. Finally, research how these systems in place utilize detection and how the detection is connected to warning systems.

2.3.2 Task 3.2: Decision Matrix for Wrong-Way Driver Warning System

A decision matrix will be created following a compilation of the information found when researching wrong-way driving warning systems. The decision matrix will allow the team to make an educated decision on what type of warning system will be implemented in the wrong-way driving system and if there is a need for the design of a new warning system. The criteria will be based on what the team feels is important to maintain the integrity of the project and will best prevent the wrong-way driver from continuing their course.

2.3.3 Task 3.3: Decision Matrix for Right-Way Driver Warning System

A decision matrix will be created following a compilation of the information found when researching right-way driving warning systems. The decision matrix will allow the team to make an educated decision on what type of warning system will be implemented in the wrong-way driving system and if there is a need for the design of a new warning system. The criteria will be based on what the team feels is important to maintain the integrity of the project and will best warn the right-way drivers of an oncoming wrong-way driver.

2.3.4 Task 3.4: Construction Documents

If a redesign of current systems for either wrong-way driver warning systems or right-way driver warning systems is found to be necessary from our decision matrices, the team will develop construction documents (CDs) which shows the characteristics of the device in the level of detail necessary for construction. Items such as dimensions, part types, physical appearance, and how the systems work will be outlined within the CDs. Additional CDs of these warning systems may be necessary for a small-scale prototype of the complete wrong-way driving system for system testing. CDs of the warning systems will be completed utilizing AutoCAD.

2.3.5 Task 3.5: Parts Acquisition

If a new warning system is to be created for the team's prototype system, necessary parts may need to be ordered. Since some parts do not necessarily have short shipping times, some parts will take up to a couple weeks to ship. Part ordering will be done using online resources when available, if not, vendors specific to warning systems will be contacted for assistance in part ordering. In the meantime, the team can build the infrastructure that allows the use of the part so that when it arrives, the part can be installed, and testing can begin immediately after.

2.3.6 Task 3.6: Testing

The warning systems will require testing as both an individual component and as a part of the complete wrong-way driving system. Testing will be done for the warning system's effectiveness and functionality. A report of the testing analysis will be conducted post-testing. The results of the tests performed will be incorporated in the 50% report.

2.4 Task 4: Communication Systems

2.4.1 Task 4.1: Research Communication Systems

Before a viable communications system can be contemplated, research must be completed regarding modes of communication used by DOTs, right-way drivers, and wrong-way drivers. The system that DOTs use to report events researched so that the WWD system can be merged with the standard. The end goal will be to seek the most effective way within the constraints of the project to notify the immediate users and the state DOT that there is a wrong-way driver in the vicinity.

2.4.2 Task 4.2: Decision Matrix for Wrong-Way Driver Communication System

A decision matrix will be created using information found when researching communication systems with regards to wrong-way drivers. The decision matrix will be composed of possible modes of communication allow the team to make an educated decision on what mode of communication will be implemented in the wrong way driving system. The criteria will be based on what the team feels is important to maintain the integrity of the project.

2.4.3 Task 4.3: Decision Matrix for Right-Way Driver Communication System

A decision matrix will be created using information found when researching communication systems with regards to right-way drivers. The decision matrix will be composed of possible modes of communication allow the team to make an educated decision on what mode of communication will be implemented in the wrong way driving system. The criteria will be based on what the team feels is important to maintain the integrity of the project.

2.4.4 Task 4.4: Parts Acquisition

Once a decision is made, the team must order the necessary parts. Since some parts do not necessarily have short shipping times, some parts will take up to a couple weeks to ship. In the meantime, the team can build the infrastructure that allows the use of the part so that when it arrives, the part can be installed and testing can begin immediately after.

2.4.5 Task 4.5: Testing

The communications system will be tested preliminarily before installing it to the rest of the system. The tests will be done on a small-scale and the events will be simulated. It must show that it can interface with the DOT as well as wrong and right-way drivers near the occurring event before the team is able to move forward. The results of the tests performed will be incorporated in the 50% report.

2.5 Task 5: Renewable Power Supply Source

2.5.1 Task 5.1 Researching a Way to Generate Renewable Power

Based on the design and the schematic of the system including detection, warning, and communication, the team will figure out how much power and voltage does the system need. Afterwards, the team will look for products of the shelf that satisfies the power and voltage needed for every kind of renewable energy whether it's wind, solar, hydro or hybrid systems.

