AirTack

School of Engineering Science • Simon Fraser University
Burnaby, BC • V5A 1S6

January 19, 2013
Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
V5A 1S6

Re: ENSC 440 Project Proposal for a Real-time Gas Monitoring System

Dear Dr. Rawicz:

The attached document, ***Proposal for a Real-time Natural Gas Monitoring System***, summarizes our Capstone Engineering Science Project. Our objective is to design a real-time home monitoring system capable of detecting levels of various gases and other important environmental factors and respond accordingly via text message notification, electrical shutoff and ventilation management.

This proposal provides a general view of our product, the design considerations, our funding and information resources, an approximation of required budget and finally scheduling of various states of the project.

Throughout this document we will also examine market potential for this. Our group consists of four creative, motivated and disciplined fourth and fifth-year engineering students: Rouzbeh Roshanravan, Samuel To, Tessa Ryan, and Marvin Lee. If you have any questions or concerns about our proposal, please feel free to contact me by phone at (604) 710-5476 or by e-mail at rra19@sfu.ca.

Sincerely,

Rouzbeh Roshanravan

Rouzbeh Roshanravan
President and CEO
AirTack

AirTack

Proposal for a

Real-time Gas Monitoring System

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Submitted to:

Dr. Andrew Rawicz – ENSC 370
Steve Whitmore – ENSC 305
School of Engineering Science
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1.1

Executive Summary

John has had asthma his whole life, and his wife Alice has always had similar sensitivities. The family lives in an apartment in a densely populated metro area to be close to John's office, but the air quality in and around the house is poor. Alice home-schools the children who are six and seven years old, so much of their time is spent in the house. Shortly after their oldest child turned six, she was diagnosed with asthma just like her father, and her asthma attacks have only become more frequent…

With 235 million asthma sufferers worldwide (World Health Organization, 2011) and 8.5% of Canada's population (over age 12) afflicted (Statistics Canada, 2010), this situation is all too common. Children and the elderly are particularly susceptible to health problems caused by air pollution, though we can all feel its effects. External air pollution from cars, industrial processes, and a host of other sources easily finds its way in, and some household appliances burn natural gas right inside the home. Unfortunately, the burning of fossil fuels releases a cocktail of pollutants into our air which can be hazardous to human health. Air pollution including fumes, chemicals, odours, smoke, smog, etc. has long been associated with heart and lung diseases like asthma. Additionally, particulate matter, excessive carbon monoxide and carbon dioxide are among the products of hydrocarbon combustion that act as triggers.

If the home and workplace are to be safe and healthy environments, the condition of the air is crucial. Many individual devices have been designed to monitor levels of gases like carbon monoxide and even methane. These systems are useful- their alarms go off when conditions have deteriorated to the point that toxin levels pose a serious risk to human health. However, individually they are incapable of providing real-time statistical data. Moreover, they are unable to respond to toxin levels in any way which may correct the source of the problem, thereby ensuring stability in environmental conditions throughout the day.

This document proposes the development of a new device which combines the sensing and response of many crucial monitoring devices into one "multi-monitor". This real-time home monitoring system will be capable of detecting various gases and other environmental factors and shall respond accordingly. Detected substances include natural gas, carbon monoxide, carbon dioxide, smoke (particulate) and humidity (H2O in the air). Temperature will also be monitored in order to establish covariance in the detected substances with heat. Real-time responses to sensed information by initial completion of this project include delivery of SMS alerts and turning a fan on. Future development will include mechanical shut-off and circuit breaking.

The AirTack team consists of four skilled and dedicated fourth-year engineering students with experience in diverse areas, including embedded systems design, software engineering, digital/analog circuit design, signal processing and statistical data analysis. We propose that the project lifecycle for this endeavour will encompass research, design, construction, integration and testing. The project cycle shall span a 13 week period with a completion deadline set to April 1st, 2013 for a working prototype. This project is budgeted at $624, which we expect to obtain from a variety of sources.

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1. Introduction

"All of us face a variety of risks to our health as we go about our day-to-day lives.... Indoor air pollution is one risk that you can do something about." — US EPA.

A day rarely goes by where we aren't exposed to concern over the state of our environment and the effect it will have on the health and future of today's generation and our children. Air pollution is a part of daily life, especially for people living in urban areas. The increased health care costs, reduced productivity and missed days of work attributable to air pollution costs the Canadian economy billions of dollars annually. (Environment Canada, 2012)

Right now, there are few things consumers can do to make a significant impact on the quality of the air they breathe on a daily basis. Riding a bike to work, carpooling and eating locally are all great contributions to reducing Canadian society's carbon footprint, but unfortunately these actions don't have significant, immediate implications on our capacity for respiratory health.

