FAMU-FSU College of Engineering
Department of Electrical and Computer Engineering

PROPOSAL

EEL4911C – ECE Senior Design Project I

Project title: **Autonomous Water Quality Sampler**

Team #: 8

Student team members:

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Dr. Nicolas Wienders, Oceanography

Submitted in partial fulfillment of the requirements for

EEL4911C – ECE Senior Design Project I

October 20, 2011

Project Executive Summary

This proposal is submitted in response to:

Invitation for Bid:
Project #8

AWQuSam, Engineering will be providing a turn-key autonomous water quality sampler that will be utilized for acquiring hydrographic and water quality data by the Florida State University Department of Oceanography. As requested in the solicitation, the system will be designed and implemented to support the gathering of water quality and hydrographic data along Florida's coastal environment. The AWQuSam will drive itself across a bay, at least 5km, navigating with GPS, recording key oceanographic parameters, and relaying samples of data to a base station.

To accomplish these tasks, the AWQuSam will employ means that facilitate acquisition of useful scientific data, such as temperature and salinity, in the shallow environments of the Florida shelf. Signal processing will be performed via a PIC microcontroller aboard the AWQuSam. All acquired data will be logged onto an SD memory card for analysis by researchers.

A GPS system will be incorporated into the AWQuSam for use by the navigation, guidance and recovery systems. In addition to the AWQuSam, a base station will be developed in order to receive streamed data from the AWQuSam.

The primary objective of the AWQuSam is to remain autonomous, navigating and performing the aforementioned tasks, for the duration of the trip.

Presently, there is no such autonomous system for effectively collecting hydrographic data in shallow environments. The team believes their creative, potentially transformative, concepts can revolutionize oceanographic research by advancing discovery in this area.

The team of engineers is confident the data reflected in this document represents innovative test and evaluation techniques. Attention has been paid to detail, and the team holds a firm commitment to completing this task in an efficient and accurate manner.

1 Introduction

1.1 Acknowledgements

AWQuSam Engineering would like to thank the FAMU / FSU College of Engineering and the Florida State University Department of Oceanography for monetary contributions toward the development of the Autonomous Water Quality Sampler, hereafter referred to as the AWQuSam. Thanks, also, to researchers within the Florida State University Department of Oceanography for contributing oceanographic expertise and equipment necessary for developing the AWQuSam.

1.2 Problem Statement

There is a need for water quality and hydrographic data from the coastal environment in order to understand the processes that mix and transport nutrients, carbon, pollutants, and other material entering the ocean from sources on land.

Ship-based measurements are expensive because of the operating cost for a sea-going vessel and crew. New platforms for sampling the ocean at high resolution are being used now in many coastal regions around the United States. These platforms, called gliders, are roughly torpedo shaped and, like gliders in the atmosphere, have a relatively large glide ratio in order to translate vertical motion into horizontal distance.

In the shallow environment of the Florida shelf, there is no room for large vertical excursions to provide for the buoyant force to drive the horizontal motion and gliders are not practical.

A new kind of platform is needed that moves across shallow bays and estuaries and measures key water quality parameters like temperature and salinity.

The AWQuSam is a fully autonomous surface vehicle designed to navigate the shallow waters along the Florida coast. Routes can be programmed into the AWQuSam prior to excursion, and the AWQuSam will navigate the route, collecting key oceanographic data along the way. A GPS system will be incorporated into the AWQuSam for use by the navigation, guidance and recovery systems.

The AWQuSam will process scientific information, such as temperature and salinity, from sensors located in the water. Signal processing will be performed via a PIC microntroller aboard the AWQuSam. All acquired data will be logged onto a SD memory card for analysis by researchers. Samples of data will be streamed via license-free channel to a receiver for real-time analysis. A base station will be developed in order to receive streamed data from the AWQuSam.

1.3 Operating Environment

The AWQuSam will be operated in the shallow environment of the Florida coastal shelf. It will be operated and/or stored in a salt-air atmosphere with humidity levels potentially reaching 100%. While operating, the AWQuSam may experience extended exposure to sunlight. During the summer months, the AWQuSam may be stored in temperatures of up to +70°C and while operating, may be exposed to temperatures of up to +55°C. In addition, the AWQuSam may experience winter storage temperatures as low as -20°C and operating temperatures of -5°C. The AWQuSam may experience crashing waves of up to 1m in height, winds of 40knots, and driving rainfall.

1.4 Intended Use(s) and Intended User(s)

The AWQuSam is intended to be used by oceanographic researchers. It will primarily be deployed by users with at least a Bachelor's degree and knowledge of the system. However, the AWQuSam may be deployed by individuals with no knowledge of the system, and it shall be designed to allow such a user to deploy the system. Untrained personnel will be able to program a new mission path into the AWQuSam with only the aide of instructional documentation. Once deployed, the AWQuSam will be fully autonomous. Collected data will be analyzed by oceanographic researchers.

The AWQuSam will be used to collect precise hydrographic and water quality parameters near the surface of the Apalachicola bay area and other shallow water environments. It will record water temperature and conductivity information. The AWQuSam will be used to collect this oceanographic data in an environment where there is presently no effective method for collecting such data. It is not intended to collect data on land or in deep ocean environments.

1.5 Assumptions and Limitations

The AwQuSam shall measure and record water temperature to a precision of 0.01ºC at a rate of 8 samples per second. It shall measure and record water conductivity to 0.01 S/m at a rate of 8 samples per second. Temperature, conductivity, and position will be transmitted to a base station receiver at a rate of one time every 5 minutes. The AWQuSam will not be deployed for missions longer than 12 hours. The system is to be used only for surface water applications, and is not be deployed in areas with ocean currents in excess of 5 knots or with waves greater than 2m in height. The end user will program paths into the AWQuSam using GPS coordinates.

The end product shall be no larger than 1.2m in length, 0.8m in width, and 0.5m in height (excluding antennas) to facilitate easy transport in the back of a van to and from a launch site. It shall weigh no more than 40kg to allow for deployment by one to two persons. An AWQuSam prototype shall be designed and delivered by April 13, 2011 with expenditures not to exceed $1000.

1.6 Expected End Product and Other Deliverables

One (1) Autonomous Water Quality Sampler prototype will be delivered to facilitate the gathering of oceanographic data in shallow coastal waters. Its path will be programmable by the end-user. Once programmed, the AWQuSam shall propel itself across the surface of bays and estuaries recording water temperature and conductivity.

The AWQuSam will be delivered with documentation detailing instructions for programming new paths. Documentation will also be provided with instructions for performing maintenance and for servicing the system or components. Prototype and documentation shall be delivered by April 13, 2011.

2 Concept Generation & Selection

The team considered a variety of options before identifying the best design solution for the AWQuSam. A number of factors were considered in order to both satisfy design requirements and also design within budgetary constraints. The proposed product design is a unique, original, and innovative design, but this section will discuss alternative concepts that were rejected by the team.

2.1 Central Processing

The team discussed and analyzed several central processing options. It was discussed that an onboard Linux-based computer be used and all data be logged to this machine. This option lacked the flexibility our application needs. Another option was to use an FPGA development board, but identifying a board with the I/O requirements and within our budget was not feasible. A microcontroller development board (PIC Explorer 16) allows for rapid processing and greater flexibility, while also providing a more scalable platform.

2.2 Conductivity Sensors

A number of vendors were consulted in order to determine the conductivity sensor best suited for this design. The most practical option from YSI is their 600R model conductivity/ temperature sensor. This series can sample at 10Hz. However, the sensor costs $2062 per unit, plus $85 for each pigtail connector for integration with our development board

Forston Labs offered a conductivity sensor for $125 per unit, but they only resolve to 0.02ppt. In addition, the response time of this conductivity sensor is too slow for our application.

PME offered a rapid-response conductivity sensors, as well. However, this option is not very stable. Engineers at PME recommended to us that their sensors or not well suited for twelve hours of unattended operation. These sensors do not resist fouling and are quite fragile.

The Florida State University Department of Oceanography offered Seabird's SBE-4 conductivity sensor for use with the AWQuSam without charge. This sensor does provide a precise and rapid-response that satisfies our requirements. This is the option we will be utilizing in our design.

2.3 Temperature Sensors

A variety of temperature sensors are available. Thermocouples offer a fast, almost immediate, response to temperature changes. However, they are best suited for extremely high temperature. RTDs are stable temperature sensing devices. However, because they are best suited for a wide temperature range, detailed precision is not guaranteed.

Our application requires measuring a relatively limited temperature range. However, accuracy and sensitivity to small changes is important over this range. A fast-response thermistor will likely be the best solution. In general, this option is the least expensive of the three. A specific sensor has not yet been determined, as we are awaiting responses from several temperature sensor vendors to determine the best solution for our application.

2.4 Data Communications

To achieve the 5km data transmission requirements, a number of options were assessed. A satellite link approach, like Iridium Short Data Burst would work, but it requires a subscription service. Another solution is to use a mobile phone. The idea is to pass data to it via USB, and write an application to upload the data to a serve or transmit via SMS message. This approach would only work in areas where cellular service is available. (It is available in the Apalachicola Bay area). However, this option also requires a subscription service in the form of a cellular plan and a dedicated phone.

An option exists wherein a VHF radio on the 2-meter frequency band could be used as a packet radio system. This option requires additional hardware in the form of a terminal node controller. This setup could be utilized to establish a point-to-point radio connection for transmitting data from the AWQuSam to a base station receiver. This option requires an amateur radio license. The cost of purchasing a 1200 bps AFSK TNC and a 2-meter frequency (144-148 Mhz) compatible radio was likely to exceed our budget, even before considering the added cost of acquiring an FCC license.

Consequently, the option we are proposing is a Multi-Use Radio Service application. This option allows us to achieve the 5km data transmission range requirement over open-water. In addition, it only requires the use of a single major hardware element - a VHF MURS radio transceiver with an integrated modem. This option is less power-intensive than packet radio. Another factor contributing to this decision is that MURS frequency bands (151-154 MHz) are unlicensed, so an amateur radio license is not required.

To select a suitable radio transceiver, the team performed some quick calculations to determine the receive sensitivity required to achieve the desired transmission range (5km). From the Friis Transmission Equation:

$$P_r = P_t + G_t + G_r + 20log(\frac{\lambda}{4\pi R})$$

$$P_r = 27dBm + 6dBi + 6dBi + 20log(\frac{1.96m}{4\pi 5000m}) = -51.12dBm$$

In the above equation, a transmission power of 0.5W was assumed over a maximum distance of 5km, with receive and transmit antenna gains of 6dB over isotropic. The wavelength, λ, based on a frequency in the 151-154MHz MURS band. We see that our receiver must have a sensitivity of -51.12dBm to transmit over this range with these antennas. The RV-M3-M module has a receive sensitivity of -117dBm, so it is suitable. In addition, it is capable of transmitting at a higher power if we desire, but we want mindful of power consumption.