2.5.2 Task 5.2 Decision Matrix

When the team figures out what the methods to generate renewable energy available in the market, they will have to analyze the environmental data that involves utilizing the natural resources such as sun, winds, and rivers in the designated area, Kachina Village. Based on this analysis, the team will figure out which off the shelf systems makes the best out of the natural resources available in Kachina Village.

2.5.3 Task 5.3 Order the System

After the makes their decision upon the renewable power supply generating method, they have to order that product and make sure it provides the vendor of the application that the system will be used for. Also, they can ask for an expert in the making company of the system to give them some tips and instructions that can help them in their application.

2.5.4 Task 5.4 Testing

As soon as the system arrives, the team has to verify that they can operate the system well and test in the environment in the designated area, Kachina Village. Also, the team has to verify that the renewable energy generator is supplying enough power as advertised to run the system for the desired period of time.

2.6 Task 6: Prototype

After we conduct the first four phases of the project design, the team is required to prove to the client that the system works properly. The prototype phase consists of assembly, tests and a report with the results of the prototype testing.

2.6.1 Task 6.1: Assembly

In the assembly part, the team will first make sure that all the parts ordered previously in the previous phases are delivered and in working conditions. After that, the team will come up with the design of the system that combines detection, warning, and communication system together. Subsequently, the team will build up the system based on the schematics that the team came up with the system design. Moreover, the team will calibrate sensors and other details so the system works in harmony together

2.6.2 Task 6.2: Testing

Following the assembly part, the team will have to test and simulate the system in a small-scale environment to verify the performance of the system and its compliance with the defined criteria and constraints. Furthermore, the team will test the system in different environmental conditions, representing possible conditions that the system may face when build

2.6.3 Task 6.3: Final Design

Finally, the team will use the feedback provided by the testing phase to incorporate changes to the prototype and propose a final prototype design. It is important to note that the team will not provide a full-scale prototype nor will test the prototype in an actual roadway or similar location.

2.7 Task 7: Project Management

2.7.1 Task 7.1: Meeting with Technical Advisor

Meetings with the technical advisor will occur biweekly.

2.7.2 Task 7.2: Meeting with Client

Meetings with the client will occur monthly, where project updates will be given.

2.7.3 Task 7.3: Meeting with Grading Instructor

Meeting with the grading instructor will occur biweekly, or when needed for advice or guidance.

2.7.4 Task 7.4: Team Meeting

A team meeting will occur weekly, or as needed to meet deadlines or to work on the project.

2.7.5 Task 7.5: Capstone Deliverables

2.7.5.1 Task 7.5.1: 50% Report

The team will create a comprehensive report at the halfway point within the project progression updating the client as to what has been conducted so far and what work there is left to be done.

2.7.5.2 Task 7.5.2: 100% Report

The team will make available a final comprehensive report showing test results, characteristics of the tests and devices used, tests raw data and the final results of the project.

2.7.5.3 Task 7.5.3: Construction Documents

Compile all construction documents used for designing the system. The documents will have the level of detail necessary for production and installation of the devices.

2.7.5.4 Task 7.5.4: Website

Create a final website which describes the team's work throughout the year and what has been done to mitigate wrong-way driving.

2.7.5.5 Task 7.5.5: Presentation

Create a final presentation which describes the team's work throughout the year and what has been done to mitigate wrong-way driving.

2.7.5.6 Task 7.5.6: Status Presentations

Create status presentations which update the class as to what has been completed up to the presentation date and what future tasks are still needed to be completed. These presentations will take place at any time during the semester.

3.0 PROJECT SCHEDULE

The project will start on January 22nd of 2018. The first main task that the team will address is the site investigation, which is collecting the basic information needed for the continuity of the project. It should take only a few days to finalize this first part. Following the site investigation, the team will work on researching, designing, and testing the 3 main parts of the system: detection, warning, and communication. This second phase will take around 2 months to be completed. The end of phase 2, which will represent half of the project, the team will deliver the 50% Report.

With the system defined, the team will research and assemble the power supply of the system. This is the last step in the prototyping phase of the project. Once the power supply is in place, the team will start prototyping the system. Tests will be performed and a final design for the prototype will be proposed. With the end of the prototyping phase, the team will focus on finalizing the final report, website, and presentation. During the final week of the semester, the team will present its findings and the final prototype design.