The objective of our project is to develop a highly modular, universal air monitoring system for the home. This device, equipped with several chemical-specific sensors and easily expandable with additional sensors, will monitor levels of known harmful substances in the air in real time. Data will be sent back to a compact central server in the home for analysis and response determination. If abnormally high or unsafe levels of an airborne substance are detected, the user will be alerted immediately via SMS to their cellphone. A simple command and response system through SMS will allow the user to reply to the system with a desired course of action. Secondary responses include the activation of a ventilation system, either automatically or by user feedback depending on a severity threshold. Users may also plug their cellular device into the central server to access statistical information in real time, including data trends and possible correlations with temperature. Future iterations of this design will include a circuit breaking mechanism and mechanical gas shutoff.

The real-time nature of this system's operation gives the user piece of mind, ensuring the safety of people and property within the home. Many of the monitored substances pose significant hazards- carbon monoxide and natural gas are poisonous, CO is also odourless and natural gas is highly explosive. Even if levels of these and other toxins are not serious enough yet to evacuate a dwelling, the warnings give families the chance to address any underlying causes. The system goes beyond the typical monitor functionality, providing more than just an alarm system. Data trending and temperature correlation provides additional information that will help them pinpoint the source(s), potentially saving lives. Most importantly, this device empowers people to control their exposure to harmful substances within their home and can plan an invaluable role in managing diseases like asthma and other serious respiratory conditions.

This document is a proposal product, providing an overview of its inception including design considerations, funding sources, and project scheduling. A system overview and projected budget are included, and Gantt and milestone charts are provided in Appendix 1.