2.5 Propulsion Sytem

For the AWQuSam a jet drive type system is better suited for the task since the environment in which it would be operating is very shallow sometimes even with exposed surfaces. Conventional propeller driven systems require some depth for them to function properly. Also a Propeller driven system has the possibility of accumulating weeds and debrie on the propeller which could slow down a mission or even completly stall it. The jet drive system design will incorporate a water pump designed for “semi trash” use which means it can handle water with debris and foreign objects in it.

3 Proposed Design

3.1 Overview

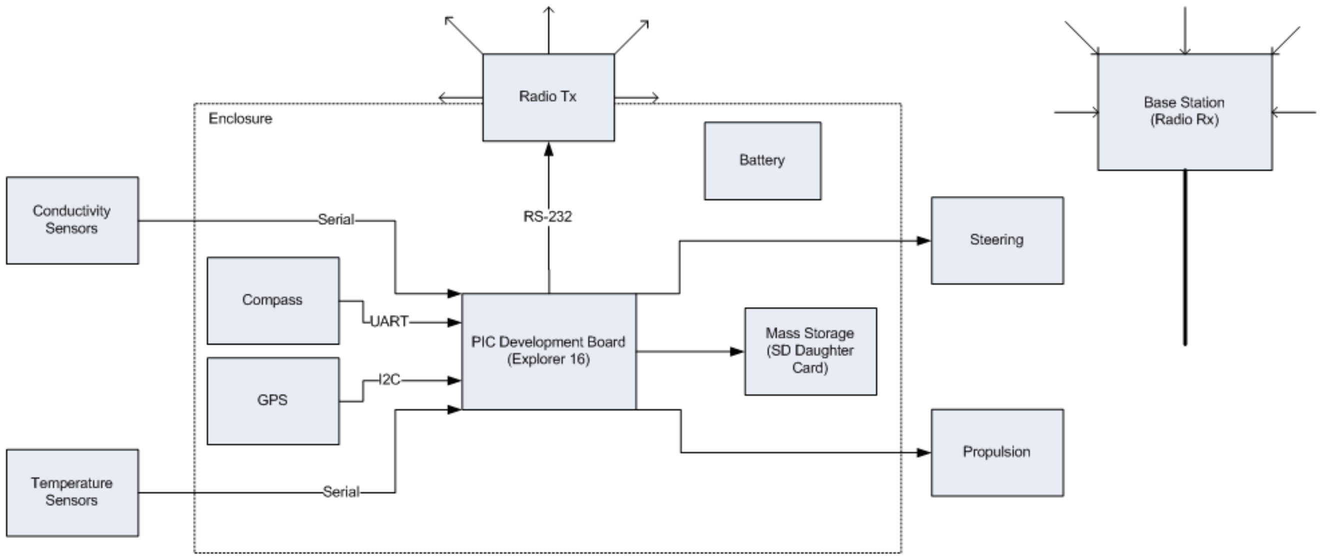

Figure1: Top-level block diagram of AWQuSam system

As Figure1 details, the AWQuSam will revolve around a microcontroller development board. It will receive inputs from conductivity and temperature sensors. This information will be logged to our mass storage device (SD memory card). Data from the GPS module and compass will be used to drive the AWQuSam's propulsion and steering system. All critical hardware will be enclosed in a water-tight enclosure to ensure the final design satisfies operating environment requirements. The following sections will discuss individual modules in greater detail.

3.1.1 Conductivity Sensor

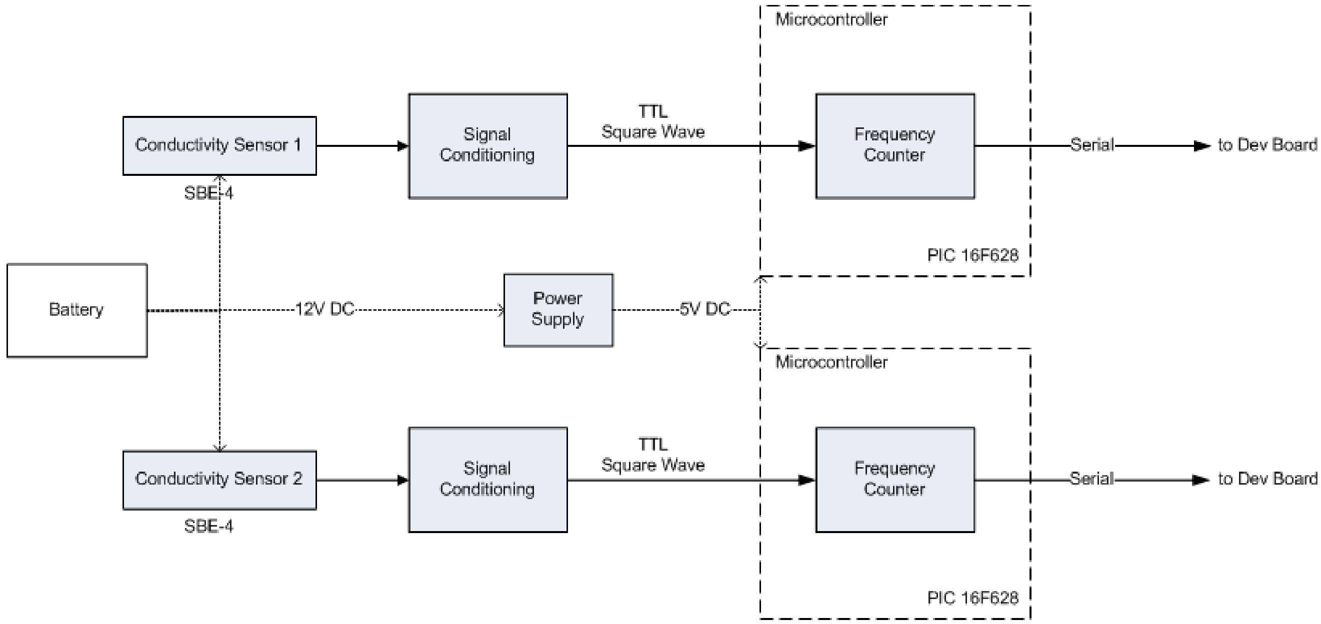

Figure2: Conductivity Sensors Block Diagram

Conductivity data will be gathered from two conductivity sensors (SBE-4). One conductivity sensor will be placed at the surface of the water, and the other will be placed six inches below the first sensor. The conductivity sensor devices output a variable frequency signal that corresponds to the conductivity. This signal will be conditioned to produce a TTL level square-wave signal of the same frequency. This conditioned signal will serve as an input to a microcontroller. The microcontroller will serve as a frequency counter and output the frequency via RS-232. The relationship between the frequency output and the conductivity is known, so the microcontroller can then perform additional processing of the signal.

3.1.2 Temperature Sensors

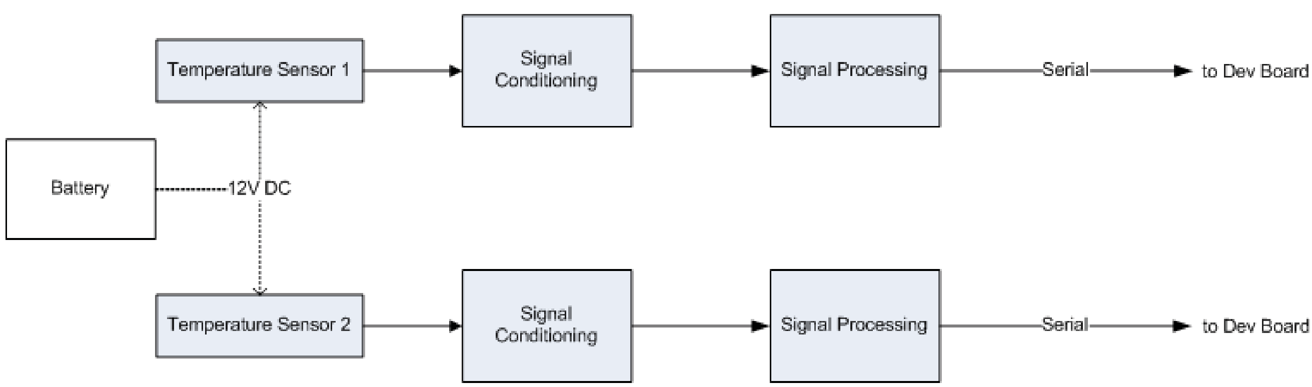

Figure3: Temperature Sensors Block Diagram

Temperature data will be gathered from two temperature sensors. One temperature sensor will be placed at the surface of the water, and the other will be placed six inches below the first sensor. The output of the temperature sensor will be conditioned as required. This signal will be analyzed to produce a corresponding output temperature for use by the development board.

3.1.3 Radio Tx

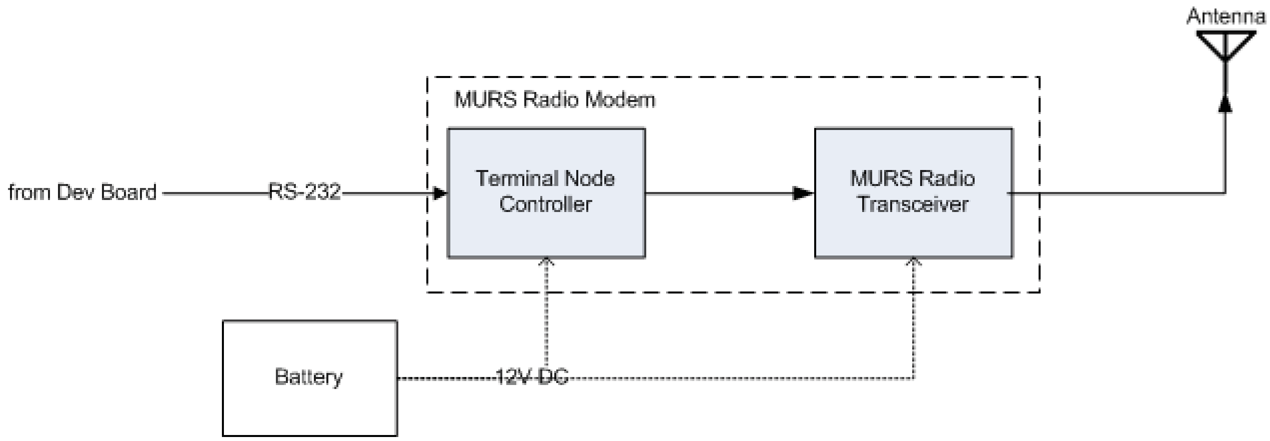

Figure4: Radio Transmit Block Diagram

Periodic samples of data (conductivity, temperature, position) are to be transmitted for real-time analysis. Our proposed design is to use a Multi-Use Radio Service system for communicating samples of obtained data. Every five minutes, data will be relayed from a serial output on the development board. This information will pass through a terminal node controller (TNC) where it will be modulated into audio signals for transmission by the radio. The TNC will also compute a checksum (CRC) to be used by the base station receiver. The proposed design includes a 1200 bps serial connection and data transmission on a 151-154Mhz frequency band. The transmitter antenna shall be removable to satisfy storage requirements.