3.1 Critical Path

Another important aspect of the schedule needs to be mentioned separately, the critical path. The critical path is highlighted in the Gantt Chart found in the next section in the activities that are red. This was set to be the critical path since if there is a delay on any of these activities that will delay the entire project. Therefore, these tasks require special attention when managing the project.

The critical path starts with the first site visit. Without the basic understanding of the area of study, it will not be possible to do any further work. The second part of the critical path is the warning system development. This part of the development of the basic components is the one that will require more time to be developed, and the last one to be completed before the next phase: power supply. Since warning system is a predecessor of the power supply if there is a delay in the warning system development the entire project will be delayed. The team will take special care of this phase of the project making sure that all sub-tasks are being developed in a timely manner. If needed, extra hours will be assigned to keep deliverables on time. Once the power supply phase starts, all the subsequent tasks follow the critical path. All of them will require our attention since they are all dependable on each other.

3.2 Gantt Chart

ID	Task Name	Duration	Start	Finish
1	Start of Project	0 days	Mon 1/22/18	Mon 1/22/18
2	**1 Site Investigation**	**3 days**	**Mon 1/22/18**	**Wed 1/24/18**
3	1.1 1st Site Visit	1 day	Mon 1/22/18	Mon 1/22/18
4	1.2 2nd Site Visit	1 day	Tue 1/23/18	Tue 1/23/18
5	1.3 Geometric data collection	1 day	Wed 1/24/18	Wed 1/24/18
6	**2 Detection Design**	**16 days**	**Tue 1/23/18**	**Tue 2/13/18**
7	2.1 Research Detection	5 days	Tue 1/23/18	Mon 1/29/18
8	2.2 Tech Specs	5 days	Tue 1/30/18	Mon 2/5/18
9	2.3 Parts Requisition	2 days	Tue 2/6/18	Wed 2/7/18
10	**2.4 Assembly and Testing**	**4 days**	**Thu 2/8/18**	**Tue 2/13/18**
11	2.4.1 Assembly	3 days	Thu 2/8/18	Mon 2/12/18
12	2.4.2 Driving test	1 day	Tue 2/13/18	Tue 2/13/18
13	2.4.3 Multi-lane driving test	1 day	Tue 2/13/18	Tue 2/13/18
14	2.4.4 Environment test	1 day	Tue 2/13/18	Tue 2/13/18
15	**3 Warning System Design**	**21 days**	**Tue 1/23/18**	**Tue 2/20/18**
16	3.1 Research	5 days	Tue 1/23/18	Mon 1/29/18
17	3.2 Decision Matrix WWD	2 days	Tue 1/30/18	Wed 1/31/18
18	3.3 Decision Matrix RWD	2 days	Thu 2/1/18	Fri 2/2/18
19	3.4 Construction Docs	5 days	Mon 2/5/18	Fri 2/9/18
20	3.5 Parts Requisition	2 days	Mon 2/12/18	Tue 2/13/18
21	3.6 Testing	5 days	Wed 2/14/18	Tue 2/20/18
22	**4 Communications Design**	**16 days**	**Tue 1/23/18**	**Tue 2/13/18**
23	4.1 Research	5 days	Tue 1/23/18	Mon 1/29/18
24	4.2 Decision Matrix for Wrong-Way Driver	4 days	Tue 1/30/18	Fri 2/2/18
25	4.3 Decision Matrix for Right-Way Driver	4 days	Tue 1/30/18	Fri 2/2/18
26	4.4 Parts Requistion	2 days	Mon 2/5/18	Tue 2/6/18
27	4.5 Testing	5 days	Wed 2/7/18	Tue 2/13/18
28	50% report	5 days	Wed 2/21/18	Tue 2/27/18
29	**5 Power supply design**	**12 days**	**Wed 2/28/18**	**Thu 3/15/18**
30	5.1 Research	5 days	Wed 2/28/18	Tue 3/6/18
31	5.2 Decision Matrix	2 days	Wed 3/7/18	Thu 3/8/18
32	5.3 System Requisition	2 days	Fri 3/9/18	Mon 3/12/18
33	5.4 Testing	3 days	Tue 3/13/18	Thu 3/15/18
34	**6 Prototyping**	**15 days**	**Fri 3/16/18**	**Thu 4/5/18**
35	6.1 Assembly	5 days	Fri 3/16/18	Thu 3/22/18
36	6.2 Testing	5 days	Fri 3/23/18	Thu 3/29/18
37	6.3 Final Design	5 days	Fri 3/30/18	Thu 4/5/18
38	100% report	5 days	Fri 4/6/18	Thu 4/12/18
39	Presentation	5 days	Fri 4/13/18	Thu 4/19/18
40	Website	5 days	Fri 4/13/18	Thu 4/19/18
41	Conclusion of the Project	0 days	Thu 4/19/18	Thu 4/19/18