2. System Overview

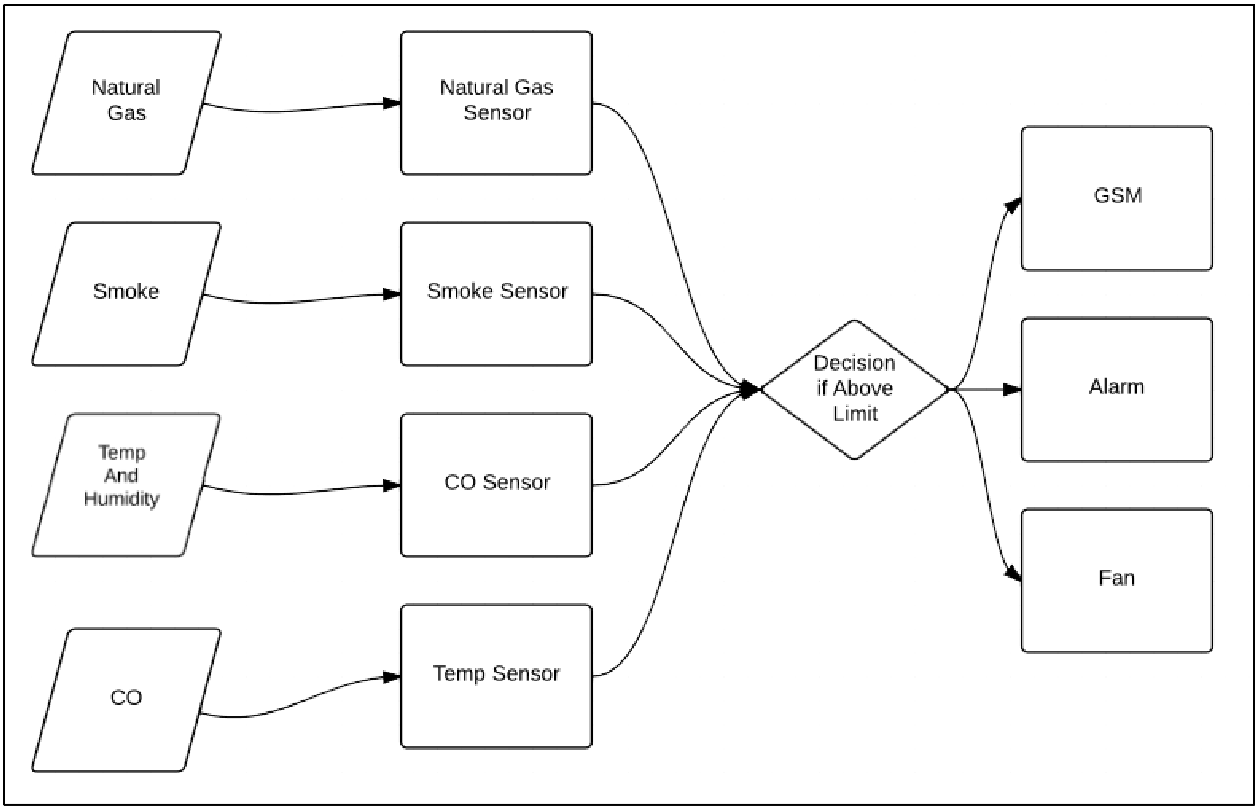

Figure 1 – AirTack Multi-monitor System Operation Overview

Figure 1 gives a conceptual overview of the input and output organization and operation of the system. The decision if substance levels are above or below programmed threshold limits is made by a simple central server, which is responsible for all data processing and response generation- triggering SMS response and ventilation control. Communication with the central server is done via power line communication, which makes the system easily installable and highly scalable within the home. Additional rooms within the house can be equipped with sensors quickly and easily and new sensors to detect other potentially hazardous toxins or environmental levels can be added. The versatility of the central monitoring system (the server) is such that statistical data analysis can also be performed, providing the user with trend information which may help pinpoint the cause of any issues including correlation with temperature and humidity. The user may also plug their cellular device into the central server to view graphical representations of this data.

3. Design Considerations

From researching existing environmental safety systems, we have created a set of goals that our product must meet. Significant design decisions were made to our solution so that we meet our goals. The goals are:

- Measure several environmental hazards
- Take preventative actions to minimize damage
- Inexpensive to install and use
- Robust and reliable network

The reasoning behind these goals and the proposed decisions are explained below.

Currently, all new homes are required to have smoke detectors installed, however these systems only detect smoke in the air. Furthermore, the various home systems are all equipped with alarms, but there are few systems that expand upon this basic alert system and take an active role in preventing risk to humans and property damage. For example, in commercial systems there are smoke monitors that physically activate fire suppression systems in the case of a fire, but these response systems are not commonly available for application in a residential home. The system that we propose will be capable of monitoring several different substances such as natural gas and carbon monoxide. In addition, the multiple user alert systems in our product and active, real-time response to prevent property damage set the system above similar, individual-substance monitors already on the market. If the natural gas sensor in our product detects gas, the system will turn on a fan to vent the room or shut off the gas line to prevent a buildup of gas.

One of the main expenses in a monitoring system is the installation cost. In new buildings, installation is simple as the fire alarm system is integrated into the building as it is built. These alarm systems are connected with wires so that all the alarms will sound if one of the sensors detects smoke. With older buildings, it may be difficult to install a wired system without cutting open the walls. Basic smoke detectors may be installed in older homes, but this limits the feature set- they are not connected through a network or rely on wireless communication. This product is a critical system- downtime is not acceptable and poses an immediate threat to human safety. This led to the decision to connect our devices using power line communication, which provides a direct wired connection to every sensor using existing power lines in the wall to communicate. This design decision will virtually eliminate installation costs for the consumer as well as provide an extra level of safety. Wired communication via power line does not rely on wireless networks, which may experience interference and downtime.

4. Proposed Design Solution

We propose to build a network of sensors to monitor the home for several environmental factors such as natural gas, CO, and smoke. Power line communication will connect each module of the device, using existing building infrastructure while remaining 'wired', rendering this critical safety system economical and reliable. This system extends the functionality of a basic smoke detector into a complete safety system that is stable and highly scalable. This product will benefit the home owner by providing a safety system that is low cost, can perform numerous functions and is easy to install and expand with additional sensors. In addition, our product has the ability to alert the owner if monitored substances reach possibly dangerous levels and actively prevent damages to the home through its response systems (ventilation management).