3.1.4 Base Station

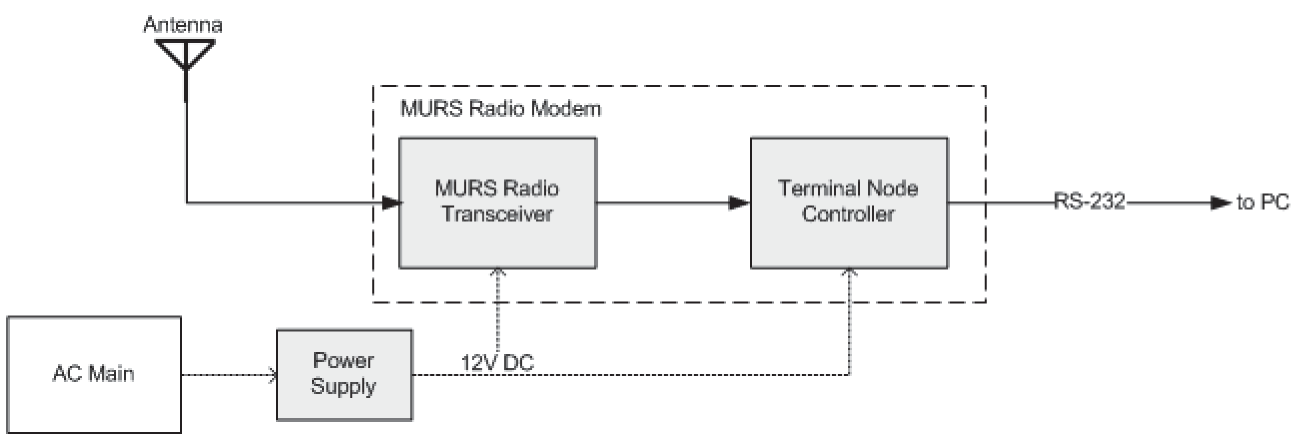

Figure5: Base Station Radio Receiver Block Diagram

The base station will receive samples of data (conductivity, temperature, position) transmitted by the AWQuSam. We will utilize a packet radio system. A VHF MURS radio transceiver will receive data from the AWQuSam on a 151-154Mhz. This audio signal will be demodulated, the data unformatted, and the output will be sent to a terminal on an analysis PC for display. When a packet is received, the TNC will perform error detection. The serial byte stream will be sent to the PC only if the message is correct.

3.1.5 Housing

The housing will enclose all the electronic and mechanical components but allow for easy access. It will provide the buoyancy for the AWQuSam even if it capsizes therefore it should displace more volume of water than the entire weight of the craft. It should be water tight where the electronic components are to avoid them being damaged if it capsizes. The housing will be engineered to be hydrodynamic for it to be as energy efficient as possible. It shall be light so that its weight won't be counter to our required buoyancy.

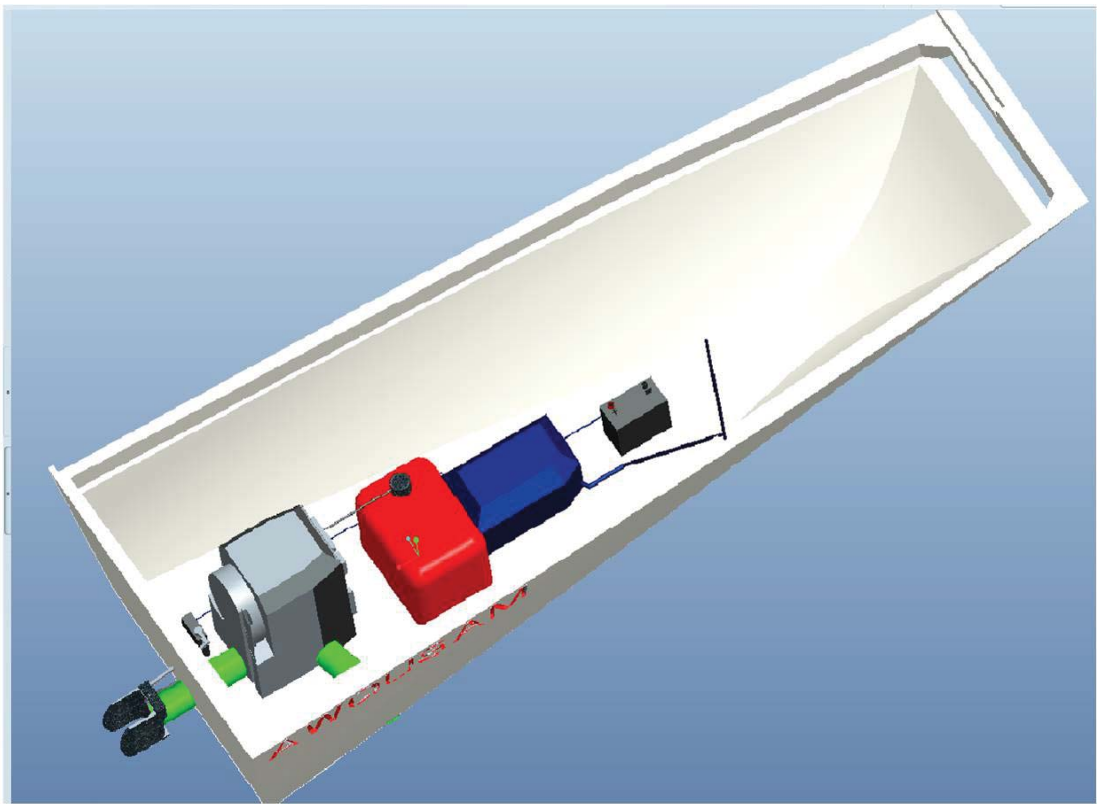

Figure 6: Prototype isometric view: white hull represents housing potentially made out of aluminum.

We considered two possible designs for the hull: (1) V-hull to help cut through the waves; (2) Flat-bottom to maximize shallow draft. We propose a hybrid of the two designs, as illustrated in Figure7.

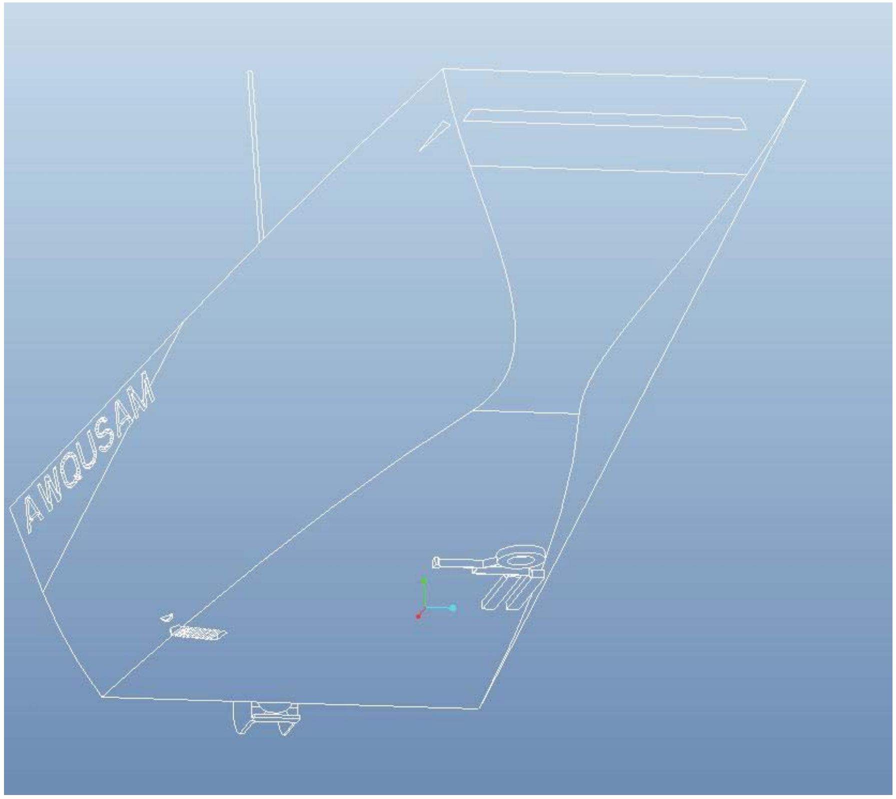

Figure7: Concept hull design: hybrid flat and v-hull shape. Notice under water sensors (right) and screened water inlet (left).

The AWQuSam is designed to move in shallow water so most of the volume should be above the surface. The walls of the craft will be high to prevent large amounts of water to enter the deck yet any opportunity will be taken to minimize the effects of side wind drag.

The hull is designed to be made of thin aluminum sheets cut to specification and arranged around an aluminum frame. Seams will be welded together to ensure water tightness and structural rigidity. If this proof to be difficult to engineer or too expensive we will contemplate on the idea of buying an existing small "jon boat".

Any protrusions made on the hull for sensors, wires, antennas, steering linkages, etc... should be sealed with marine sealant and appropriate couplings.

3.1.6 Propulsion System

The propulsion system for the AWQuSam is designed to allow for effective movement around shallow and turbulent waters. It will be powerful enough to move against currents of up to 5 knots. It will be programmable and have varying speeds depending on environmental conditions. The propulsion system will provide enough power for at least 9 hours of continuous use.

The propulsion system will be modeled as a water jet drive using a gas-powered water pump typically used in applications where high volumes of water need to be removed such as draining a pool. This will allow for the propulsion system to be almost completely above water providing effective propulsion in shallow waters. The system works similarly to a jet ski in that it will take water from an inlet and accelerate through a nozzle under pressure and shoot it out producing thrust.