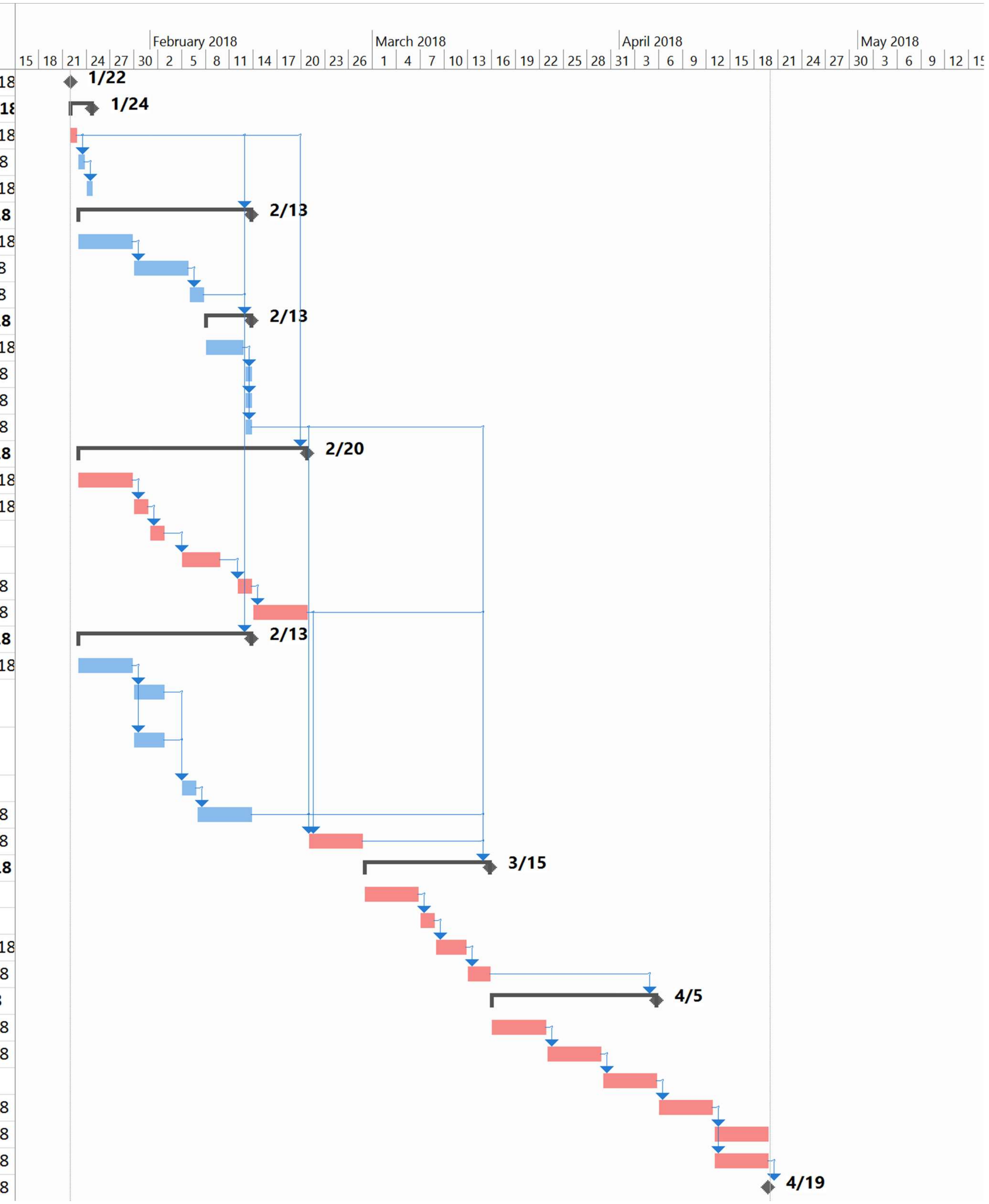

Figure 3-1: Gantt Chart for the Project

3.3 Start and End Dates of Tasks

Table 3-1: List of Tasks

ID	Task Name	Duration	Start	Finish	Predecessors
1	Start of Project	0 days	Mon 1/22/18	Mon 1/22/18	
2	**1 Site Investigation**	**3 days**	**Mon 1/22/18**	**Wed 1/24/18**	
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4	1.2 2nd Site Visit	1 day	Tue 1/23/18	Tue 1/23/18	3
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7	2.1 Research Detection	5 days	Tue 1/23/18	Mon 1/29/18	
8	2.2 Tech Specs	5 days	Tue 1/30/18	Mon 2/5/18	7
9	2.3 Parts Requisition	2 days	Tue 2/6/18	Wed 2/7/18	8
10	**2.4 Assembly and Testing**	**4 days**	**Thu 2/8/18**	**Tue 2/13/18**	**9**
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36	6.2 Testing	5 days	Fri 3/23/18	Thu 3/29/18	35
37	6.3 Final Design	5 days	Fri 3/30/18	Thu 4/5/18	36
38	100% report	5 days	Fri 4/6/18	Thu 4/12/18	37
39	Presentation	5 days	Fri 4/13/18	Thu 4/19/18	38
40	Website	5 days	Fri 4/13/18	Thu 4/19/18	38
41	Conclusion of the Project	0 days	Thu 4/19/18	Thu 4/19/18	40

4.0 STAFFING

4.1 Staff Descriptions

To complete the rural wrong-way driving project, a staff team will be selected to complete tasks throughout the project duration. The selected staff includes a project engineer, civil engineer, electrical engineer, lab technician, administrative assistant, and an intern. The project engineer will oversee the project and approve the final design to ensure the WWD project is up to code and will function as intended. Civil and electrical engineers will complete engineering design tasks specific to their respective fields to assist in the design of the project. The Lab Technician works as part of a team of technicians to organize, setup, execute, and document all test-related activities in the lab. Administrative assistants are responsible for providing various kinds of administrative assistance for the other members of the staff and office as needed.

4.2 Staff Qualifications