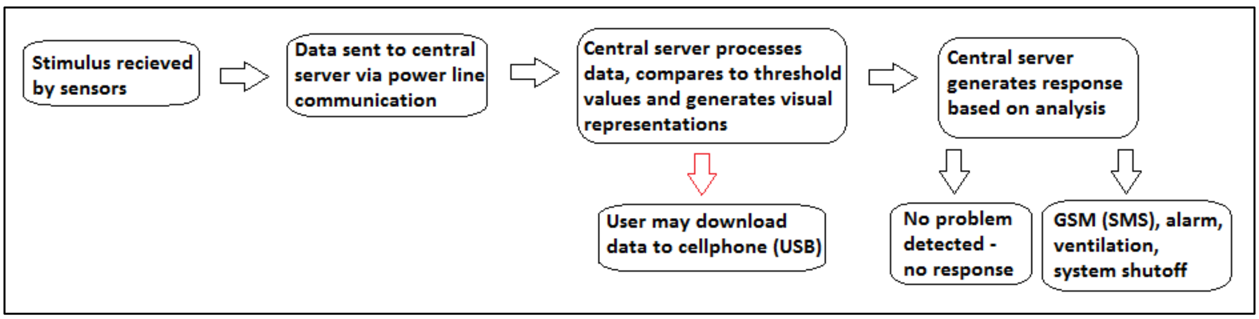

Figure 2 – System Flowchart

In this project's approach, the functionality of the traditional alarm system is expanded upon to include phone messaging (SMS) and reactive actions such as venting the room or shutting off the gas supply. Our product also expands on the number of potential hazards and conditions that are monitored, including CO, CO_2, natural gas, smoke (particulate), humidity and temperature all in a single device.

Our device uses several Arduino microcontrollers to monitor conditions, process data and take action in response to data samples, taken in real time. A GSM shield for the Arduino allows the system to send SMS text alerts to the user's cellphone. Sensors are attached to the Arduinos via analog pins. Communication between the sensor module, central server and other modules is done through power line communication. Expansion of the system for more sensors or more rooms monitored is easy due to this method of communication and the highly modular nature of the design. This fact also mitigates the eventual cost of our system to the consumer- just the necessary functions (sensors, response) can be chosen for inclusion and future expansion is possible.

The main constraint to our proposal is the limited time frame to design and built a prototype. With only three months of development, the number of utilities that can be added to the prototype is limited. Our development will be focused on the basic functionality of the system. As such, the design of the prototype will use mostly of the shelf components. Furthermore, in the scope of this ENSC 440 project, we are not considering getting our device certified to be used in a home environment, though we will use certification levels as guidelines in testing to measure the accuracy of our system.

If a longer development time was given we could improve on the design of the system by integrating smaller sub-circuits into a unit. More utilities and functions can be added to the design creating a more complete product.

5. Sources of Information

Based upon our proposed design, we plan to thoroughly research several topics and sources before and throughout the project.

Arduino microcontrollers are providing the backbone of our system, and so we plan to consult relevant datasheets as we construct the prototype. These datasheets will include those for the Arduinos themselves, the shields we are planning on using and other hardware we interface into the system. We will be implementing sensors and SD memory into the system to store the real-time data collected by the sensors, so documentation surrounding that integration and the necessary programming interfacing will also be consulted. These documents are widely available online and in Arduino hobbyist communities and we will seek information in these communities as well as the need arises.

Additionally, colleagues, alumni and staff at Simon Fraser University with strong backgrounds in embedded systems design and implementation will be consulted should we have difficulties or require guidance in the process. Online and textbook resources will also be utilized in the implementation of power line communication in our device.

Statistical analysis is also an instrumental capability of our system, taking in sensor data and establishing data trends for user interpretation. In order to ensure we model our information in a correct and user-friendly way, we will consult with colleagues, alumni and staff at Simon Fraser University with strong backgrounds in statistics.

Usability is also of paramount concern as this product is geared for use in the family home where individuals may not have a high degree of technical knowledge or experience. We will consult with a variety of people throughout the project to ensure operation of the finished product is obvious and user-friendly.

6. Budget and Funding

6.1. Budget

Table 1 provides a list of the projected budget for the multi sensor air detection system. For the purpose of simplicity, some parts have been grouped together, including the different types of sensors and microcontrollers that will be utilized.

Equipment	Estimated Cost ($)
Arduino Microcontrollers (3)	$ 90.00
Sensors	$ 40.00
Power line Communication Module	$ 165.00
GSM Cellular Module	$ 100.00
Microcontroller Accessories	$ 75.00
Test Equipment	$ 50.00
Subtotal	**$ 520.00**
20% Contingency and Shipping	$ 104.00
Total	**$ 624.00**

Table 2 – Equipment Cost Breakdown

6.2. Funding

Taking into consideration the average cost of individual home monitoring systems, the initial costs in the design and implementation of this project seem high. It is important to note however that the initial capital required will greatly exceed the cost of the finalized product. Instead of using off the shelf products, parts that are easy to manufacture in large quantities will be substituted into the design before it goes to market. As time progresses, the cost of current technology also decreases as newer products come to market.