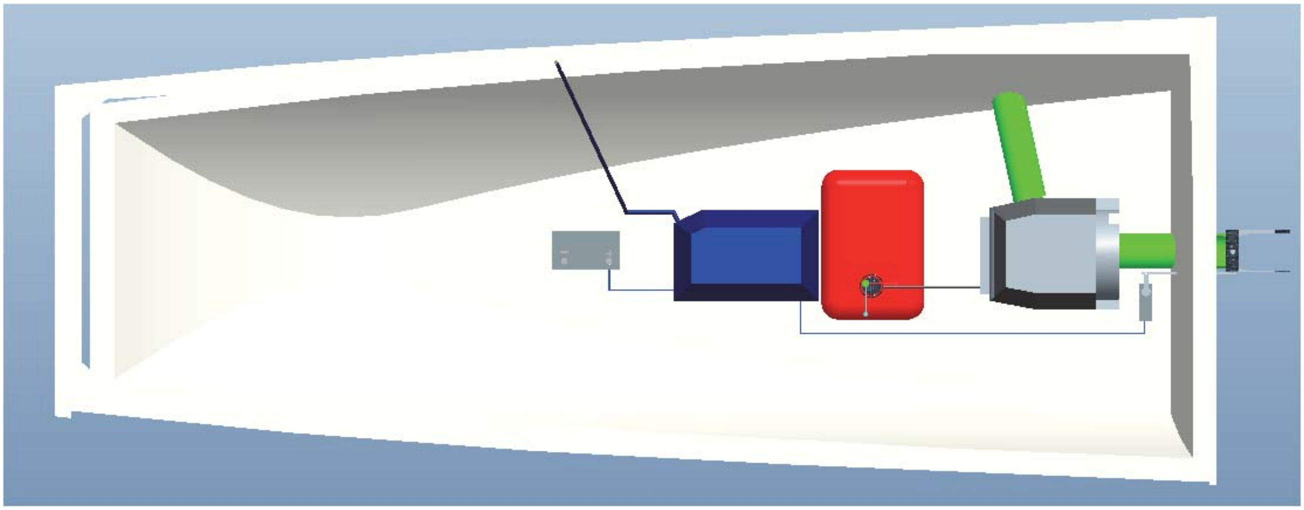

Figure8: Prototype top view: (1) right metallic box represents water pump jet drive; (2) green tubes represents inlet and outlet hoses.

In order to control the propulsion a servo motor needs to be connected to the throttle. This is required to increase and decrease speed as well as completely shutting down the motor. Depending on the water pump we purchase and its specs we might need to add a second servo motor to manage the "kill switch".

Based on the research we have done the design will require a 5 gallon gas tank connected to the water pump to fulfill the required run time. The water pump gas engine has an internal fuel tank but is gravity fed. To ensure that it remains full a small fuel pump will turn on intermittently to transfer fuel from the external fuel tank to the internal fuel tank of the water pump. This rate will be based on the averaged fuel consumption. Another option is to have it connected to the microcontroller and have it to work on a rate based on speed to fuel rate consumption.

3.1.7 Steering System

The steering for the AWQuSam is essential for its navigations. Its designed to keep the AWQuSam on track regardless of environmental conditions like currents or side winds. It will be mechanically tough so that it will not suffer any damage from choppy waves. It will allow for the nozzle to turn 30-40 degreess from the normal axis.

The steering will be controlled by a servo motor connected to the microcontroller on the main development board and will correct itself as a function of how far it deviates from the path. The nozzle will be turned by a mechanical arm linkage which runs through the transom wall on the back of the boat. Since the linkage arm runs through the transom wall and will be close to or below the water level we must ensure this enclosure is water tight yet still allows the arm to move accordingly.

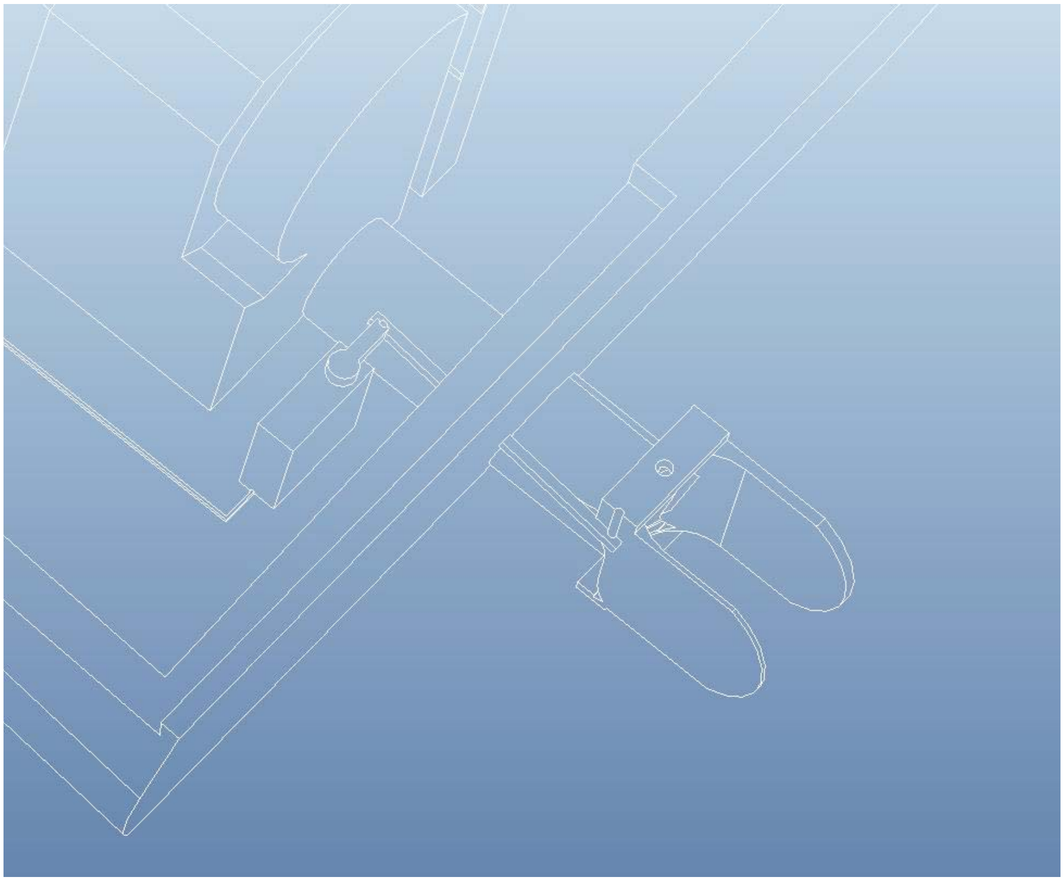

Figure9: Steering System: shown above the servo motor,linkage arm and swiveling steering nozzle mounted to the outlet tube.

4 Statement of Work (SOW)

4.1 Task 1: Project Management

Responsible Engineer: Brad Wells

Brad Wells, Project Manager, has developed a project schedule (See Section 7). Important engineering milestones have been identified. The team will hold weekly meetings to check status of the project and to verify appropriate progress has been made each week. During each meeting, the team will update an action-item register to track tasks at the present stage of the design. Also, at each meeting, the team will update a risk register to track existing risks and identify new risks. Mitigation plans for each risk will be developed.

4.2 Task 2: Preliminary Design & Development

4.2.1 Objectives

Design and develop all individual subsystems and modules necessary to satisfy design requirements and specifications.

4.2.2 Approach

4.2.2.1 Subtask 2.1: Identify / Procure Design & Analysis Tools

4.2.2.1.1 Objectives

Identify major components to be used in the final product design.
Procure design and analysis tools and begin to familiarize the team with said tools.

4.2.2.1.2 Approach

The team will identify, in detail, the components required to satisfy the requirements of the final system. Long lead items will be purchased first. At this time, the team will also procure any design & analysis software and tools deemed necessary for completion of the project. Once these tools are received, the team will familiarize themselves with the tools.

Engineer responsible for procuring items: Steven Golemme (Treasurer)

4.2.2.1.3 Test/Verification Plan

Inventory all received design software and tools. Inventory all analysis software and tools. Verify all design and analysis tools have been received. Ensure a firm understanding of the tools to be used for design and analysis of the AWQuSam system. Also, ensure a firm understanding of any new concepts to be deployed on this effort.

4.2.2.1.4 Outcomes of Task

Long-lead items will be ordered prior to completion of this task. Also, completion of this task will result in the team being familiar with all design and analysis tools and software. Members of the team will be proficient in the tools required to design and analyze the AWQuSam system. This will allow for more efficient product design.

4.2.2.2 Subtask 2.2: Design & Implement Propulsion Subsystem

4.2.2.2.1 Objectives

To intelligently make purchasing decisions considering our limited budget.
To measure and weigh the system in order to design an adequate housing.
To test the propulsion system and adequately integrate it to the device.
To integrate the throttle-servo to the microcontroller.
To calibrate the throttle to speed.
To ensure reliable long term engine runs.
To identify fuel consumption rate.
To incorporate the method of the refueling of the internal tank using a small external tank fuel pump and control system.
To identify every other possible factors of malfunction like overheating or inopportune engine shutdown due to choppy conditions, etc...

4.2.2.2.2 Approach

Responsible Engineers: Carlos Sanchez (ME), Juan Garcia de Paredes (ME)

Step 1: Purchasing a gas driven water pump as well as piping.
Step 2: Measure and weigh all the components involved in the normal operations of the pump.
Step 3: Test the normal operations of the pump for long periods of operation. Record fuel consumptions and any unexpected mishaps
Step 4: Envision attachment mechanism to aluminum frame.
Step 5: Attach the pump, fittings, and hoses to the housing.
Step 6: Test the pump as a water jet drive. Measure variable speeds. Use placebo weights for other components of the system
Step 7: Test the pump with different-diameter nozzles and record results.
Step 8: Connect steering system with propulsion system and use remote control (only for field testing purposes) to maneuver the craft.
Step 9: Incorporate external fuel tank and small fuel pump to the system.

4.2.2.2.3 Test/Verification Plan

Step 1: Purchasing a gas driven water pump as well as piping.
Assess all options in the market.
Balance performance with price of product.
Basic calculations of expected performance.

Step 2: Measure and weigh all the components involved in the normal operations of the pump.
Measure all the components of the system using tape measurers, photographs,

and a scale.

Step 3: Test the normal operations of the pump for long periods of operation.
Test the gas powered water pump in a local pool during peak hours of sunlight.
Look for any unexpected mishaps.
Record fuel consumption rates and use measurements to calibrate small fuel pump.

Step 4: Envision attachment mechanism to aluminum frame.
Using a CAD software to design an adequate attachment to the housing
Estimate cost of bolts and fittings.
Make purchase.

Step 5: Attach the pump, fittings, and hoses to the housing.
Safely and securely attach the engine to the housing.
Test the strength of the attachment by modeling normal operating conditions
Use a pressure gauge to record pressure and calculate thrust

Step 6: Test the pump as a water jet drive.
Implement remote control capabilities to the throttle just for field testing.
Test the jet drive in a local lake or even a pool for moderate periods of time.
Measure variable speeds versus throttle.
Use placebo weights to model the other components of the system
Use results to calibrate with development board.

Step 7: Test the pump with different-diameter nozzles and record results.
Design different size and shape nozzles.
Test the different options and record results of speed, overheating, and performance.

Step 8: Connect steering system with propulsion system
Use remote control (only for field testing purposes) to control the steering.
Measure the minimum turning radius.
Use results to calibrate with development board.

Step 9: Incorporate External Fuel tank
Design and attach the external fuel tank to the hull.
Use fuel consumption rates to determine the rate of work of the small fuel pump.
Incorporate small fuel pump to the system and test its performance.
Calibrate accordingly.

4.2.2.2.4 Outcomes of Task

Verify the validity of using a water pump as a jet drive for the AWQuSam
Give us feedback on the actual performance of the propulsion system.
Identify any unexpected problems with the center of balance, problems with housing and actual speed of craft and hopefully give us an idea on how to fix it.