The following members of the staff will execute the project from start to finish working in each staff position as needed to meet milestones and deliverables. Each staff member's qualifications and their relevant experience to the project are listed below.

4.2.1 Zakary Jenkins

Zakary has gained three years' experience in heavy civil and roadway construction as a skilled laborer. He is proficient in AutoCAD design, Microsoft Excel, and has gained transportation design experience from the ASCE PSWC 2017 conference as part of the transportation design team. He has gained transportation experience in traffic signal and intersection analysis, highway design, and Intelligent Transportation Systems design.

4.2.2 Hashem Albhrani

Hashem has experience in many projects involves using microcontrollers such as MSP430 and Arduino UNO. He is skilled in circuits analysis and programming languages like C++, C, and MatLab. Hashem has good knowledge in power systems and converting various types of powers using DC converters.

4.2.3 Timothy Fisher

Timothy is proficient in many languages including C, C++, Matlab, and Unix and, he is adept at analog and digital circuit analysis and design using various SPICE applications. He also is skilled in digital signal processing and digital image processing. Timothy also has experience working with microcontrollers, microprocessors, and FPGAs like Arduino, Raspberry Pi, MSP430, and Altera Cyclone IV.

4.2.4 Ian Rodrigues

Ian has 10 years of experience managing software development projects and developing web applications. Furthermore, he has 2 years of experience supporting construction project management. Within his civil engineering expertise, he is skilled in several disciplines including structural engineering, water resources, and transportation engineering.

5.0 COST OF ENGINEERING SERVICES

The billing rates of each staff member are outlined below in Table 4-1 considering base pay, benefits, overhead, and profit. The total cost of the project can be found in Table 4-2 considering the staff positions, billing hours, and the hourly rate. Total staffing cost based on billable hours and billing rates can be found in Appendix A.