Due to the relatively high prototyping costs associated with the project, multiple sources of funding have been suggested. The sources suggested are: the Engineering Science Student Endowment Fund (ESSEF), the Wighton Development Fund (due to the human element in this project) and a small grant of the Engineering Science Lab team.

While these sources of funding should be enough to account for the initial prototype, the team members are willing to accept the responsibility of funding the rest of the project should any costs go uncovered. The team members will divide the rest of the costs equally to ensure equality. There may also be plans to enter different design competitions such as Western Engineering Competition (WEC) and Dragons Den.

7. Project Schedule

Figure 3 in Appendix 1 illustrates the Gantt chart for this project's completion. The entire project is to be completed by April 1st, 2013. Figure 4 in Appendix 1 illustrates the project milestones.

8. Team Description

Rouzbeh Roshanravan – Chief Executive Officer

Rouzbeh is a fourth year Computer Engineering student at Simon Fraser University. He has completed total of five co-op terms at Ericsson, the Systems Department of Genome Sciences Center at BC Cancer Agency and CMC Industrial Electronics. He has a variety of skills both in software and hardware and is an advanced Java programmer. Additionally, he has experience programming in C#, C++, VHDL, and HC12 assembler. He has worked with microcontrollers, sensors and different lab instruments in a number of self-initiated projects.

Samuel To – Vice President of Operations

Samuel is a fifth year Computer Engineering student whose area of focus is in hardware design. His interest in hardware came from building small circuits in elementary school; this soon evolved into taking on several personal projects that were built during his spare time. He learned the process of hardware design while studying engineering in university. Previous work experience at Ericsson had him act as a hardware tester. Other skills he has include knowledge in programming in C++ and VHDL.

Marvin Lee – Chief Financial Officer

Marvin is a fifth year Computer Engineering student at Simon Fraser University with a specialty in embedded systems. He has taken courses in software engineering, digital systems, embedded systems and VLSI systems. His previous work experience involves working in software development on the Line Card Software team at Ericsson as well as a project member under a professor at the university. He has programmed on multiple levels from low level Linux drivers to Android applications. On top of his technical skills, he has a proven ability to work well in a team environment both in person and virtually.

Tessa Ryan – Chief Marketing Officer

Tessa is a fifth year Computer Engineering student at Simon Fraser University with a strong interest in embedded systems, usability design and statistics. She has taken courses in advanced statistics, digital systems, embedded systems, electronics and VLSI design and has previous work experience as a Systems Administrator at SAP Labs. Tessa also has experience in programming in C, C#, C++, VHDL and various assembly languages and is passionate about engineering solutions that work for the people. She is currently serving her second term as President of the Engineering Science Student Society at Simon Fraser University since April 2011.

9. Company Profile

AirTack consists of 4 engineers from the School of Engineering Science at Simon Fraser University: Rouzbeh Roshanravan, Samuel To, Tessa Ryan and Marvin Lee. All the members are 4th or 5th year computer engineering students which bodes well due to the nature of the project. There is a balance between both software and hardware specializations and each member is dedicated to working towards the common goal of the organization.

In terms of the corporate structure, each member has a specific role within the company. Rouzbeh Roshanravan, the Chief Executive Officer (CEO), will be in charge of the project progress as well as ensuring that the team works as a cohesive unit. Tessa Ryan will hold the title of Vice President of Marketing which involves usability engineering, generating interest through the use of social media, websites and generating capital. Marvin Lee, Chief Financial Officer (CFO), will manage the budget and resolve financial issues to make sure costs are covered. Samuel To, Vice President of Operations, is in charge of the technical aspects of the project and to make sure that the team members know what their tasks are. Which each member has their own roles, they will each be contributing at a technical level to complete the project.

To ensure that the project is finished in a timely manner, weekly meeting will be held to assess the progress and assign resources as they are needed. The meetings will be held in an "open forum" nature so that each member will be able to voice their opinions. Minutes will also be taken so that there is a record of the issues being discussed.

The workload assignments will be distributed amongst the team based on their individual strengths and weaknesses. Each member will be working individually initially while being able to help out others if it is necessary. As the modules are completed, members will be collaborating together to integrate the modules to create a system.