4.2.2.3 Subtask 2.3: Design & Implement Steering Subsystem

4.2.2.3.1 Objectives

To assess the type of servo motor necessary to turn the nozzle accordingly.
To make an intelligent purchase of all subsystem components.
To calibrate the angle of the servo arm with steering intensity.
To integrate the steering subsystem into the housing.
To ensure that the mechanical arm linakage that runs through the housing wall does not allow water to come in.
To design a mechanical linakge arm that connects the servo motor and nozzle.
To design a steering subsystem capable of making steering adjustments based on received commands from the Explorer16 Board.
To design a deflecting nozzle that fits onto the exit pipe and is clutter free.

4.2.2.3.2 Approach

Responsible Engineer: Juan Garcia (ME)

Step 1: Using CAD and other techniques to design the arm linkage between the servo motor and the nozzle.
Step 2: Make purchases.
Step 3: Build the set up and get ready for testing.
Step 4: To calibrate the angle of the servo motor with steering intensity in lab.
Step 5: Test prototype in real conditions (i.e. a pool/lake) using remote control.
Step 6: Test prototype in rougher waters using remote control.
Step 7: Integrate subsystem with development board.
Step 8: Test prototype in real-world operating conditions.

4.2.2.3.3 Test/Verification Plan

Step 1: Using CAD and other techniques to design the arm linkage between the servo motor and the nozzle.
Transform preliminary design of craft into prototype using accurate dimensions.
Assess different types of mechanical arrangements for the linkage mechanism.
Do simple hand calculations to identify the external stresses applied to the linkage.
Design prototype subsystem with dimensions.

Step 2: Make purchases.
Identify the necessary materials to use for building.
Identify the dimensions and power of the required servo motor.
Research the available options in the market.

Balance the economic and mechanical characteristics of every option.
Make purchase.

Step 3: Build the set up and get ready for testing.
Mount the servo and components into the housing of the AWQuSam.
Check for any leaks inside the hull.

Step 4: To calibrate the angle of the servo motor with steering intensity in lab.
Set up AWQuSam in the lab and see how different voltages sent out to the servo motor corrolates to steering nozzle angles.
Identify if high levels of flowing water going through the nozzle while trying to steer will affect steering.

Step 5: Test prototype in real conditions (i.e. a pool/lake) using remote control.
Install remote control components into AWQuSam soley for testing purposes. i.e. reciever, battery, antenna and servos.
Test ensemble and make necessary arrangements.

Step 6: Test prototype in rougher waters using remote control.
In real world setting such as a lake or the Appalachicola Bay itself run the AWQuSam by remote control to test the effectiveness of the steering system.
Assess the effects of main environmental conditions like currents and side winds.
Make corrections if necessary.

Step 7: Integrate subsystem with PIC development board.
Attach servo motor connections to PIC output ports and make sure they can interact flawlessly

Step 8: Test prototype in real-world operating conditions
In real world setting such as a lake or the Appalachicola Bay itself run the

Verify the effectiveness of the steering subsystem in such conditions.
Make corrections if necessary.

4.2.2.3.4 Outcomes of Task

Identify the validity of our mechanical arm linkage design.
Assess the performance of the servo motor.
Give us ideas on how to correct design if necessary.
Test the effects of the environmental conditions.

4.2.2.4 Subtask 2.4: Design & Implement Mechanical Housings

4.2.2.4.1 Objectives

To design a housing suitable to meet all the requirements imposed by the customer and all the subsystems.
To build a prototype of housing necessary to test device.
To test the performance of the housing in water.

4.2.2.4.2 Approach

Responsible Engineer: Carlos Sanchez (ME)

Step 1: Design a valid housing that satisfies all engineering needs.
Step 2: Make purchase of components.
Step 3: Assemble housing frame.
Step 4: Assemble covering sheets.
Step 5: Test housing in water and look for leaks.
Step 6: Test buoyancy of housing using placebo weights for all system components.
Step 7: Integrate all mechanical components into system.
Step 8: Test buoyancy and water-tightness of prototype.

4.2.2.4.3 Test/Verification Plan

Step 1: Design a valid housing that satisfies all engineering needs.
Using all known and estimated weights of all componets make hand calculations to design the desired strength of materials and amount of volume of water to be displaced.
Make hand drawings of possible designs.
Find the center of gravity and stability of design using either hand calculations or a CAD software.
Make engineering drawings of housing prototype.

Step 2: Make purchase of components.
Research the possible type of materials and their market value.
Make intelligent purchase balancing economics and properties.

Step 3: Assemble housing frame.
Build the frame in the ME shop of the FAMU-FSU College of Engineering.
Test the strength and rigidity of design applying small axial and torsional loads.

Step 4: Assemble covering sheets.
Assemble sheets on top of frame in the ME shop of the FAMU-FSU College of Engineering.
Test strength and rigidity.
Close all potential water leaks with sealant.

Step 5: Test housing in water and look for leaks.
Insert entire housing in a body of water (i.e. a pool or a lake) and test for leaks.
Add more sealant if necessary.

Step 6: Test buoyancy of housing using placebo weights for all system components.
Insert entire housing in a body of water (i.e. a pool or a lake) and test for buoyancy.
Test the stability of prototype in regular operating conditions.
Look for potential sources of instability.
Make corrections if necessary.

Step 7: Integrate all mechanical components into system.
Integrate propulsion and steering subsystem and keep placebo weights for other components.
Implement remote control operation.

Step 8: Test buoyancy and water-tightness of prototype.
Test prototype in real-world operating conditions using remote control.
Test for speed, stability, turning radius, and leaks.

4.2.2.4.4 Outcomes of Task

Test the validity of housing design.
Compare actual performance with expected performance.
Analyze the sources of instability and hopefully help to correct.

4.2.2.5 Subtask 2.5: Design & Implement Navigation Subsystem

4.2.2.5.1 Objectives

To design a navigation system dependent on path-planning techniques which will support autonomous mobility in the AWQuSam.
To integrate a digital compass into the navigation system to provide directional perception.
Develop motion planning strategies capable of maintaining closed loop control of the AWQuSam's propulsion system speed and steering along a pre-planned route.
Develop obstacle detection and reactive vehicle control strategies to enable AWQuSam to react to data and obstacles in real-time.
Develop mission planning strategies in charge of utilizing global positioning system and digital compass to determine intermediate waypoints necessary to complete mission.
Develop system monitoring strategies which monitor and report system health back to base station in real-time.

4.2.2.5.2 Approach

Responsible Engineer: Triesha Fagan

1. Purchase components necessary for navigation: Explorer16 Development Board, Global Positioning System, (GPS), Digital Compass, DataLogger.
   a. GPS will be capable of updating its position at a minimum rate of 1 Hz, and

have an omni-directional design.
b. Digital Compass, at a minimum, will be capable of detecting its orientation in a two-axis field.
c. Datalogger's memory capacity will be significantly large enough to accept input data from GPS and Digital Compass

2. Ensure that microcontroller is compatible with each external components interface.
3. Integrate all components with microcontroller.
4. Program GPS and digital compass to operate in-sync/on the same clock frequency.
5. Program GPS and digital compass to have similar update frequencies.
6. Program Datalogger to accept and store GPS and Digital Compass data in parallel.
7. Understand input logic for steering servo and speed controller.
8. Develop conversion chart/truth table for steering servo and speed controller, dependent on GPS and Digital Compass data.
9. Design a mission planning algorithm which allows AWQuSam to follow any arbitrary path with several goal markers which are given in an input data file.
10. Design a motion planning algorithm which maintains control of the steering and speed components of the propulsion system during mission.
11. Design system monitoring algorithm for failure in GPS, Digital Compass or Battery Level.

4.2.2.5.3 Test/Verification Plan

GPS/Digital Compass/Datalogger

Step 1: Integrate GPS and Digital Compass onto a simple TI Microcontroller.
Step 2: Integrate a simple datalogger onto microcontroller
Step 3: In order to decrease error, program datalogger to provide time data in parallel with
data collected from GPS and Digital Compass.
Step 4: Perform multiple test runs with GPS and Digital Compass.
Step 5: Compare GPS and Digital Compass data in real-time.
Step 6: Overlay a map with acquired GPS and Digital Compass to conduct an error analysis.
Step 7: Test endurance of components and SD card capacity my mounting components in
a vehicle for 10 hours. After 10 hr. duration, record state of components.

Mission Planning Algorithm

Step 1: After designing Motion Planning algorithm, implement algorithm in Simulink to test for complete coverage of mission planning strategy to ensure that AWQuSam can navigate the pre-planned route while being effected by forces (i.e wind, and waves). Algorithm should also also be able to perform reactive measures to get to its next waypoint, whenever it is pushed away from its pre-planned route.

Step 2: Once algorithm is verified, algorithm should be translated into a language compatible with the microcontroller. The same tests that were performed on the Simulink model should be performed on the microcontroller.

Step 3: Ensure that results from the microcontroller, matches the results from Simulink.

Motion Planning Algorithm

Step 1: After designing Motion Planning algorithm, implement algorithm in Simulink to test for complete coverage of motion planning strategy to ensure that AWQuSam can control the orientation of the steering servo and speed controller in order to navigate the pre-planned route and complete its mission.

Step 2: Once algorithm is verified, algorithm should be translated into a language compatible with the microcontroller. The same tests that were performed on the Simulink model should be performed on the microcontroller.

Step 3: Ensure that results from the microcontroller, matches the results from Simulink.

4.2.2.5.4 Outcomes of Task

Upon completion of task, AWQuSam will have an autonomous navigation system dependent on GPS coordinates and it's orientation with respect to the Earth's poles. The navigation system will also have control over the steering and speed of its propulsion system.

4.2.2.6 Subtask 2.6: Design & Implement Data Acquisition Subsystem

4.2.2.6.1 Objectives

Design a data acquisition system capable of retrieving precise underwater temperature and conductivity information at a rate of at least 8 samples per second.

4.2.2.6.2 Approach

Responsible Engineers: Francisco Schroeder (ECE), Brad Wells (EE)

Conductivity data will be gathered from two conductivity sensors (SBE-4). One conductivity sensor will be placed at the surface of the water, and the other will be placed six inches below the first sensor. The conductivity sensor devices output a variable frequency signal corresponding to the conductivity. We shall perform any necessary signal conditioning on the frequency outputs of the sensors. Upon doing this, we shall design frequency counters for each signal using a separate microcontroller. The relationship between the frequency output and the conductivity is known, so we shall, then, output the frequencies via RS-232 to the main development board for additional processing by that subsystem.

Similarly, temperature data will be gathered from two temperature sensors. One temperature sensor will be placed at the surface of the water, and the other will be placed six inches below the first sensor. At this time, the particular temperature sensors to be used have not been identified. Once this determination is made, appropriate signal conditioning and signal analysis will be performed. The output of this processing will be passed to the main development board in a manner similar to that outlined for conductivity data.