Table 5-1: Composition of Billing Rates [3][4][5][6][7][8]

	Composition of Billing Rates					
	Project Engineer	Civil Engineer	Electrical Engineer	Lab Technician	Administrative Assistant	Intern
Base Pay	$ 50.00	$ 40.00	$ 46.00	$ 25.00	$ 20.00	$ 14.00
Benefits	30%	29%	30%	33%	33%	0%
Overhead	60%	40%	40%	80%	20%	20%
Profit	15%	15%	15%	15%	15%	15%
Total	$ 120.00	$ 85.00	$ 95.00	$ 70.00	$ 35.00	$ 20.00

Table 5-2: Total Project Cost [3][4][5][6][7][8]

	Staff	Billing Hours	Hourly Rate ($/Hr)	Total Cost
Personnel	Project Engineer	63	$ 120.00	$ 7,560.00
	Civil Engineer	101	$ 85.00	$ 8,585.00
	Electrical Engineer	124	$ 95.00	$ 11,780.00
	Lab Technician	80	$ 70.00	$ 5,600.00
	Administrative Assistant	49	$ 35.00	$ 1,715.00
	Intern	184.5	$ 20.00	$ 3,690.00
Total Personnel		601.5	-	$ 38,930.00
Equipment		$ 1,700.00		
Testing Expenses		$ 500.00		
			Total	$ 41,130.00

6.0 REFERENCES

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7.0 APPENDIX

7.1 Appendix A – Staffing and Cost for Project Tasks

Table 7-1: Staffing and Costs Based on Billable Hours

Task	STAFF (Hrs)						Task Total	Total Cost
	Project Engineer	Civil Engineer	Electrical Engineer	Lab Technician	Administrative Assistant	Intern		
1.1 - 1st Site Visit	3	3	3	0	1	3	13	$ 995.00
1.2 - 2nd Site Visit	2	2	2	0	1	0	7	$ 635.00
1.3 - Geometric Data Collection	0	1	0	0	1	5	7	$ 220.00
2.1 - Research Detection	3	5	5	0	1	6	20	$ 1,415.00
2.2 - Tech Specifications	1	2	2	0	1	5	11	$ 615.00
2.3 - Parts Requisition	0	0	0	0	4	0	4	$ 140.00
2.4.1 - Assembly	0	2	2	10	1	0	15	$ 1,095.00
2.4.2 - Driving Test	2	3	5	4	1	7	22	$ 1,425.00
2.4.3 - Mult-lane Driving Test	2	3	5	4	1	7	22	$ 1,425.00
2.4.4 - Environmental Test	4	7	8	7	1	8	35	$ 2,520.00
3.1 - Research Warning Systems	2	5	5	0	1	6	19	$ 1,295.00
3.2 - Decision Matrix WWD	1	4	4	0	1	2	12	$ 915.00
3.3 - Decision Matrix RWD	1	4	4	0	1	2	12	$ 915.00
3.4 - Construction Documents	2	3	3	0	1	15	24	$ 1,115.00
3.5 - Parts Requisition	0	0	0	0	2	0	2	$ 70.00
3.6 - Testing	3	5	0	10	1	7	26	$ 1,660.00
4.1 - Research Communication Systems	2	0	7	0	1	6	16	$ 1,060.00
4.2 - Decision Matrix WWD	2	0	4	0	1	5	12	$ 755.00
4.3 - Decision Matrix RWD	2	0	4	0	1	5	12	$ 755.00
4.4 - Parts Requisition	0	0	0	0	2	0	2	$ 70.00
4.5 - Testing	4	2	6	10	1	7	30	$ 2,095.00
5.1 - Research Power Supply	2	0	2	0	1	4	9	$ 545.00
5.2 - Decisision Matrix	1	0	2	0	1	2	6	$ 385.00
5.3 - Parts Requisition	1	5	5	0	1	2	14	$ 1,095.00
5.4 - Testing	1	2	3	10	1	5	22	$ 1,410.00
6.1 - Prototyping Assembly	1	5	5	10	1	7	29	$ 1,895.00
6.2 - Prototype Testing	5	7	7	10	1	5	35	$ 2,695.00
6.3 - Final Design	4	4	4	5	1	6	24	$ 1,705.00
7.5.1 - 50% Report	2	5	5	0	2	10	24	$ 1,410.00
7.5.2 - 100% Report	2	5	5	0	2	10	24	$ 1,410.00
7.5.3 - Construction Documents	2	2	2	0	5	20	31	$ 1,175.00
7.5.4 - Website	2	5	5	0	3	10	25	$ 1,445.00
7.5.5 - Presentation	2	5	5	0	2	5	19	$ 1,310.00
7.5.6 - Status Presentations	2	5	5	0	2	2.5	16.5	$ 1,260.00
Total Hours	**63**	**101**	**124**	**80**	**49**	**184.5**	**601.5**	
Total Cost	**$ 7,560.00**	**$ 8,585.00**	**$ 11,780.00**	**$ 5,600.00**	**$ 1,715.00**	**$ 3,690.00**		$ 38,930.00