ENSC 440 has a large focus on group dynamics and we believe that at AirTack, we have a strong team that is able to work through and succeed at our goals.

10. Conclusion

AirTack is committed to engineering smart, usable and reliable solutions to mitigate risk of injury, death and property damage due to air contaminants like natural gas and carbon monoxide. Our product, while marketed to home owners, also stands to benefit hospitals and industrial areas. It will protect lives and have tangible financial benefits for consumers looking to control conditions in their home including heat, humidity and energy use throughout the day. The real-time data and statistical correlation information computed by the central server is easily accessable via USB connection to a cellphone. It can help pinpoint the cause of problems before they become severe, or help monitor trends in levels throughout the day. The user can dictate what constitutes desirable levels of a given substance in the air, though industry standards will be built in as a safety measure. In the case of a spike in hazardous substance levels, the system will respond immediately, notifying the user via text message, sounding an alarm, ventilating the area and informing emergency services. Future iterations of the product beyond the scope of ENSC 440/305 will include mechanical gas shutoff and circuit breaking functionality to help cut off the source of the dangerous pollutants. They will also include implementation of a remote monitoring system in which data from the central server can be sent wirelessly to the phone instead of through USB, so it is accessible from anywhere in the world.

11. References and Works Cited

Environment Canada. (2012, June 18). *Impacts of Air Pollution*. Retrieved January 16, 2013, from Environment Canada: http://www.ec.gc.ca/indicateurs-indicators/default.asp?lang=en&n=D189C09D-1

Statistics Canada. (2010). *Asthma, 2010*. Retrieved January 17, 2013, from http://www.statcan.gc.ca/pub/82-625-x/2011001/article/11458-eng.htm

World Health Organization. (2011, May). Retrieved January 17, 2013, from W.H.O. Asthma Fact Sheet No307: http://www.who.int/mediacentre/factsheets/fs307/en/index.html