4.2.2.6.3 Test/Verification Plan

The interface with the conductivity sensor, after signal conditioning, will be tested using an oscilloscope. The conductivity sensor will be placed in a solution of known conductivity, and the output frequency will be monitored. A manual calculation of the conductivity based on the frequencies before and after signal conditioning will be performed to ensure the device is calibrated properly and that our signal conditioning circuitry does not adversely affect the desired outcome.

Next, the frequency counters will be tested by inputting a square-wave signal of known frequency into the microprocessor. A signal generator will be used for this test. The microcontroller's RS-232 output will be interfaced with a Linux terminal to ensure the output frequency count matches that of the input frequency.

4.2.2.6.4 Outcomes of Task

Upon completion of the data acquisition subsystem, the primary development board will have access to information related to the temperature and conductivity for use in its data logging subsystem.

4.2.2.7 Subtask 2.7: Design & Implement Data Logging Subsystem

4.2.2.7.1 Objectives

Design a data logging subsystem capable of recording all acquired data to a SD card for use by oceanographic researchers.

4.2.2.7.2 Approach

Responsible Engineer: Francisco Schroeder (ECE)

First, early experiments will be conducted to determine how to write to the SD card from our embedded code. The team will, then, identify the capacity of the SD card required to record eight samples per second for up to twelve hours from each of: two (2) conductivity sensors, two (2) temperature sensors, and one (1) GPS module as plain text comma-separated values.
Software code will be written to write to the SD card.

4.2.2.7.3 Test/Verification Plan

The team will develop test code to write sample data to an SD card to simulate writing eight samples per second from each of: two (2) conductivity sensors, two (2) temperature sensors, and one (1) GPS module. This data will continue to be written for

30 minutes. The written data will then be scaled to 12 hours worth of data to ensure the SD card can hold all acquired data for a 12-hour mission.

The SD card will be placed in a Windows PC to ensure the data can be read from the card via a text-editor. Next, the SD card will be placed in a Linux PC to ensure the data can be read from the card via a text-editor.

4.2.2.7.4 Outcomes of Task

Upon completion of this task, a subsystem capable of writing to an SD card will be developed. This subsystem will be ready for integration with the data acquisition subsystem.

4.2.2.8 Subtask 2.8: Design & Implement Data Transmission Subsystem

4.2.2.8.1 Objectives

Design a data transmission subsystem capable of transmitting samples of data to a base station receiver every 5 minutes. The system shall be capable of transmitting over a distance of 5km.

4.2.2.8.2 Approach

Responsible Engineers: Triesha Fagan (EE), Steven Golemme (CpE)

1. Procure VHF MURS Radio Modem, Antenna
2. Design cable for connecting development board to radio modem.
3. Conduct early experiments to determine most effective method of using the PIC's RS-232 output as dumb terminal.
4. Ensure parameters of the radio modem and PIC microcontroller agree.
5. Design power supply compatible with mobile VHF radio.
6. Configure radio transceiver to transmit over desirable carrier frequency.
7. Configure radio modem to use Packet Mode
8. Implement power management features to minimize power consumption while idle.
9. Obtain FCC certification of end-product

4.2.2.8.3 Test/Verification Plan

1. Write sample data to PIC's RS-232 output connected to radio modem.
2. Verify TNC modulates bit stream into audio signal.
3. Verify radio transmits signal over desirable frequency.
   a. If radio does not transmit, place modem into Command Mode and verify settings
4. Observe power requirements during transmission and while idle.

4.2.2.8.4 Outcomes of Task

Upon completion of this task, a system will be developed that can be used to transmit periodic samples of data over the air. This VHF signal will be used by the base station receiver.

4.2.2.9 Subtask 2.9: Design & Implement Base Station Receiver

4.2.2.9.1 Objectives

Design a base station receiver capable of retrieving samples transmitted by the AWQuSam.

4.2.2.9.2 Approach

Responsible Engineers: Triesha Fagan (EE), Steven Golemme (CpE)

1. Identify antenna requirements.
   a. Be mindful of FCC restrictions for MURS operation
2. Construct MURS base station antenna with ground plane, mounted on mast.
3. Design cable for interfacing computer terminal and radio modem.
4. Configure radio transceiver to listen to desired carrier frequency.
5. Develop application to monitor serial port

4.2.2.9.3 Test/Verification Plan

1. Ensure VHF radio receives audio signals transmitted over VHF channel.
2. Open terminal and listen to serial port to which radio modem is connected.
3. Verify radio modem demodulates and decodes audio signal. Ensure error detection techniques are implemented.
4. Observe messages appearing at computer terminal.
5. Obtain FCC certification of end-product.

4.2.2.9.4 Outcomes of Task

Upon completion of this task, a radio receiver will be developed that can be used to decode transmitted data. This data can be displayed on a computer terminal in an easy to read format.
The base station receiver will be ready for integration with the AWQuSam data transmitter.

4.2.2.10 Subtask 2.10: Design & Implement User Interface

4.2.2.10.1 Objectives

Design a user interface that allows the end-user to program paths into the AWQuSam using GPS coordinates of waypoints and final destination.

4.2.2.10.2 Approach

Responsible Engineer: Steven Golemme (CpE)

1. Interface development board with keypad and LCD display.

2. Incorporate key combination for entering "Program Mode"
3. Develop code to facilitate programming AWQuSam using keypad.
    a. Prompts will be displayed on LCD display as indicated below:

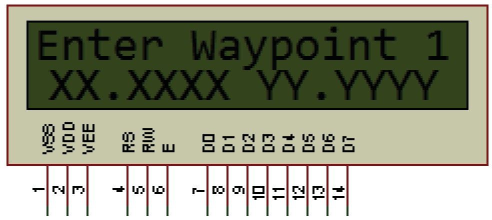

Figure10: Sample Programming Screen. Input will be via keypad

    b. Pressing a certain key will allow user to add another waypoint.
    c. Pressing a different key will allow user to finish adding waypoints.
4. Documentation shall be developed with instructions for programming AWQuSam

4.2.2.10.3 Test/Verification Plan

1. Verify AWQuSam can be placed in a "Program Mode."
2. Verify LCD prompts are clear and concise.
3. Verify keypad can be used to program AWQuSam.
4. Utilizing only the instructions developed, ensure an untrained user can program new mission paths into the AWQuSam.

4.2.2.10.4 Outcomes of Task

Upon completion of this task, the AWQuSam will have a user interface that allows for on-the-fly programming of new mission paths using GPS coordinates of waypoints.

4.2.3 Test/Verification Plan

All subsystems shall function according to their respective test/verification plans.

4.2.4 Outcomes of Task

Upon completion of this task (including all subtasks), subsystems will be ready for the next phase of the project-- product integration.

4.3 Task 3: Product Integration

4.3.1 Objectives

Integrate all subsystems design during preliminary design and development phase (see section 4.2).

4.3.2 Approach

4.3.2.1 Subtask 3.1: Integrate Data Acquisition, Data Logging Subsystems

4.3.2.1.1 Objectives

Integrate Data Acquisition and Data Logging subsystems such that all information measured in the former is logged to a memory card via the latter.

4.3.2.1.2. Approach

Responsible Engineers: Francisco Schroeder (ECE), Brad Wells (EE)

The individual subsystems of this task have been tested and verified to function independently. Engineers will use temperature, conductivity, and GPS position as inputs to the previously designed data logging subsystem. This information will be recorded as plain-text comma separated values.

To facilitate more rapid processing of information, the frequency output (kHz) of the conductivity sensor will be logged. The analysis computer will perform the conductivity calculation-- a function of this frequency and the recorded temperature.

Time must be spent synchronizing data retrieved from sensors to ensure a given set of measurements is recorded at the same position

4.3.2.1.3 Test/Verification Plan

Write all data collected from each of: two (2) conductivity sensors, two (2) temperature sensors, and one (1) GPS module to an SD card. This data will continue to be written for 30 minutes. Verify each input has eight entries per second in the log.

4.3.2.1.4 Outcomes of Task

Completion of this task will result in a system capable of measuring and recording 8 samples per second of oceanographic data (conductivity, temperature, and position).

4.3.2.2 Subtask 3.2: Integrate Navigation, Propulsion, Steering Subsystems

4.3.2.2.1 Objectives

Data from GPS and compass shall be used to make adjustments to steering angle and propulsion.

4.3.2.2.2 Approach

Responsible Engineers: Triesha Fagan (EE), Juan Garcia (ME)

1. Periodically (as power constraints permit) process current heading and compare with the heading required to arrive at the current destination waypoint.
   a. If headings do not match, send signal to servo motor of steering subsystem to make appropriate adjustments to heading.

2. Compare GPS location and compare with the location of the current destination waypoint.
   a. If headings match, move onto next waypoint.

4.3.2.2.3 Test/Verification Plan

Program AWQuSam to navigate a path consisting of one waypoint and a final destination
Ensure AWQuSam navigates to the waypoint before arriving at final destination

4.3.2.2.4 Outcomes of Task

Upon completion of this task, the AWQuSam will be an autonomous vehicle, capable of navigating a programmed mission path.

4.3.2.3 Subtask 3.3: Integrate Data Transmission, Base Station Systems

4.3.2.3.1 Objectives

Integrate Data Transmission and Base Station Receiver subsystems such that data transmitted by the AWQuSam is received at a terminal on the base station computer.

4.3.2.3.2 Approach

Responsible Engineers: Steven Golemme (CpE), Francisco Schroeder (ECE)

1. Gain familiarity with control mode and command modes of the terminal node controller.
2. Establish point-to-point connection
   a. Configure radios to utilize the same RF channel
   b. Configure unit address of transmitting modem to match the unit address of the receiving modem
3. Send commands to base station receiver.

4.3.2.3.3 Test/Verification Plan

Verify packets sent from AWQuSam are received at base station terminal.
Place 5km between transceivers, and ensure messages are still received at the base station.

4.3.2.3.4 Outcomes of Task

Upon completion of this task, a data communication system will be established for relaying data from the AWQuSam to a base station receiver.

4.3.2.4 Subtask 3.4: Integrate Components in Mechanical Housing

4.3.2.4.1 Objectives

Integrate major components in mechanical housings.

4.3.2.4.2 Approach

Responsible Engineer: Carlos Sanchez

Place components in mechanical housing of AWQuSam. Ensure components fit snugly and are secured. Ensure enclosures designed to be water-tight remain water-tight when components are placed inside.

4.3.2.4.3 Test/Verification Plan

Verify components experience minimal movement in enclosures. Verify the same when placed on choppy waters. Verify there is zero water intrusion into water-tight containers when subjected to waves and rain.

4.3.2.4.4 Outcomes of Task

Upon completion of this task, all components will be securely housed in the AWQuSam. Following completion of this integration task, the AWQuSam will have its delivarable appearance suitable for the Apalachicola Bay operating environment.

4.3.3 Test/Verification Plan: Abbreviated System Testing

1. Verify all modules requiring communication with other modules are successfully integrated.
2. Verify all data acquired are logged to memory card at least eight times each second.
   a. Verify the AWQuSam measures and records position, water temperature, and water salinity.
3. Verify user interface allows for programming of new path routes.
4. Verify data from GPS and compass are used to drive propulsion and steering systems.
   a. Program the AWQuSam with starting point, one waypoint, and finishing point.
   b. Verify the AWQuSam successfully arrives at the finishing point.

4.3.4 Outcomes of Task

Upon completion of this task, core subsystems will be integrated. Each module requiring communication with other modules will be successfully integrated.

4.4 Task 4: Final Design Delivery

4.4.1 Objectives

Deliver an autonomous water quality sampler prototype that satisfies the requirements outlined by the customer. This prototype will be a useful research platform in the shallow waters of the Florida shelf.

4.4.2 Approach

4.4.2.1 Subtask 4.1: Contractor Verification Testing

4.4.2.1.1 Objectives

Ensure the AWQuSam satisfies all requirements outlined in the requirements specification.

4.4.2.1.2 Approach

Follow procedure outlined in 4.4.2.1.3.

4.4.2.1.3 Test/Verification Plan

4.4.2.1.3.1 Subtask 4.1.1: Operating Environment Requirements

Salt Atmosphere

The AWQuSam shall be subjected to the saline coastal atmosphere for 48 hours. Following exposure, all electrical connector covers, and any ancillary covers shall be opened or removed. Verify the AWQuSam does not show evidence of corrosion, erosion or pitting. Verify the AWQuSam completes a functional checkout.

Solar Radiation

The AWQuSam shall be subjected to not less than two (2) continuous diurnal cycles of solar radiation. The direction of the solar radiation shall be incident to the top of the AWQuSam in the normally installed orientation. Verify the AWQuSam passes a functional checkout during the peak cycle temperature and post-test.

Humidity

The AWQuSam shall be subjected to not less than two (2) three-hour cycles of exposure to humidity levels of 95 ±4%. During the first period of exposure, the AWQuSam shall be powered off. Perform a functional checkout at the end of that cycle. During the second period of exposure, the AWQuSam shall be powered on. Verify the AWQuSam passes a functional checkout following the cycle. Also, verify that no visual damage has occurred to the AWQuSam.

High Temperature

The AWQuSam shall be subjected to one 24-hour typical diurnal cycles with temperatures proportionally adjusted such that the lowest temperature shall be +25°C and the highest temperature shall be +55°C. During this test, the AWQuSam shall be in operating configuration and powered on. Following completion of this test, verify that the AWQuSam is still operating functionally.

Then, the AWQuSam shall be subjected to not less than two (2) 24-hour typical diurnal cycles with temperatures proportional adjusted such that the maximum temperature is 70°C. The AWQuSam shall be in storage configuration and powered off during this test. Following exposure to high temperature storage conditions, verify that no visual damage has occurred. Verify conformance with a post test functional checkout.

Low Temperature

The AWQuSam shall be subjected to one 24-hour typical diurnal cycles with temperatures proportionally adjusted such that the lowest temperature shall be -5°C and the highest temperature shall be +15°C. During this test, the AWQuSam shall be in operating configuration and powered on. Following completion of this test, verify that the AWQuSam is still operating functionally.

Then, the AWQuSam shall be subjected to not less than two (2) 24-hour typical nocturnal cycles with temperatures proportional adjusted such that the minimum temperature is -20°C. The AWQuSam shall be in storage configuration and powered off during this test. Following exposure to low temperature storage conditions, verify that no visual damage has occurred. Verify conformance with a post test functional checkout.

Rain and Water

Weigh the AWQuSam. Then, subject the AWQuSam to 30 minutes of rain falling at a rate of no less than 5cm/hr. The wind velocity for this test shall be 10 m/s. After the test, weigh the AWQuSam again. The weight shall remain unchanged ±0.1%. Verify the AWQuSam completes a functional checkout.

Water Immersion

Weigh the AWQuSam. Place the AWQuSam in operating conditions (with all seals sealed and connectors capped). Immerse AWQuSam in water such that the upper-most point is maintained at a depth of 1m beneath the surface of the water for 5s. Following immersion, verify the AWQuSam completes a functional checkout. Wait 24 hours and weigh the AWQuSam again. The weight shall remain unchanged ±0.1%. If water intrusion has occurred, the AWQuSam shall be opened to determine the probable point of water entry.

4.4.2.1.3.2 Subtask 4.1.2: Functional Requirements

Power on the AWQuSam. Program the AWQuSam with starting point, one waypoint, and finishing point. The length of the mission shall be no less than 10km.

Verify the AWQuSam successfully arrives at the finishing point and that the mission occurred at an average speed of no less than 5 knots. Upon arrival at finishing point, allow AWQuSam to keep recording data until the mission duration is twelve hours.

Verify the AWQuSam measures position, water temperature, and water salinity at a rate no slower than that outlined in Requirement 3.3.2.1.

Verify the AWQuSam records position, water temperature, and water salinity for the entire duration of the mission with precision outlined by Requirement 3.3.5.

Verify that one sample is transferred to a base station receiver approximately every 5 minutes. Also, verify that all recorded data is offloadable for analysis on an analysis computer.

4.4.2.1.3.3 Subtask 4.1.3: Performance Requirements

Stability

Place AWQuSam in water. While AWQuSam is operating, it shall be subjected to variable winds with maximum speed of 40 knots. AWQuSam shall not capsize. It should continue along its programmed course.

Buoyancy

The AWQuSam will be placed in salt water. The structure shall remain stable and on the surface at all times taking into account waves and currents.

4.4.2.1.3.4 Subtask 4.1.4: Structural Requirements

Weight

The AWQuSam will be put on a scale and weighed to ensure it is within the 18kg limit.

Size

The AWQuSam shall be measured with a measuring tape to ensure it does not exceed the following specifications:

Length: 1.2m
Width: 0.8m
Height: 0.5m (excluding antennas)

Transportability

Handles shall be subjected to rigorous testing to verify their strength.

Propulsion/Steering

Steering shall be tested in light currents similar to the ones experienced along Florida's Gulf coast.

The AWQuSam shall successfully navigate around two bouys that are 3m. apart.

Robustness

The structure of the AWQuSam and its joints shall be submitted to stress tests that are not yet specified.

Housing

Casing alone shall be tested by submerging in water 3m for 1 minute. Casing should remain water tight.

4.4.2.1.3 Outcomes of Task

Following completion of this task, findings will be ready for analysis to determine whether additional engineering work is required to satisfy requirements.

4.4.2.2 Subtask 4.2: Post-CVT Development

4.4.2.2.1 Objectives

Modify AWQuSam design to ensure it satisfies all requirements as outlined in customer's requirements specification.

4.4.2.2.2 Approach

Responsible Engineers: All

Analyze results of contractor verification testing. Determine findings as a result of failed tests. Address findings and implement changes driven by CVT.

4.4.2.2.3 Test/Verification Plan

If new design work was required, repeat Task 4.1: Contractor Verification Testing

4.4.2.2.4 Outcomes of Task

Following completion of this task, a design will be implemented that satisfies all requirements outline in Requirements Specification documentation. Product will be ready for delivery.

4.4.3 Test/Verification Plan

Contractor Verification Testing (See section: 4.4.2.1)

4.4.4 Outcomes of Task

Upon completion of this task, a prototype AWQuSam will be delivered. This vessel will be capable of navigating a programmed mission path, recording water conductivity and water temperature data along the way.

4.5 Documentation

The AWQuSam will be delivered with documentation detailing instructions for programming new paths and for establishing a connection between the AWQuSam and the Base Station. Documentation will also be provided with instructions for performing maintenance and for servicing the system or components.

In addition to the aforementioned documentation, a final design review will be delivered. This document will include all engineering design work (drawings, schematics, bill of materials) required to build additional AWQuSam prototypes.

5 Risk Assessment

ID	Risk Item	Probability	Impact	Mitigation Plan
1	Temperature Sensors - Identifying a sensor that satisfies precision requirements, sampling frequency capabilities, and also budget constraints introduces a risk.	High	Medium	The team is prepared to discuss with customer relaxing precision requirements from 0.01°C to 0.1°C.
2	GPS - Rapid response GPS sensor only outputs 4 sample per second. We are required to log 8 samples/second.	High	Low	We will assume straight-line travel between GPS reports and interpolate intermediary position reports.
3	Power - Combustion of liquid fuel may alter sampled temperature data.	Medium	Low	Sensors will be placed forward of engine to reduce thermal contamination.
4	Antenna - MURS antennas can be difficult to obtain.	Medium	Medium	Data Transmission and Base Station design and development are later in the project schedule in order to accommodate any delays.
5	Radio - Selected transceiver may only be available to OEM's or in bulk quantities.	High	High	The option outlined in Section 2.4, Paragraph 2 could be implemented, possibly on MURS frequency band.

6 Qualifications and Responsibilities of Project Team

AWQuSam Engineering has a diverse team of experienced engineers. We have the experience to design, test, repair, build and support electronic and mechanical equipment. Our mechanical engineers have experience across a broad spectrum of engineering mechanics including design and fabirication. Our electrical engineering staff has expertise in electromagnetic field theory, communications, and control systems. The team's computer engineers are experienced with field programmable gate arrays and microcontroller based applications. This background is more than sufficient to complete this project in a timely and satisfactory manner.

Our primary business objective is to meet our customers' requirements by providing quality service and designing with integrity. The quality of our service is a direct consequence of our team's commitment to continual excellence.