Appendix 1: Figures

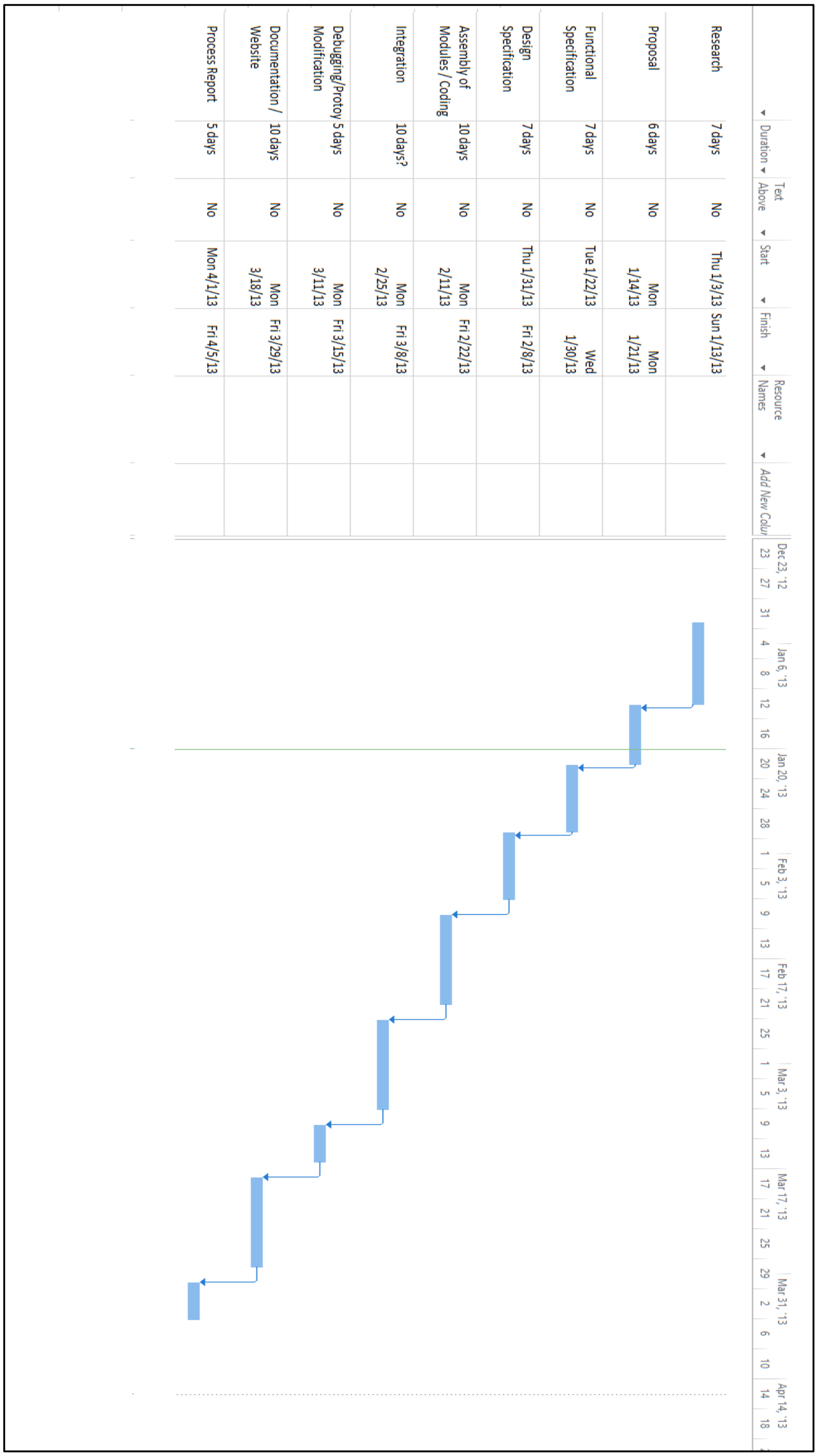

Figure 3 – Project Gantt Chart

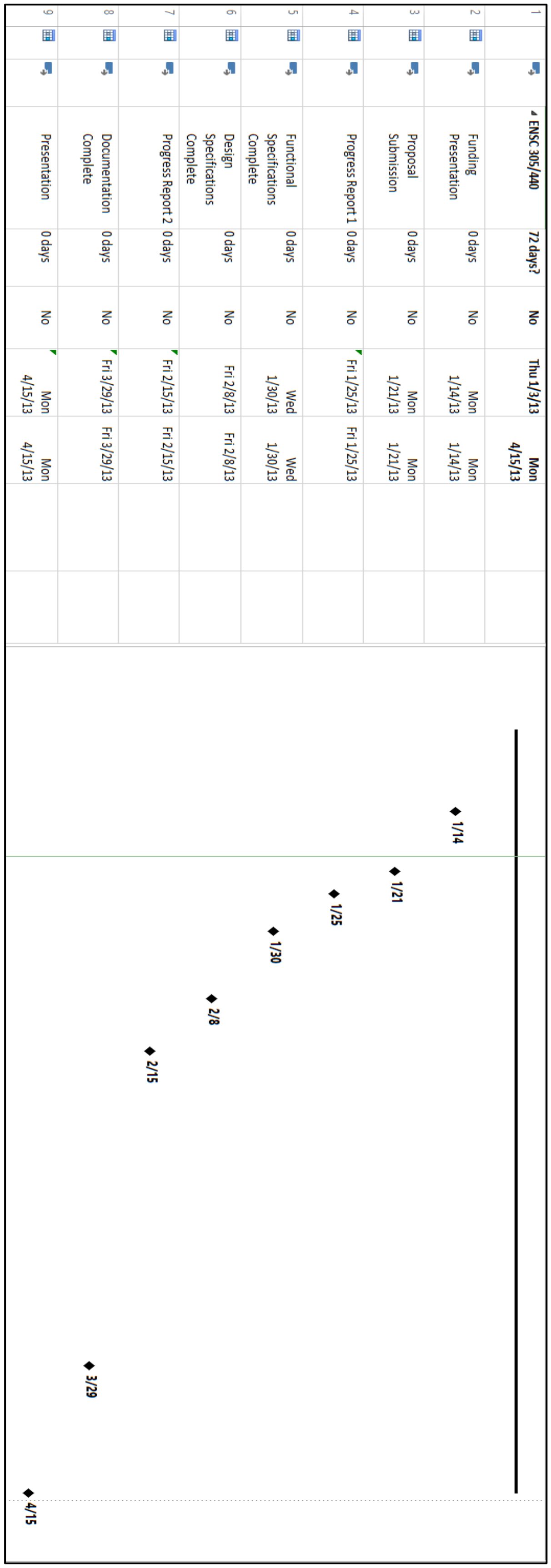

Figure 4 – Project Milestone Chart