Task	Assignment
1	Brad Wells
2.1	Steven Golemme
2.2	Juan Garcia / Carlos Sanchez
2.3	Juan Garcia
2.4	Carlos Sanchez
2.5	Triesha Fagan
2.6	Francisco Schroeder / Brad Wells
2.7	Francisco Schroeder
2.8	Triesha Fagan / Steven Golemme
2.9	Triesha Fagan / Steven Golemme
2.10	Steven Golemme
3.1	Francisco Schroeder / Brad Wells
3.2	Triesha Fagan / Juan Garcia
3.3	Steven Golemme / Francisco Schroeder
3.4	Carlos Sanchez

Table6.1: Task Assignments

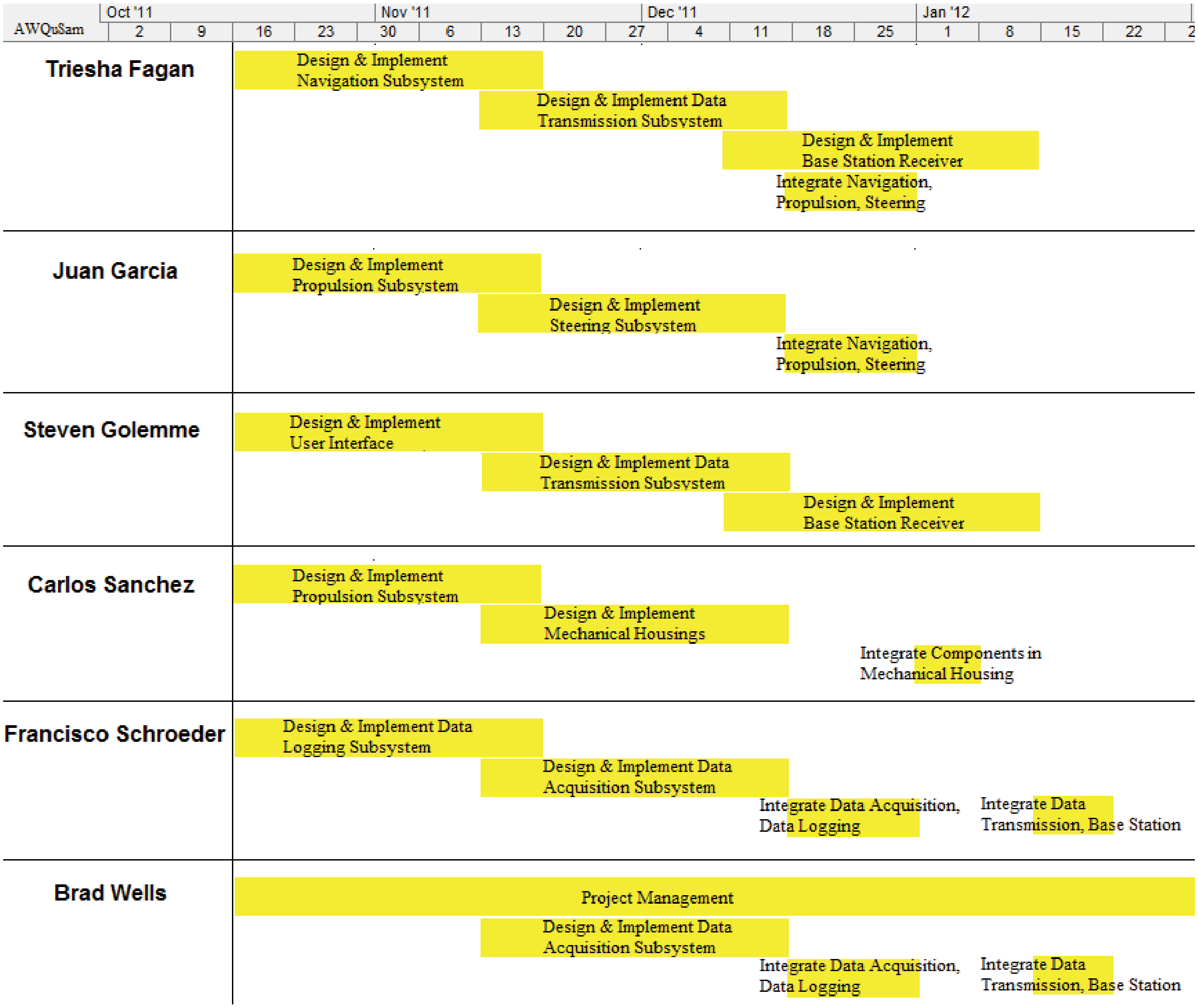

Chart: 6.1: Task Assignments by Date

Brad Wells

Brad is a senior electrical engineering student at Florida State University, where he has maintained a 4.0 GPA. Brad has taken relevant course-work in electromagnetic field theory, digital communications, control systems, and semiconductor device theory. He has workforce experience to complement his formal engineering education. Brad has worked on a team responsible for designing, developing, testing and producing prototypes and refinement units for the United States Army. In order to provide on-going expertise for the Certification, Test and Evaluation (CT&E) process of this cross-domain solution, as well as integration with the U.S. Army's existing systems, Brad was contracted to provide additional support. Brad's past performance and commitment to excellence proves he is a qualified project manager and is well suited to the tasks he has been assigned.

Triesha Fagan

Triesha is a senior Electrical Engineering student at Florida A & M University. Triesha has taken relevant coursework in control systems, robotics, digital communications, microprocessor design, and computer architecture. During the 2010-2011 year, she was project manager for the Florida A & M University's Rocketry Team. During this time, the team built a full-scale rocket with a scientific payload for a NASA funded competition. She also has research experience in the areas of Physics, Robotics, and Microcontrollers. Triesha's iindustry experience consists of two summers working with Ford Motor Company, in their Product Development and Advanced Research and Innovation Department. Triesha's wide range of experience qualifies her to take responsibility for the AWQuSam's navigation system and communication system.

Juan Garcia de Paredes

Juan was born in Central America in Panama City, Panama. He is a senior in Mechanical Engineering at the FAMU-FSU College of Engineering. He is following the thermal fluids track of the major with his focus on sustainable energy. He worked in the Center for Advanced Power Systems spring semester 2011 under Dr. Rob Hovsapian doing research on a wind farm project in Texas. He currently participates in a student organization called Tallahassee Sustainability Group that works on providing a sustainable food economy for the local community.

Carlos Rafael Sanchez

Carlos is a Mechanical Engineering student at Florida State University. He has taken mechatronic related classes and is currently assisting a Robotics camp at NIMS middle school. Boats and cars have always been a great interest to carlos. He was born in Leominster Massachusetts and enjoys, guitar playing, running, drawing and cooking.

Francisco Schroeder

Francisco is a senior in Electrical and Computer Engineering student at Florida State University. Francisco has taken relevant coursework in electromagnetic fields, controls systems, digital communication, digital design, embedded system design, microprocessor design, computer architecture, VHDL, and C++ programing language. Francisco has been highly involved with student organizations. He has been a member of both SHPE (Society of Hispanic Professional Engineers) and HKN (Eta Kappa Nu Computer and Electrical Engineering Honors Society) since 2009. Francisco has been in the board for both organizations. In SHPE he was Conference Chair in 2010-2011 and in HKN, vice-president in the same period. Currently he is webmaster for SHPE and HKN's president. Francisco has job experience with the Panama Canal Authority. Here he worked as a Electrical Engineer Assistant.

Steven Golemme

Steven is a Computer Engineering student at Florida State University. Steven has taken relevant coursework in FPLDs, Computer Architecture, Computer Networks, Digital Design, Micro-processing Design, and Data Structures. Steven has expertise in programming languages such as C, C++, Java, VHDL, SQL, MySQL, Unix, CSS, and HTML. Steven has been apart of NSBE (National Society of Black Engineers) for approximately two years, where he has strived to increase the number of culturally responsible Black Engineers to excel academically, succeed professionally and positively impact the community. Along with his education, he also has had some work experience with GE Aviation Information Management Leadership Program. Steven was able to improve upon his leadership, business acumen, and technical abilities to one day become an IT leader for GE Aviation.

7 Schedule

See Appendix A1

8 Budget Estimate

Product Prototyping Budget

Item	P/N	Manufacturer	Distributor	Qty	Price per Unit	Cost
PIC Development Board w/ Programmer	DV164037	Microchip	Microchip	1	$225	$225
SD Daughter Card	AC164122	Microchip	Microchip	1	$28.50	$28.50
Conductivity Sensor	SBE-4	Seabird	In House (FSU Oceanography)	2	-	-
Temperature Sensor	TBD	TBD	TBD	2	$100	$200
Compass Module	SEN-07915	Honeywell	Sparkfun	1	$34.95	$34.95
GPS	GPS-09566	ADH Technology Co. Ltd	Sparkfun	1	$79.95	$79.95
microSD 1GB Memory Card	COM-08163	A-Data	Sparkfun	1	$9.95	$9.95
USB to Serial Converter	USB-232-1	CommFront	CommFront	1	$30	$30
MURS Radio Modem	RV-M3-M	Raveon	Raveon	2	$130	$260
Mobile Antenna	MURS45	Firestik	TBD	1	$24.99	$24.99
Base Station Antenna	MURS-BASE	Firestik	TBD	1	$39.99	$39.99
4x4 Keypad	TBD	Grayhill	TBD	1	$20	$20
Wiring and Accessories					$200	$200

Battery	Lead Acid Battery for UPS and Alarm Systems	Power Sonic	Amazon	2	13.39	26.78
Servo Motor	High Torque Water Proof Servo	Traxxas	TBD	3	27.92	83.76
Propulsion Motor	Semitrash Water Pump	Powerhouse	Northern Tool + Equipment	1	399.99	399.99
Enclosure	Aluminum Roll	Roll Valley	Home Depot	3	12.99	38.97
Frame	N258509 Square Tube	National Mfg.	Amazon	8	12.25	98
Hoses	Discharge and Suction Hoses with couplings	TBD	TBD	1	40.00	40.00
Mounting Hardware	Sealants and Bolts	TBD	TBD	N/A	40.00	40.00
SubTotal:						1880.83
Shipping & Handling						120.00
Total Proposed Expenditures:						**2000.83**

Table8.1: Product Prototyping Budget

Speculative Budget

This is simply a corporate budgeting exercise, not a record of actual intended expenditures.

A. Personnel			
Name	**Effort (Hrs)**	**Base**	**Total**
Triesha Fagan	360	$30.00	$10,800.00
Juan Garcia de Paredes	360	$30.00	$10,800.00
Steven Golemme	360	$30.00	$10,800.00
Carlos Sanchez	360	$30.00	$10,800.00
Francisco Schroeder	360	$30.00	$10,800.00
Brad Wells	360	$30.00	$10,800.00

Subtotal of Personel			**$64,800.00**
B. Fringe Benefits		**29%**	**$18,792.00**
C. Total Personel			**$83,592.00**
D. Expense		***See Table 8.1***	
SubTotal of Expenses			$2,000.83
E. Total Direct Costs		**C+D**	$85,592.83
F. Overhead Costs		**45% of E**	$38,516.77
Equipment		none	-
G. Total OCO			-
Total Project Cost			**$124,109.90**

Table8.2: Corporate Budgeting Exercise

Provide an estimated budget for the project including the following items:

Personnel

Assume $30 per hour base salary and 12-hour per week for both semesters

Fringe benefits (only on personnel)

Assume the fringe rate is 29%

Expense

supplies and small items (under $1000)

all services regardless of cost

Overhead costs

Assume the overhead rate is 45% of the direct costs)

direct costs include personnel and expense

Equipment

tangible items over $1000

Total Project Cost

Details of the budget process will be discussed in class.

9 Deliverables

One (1) Autonomous Water Quality Sampler prototype will be delivered to facilitate the gathering of oceanographic data in shallow coastal waters. Its path will be programmable by the end-user. Once programmed, the AWQuSam shall propel itself across the surface of bays and estuaries recording water temperature and conductivity.

The AWQuSam will be delivered with documentation detailing instructions for programming new paths and for establishing a connection between the AWQuSam and the Base Station. Documentation will also be provided with instructions for performing maintenance and for servicing the system or components.

Prototype and documentation shall be delivered by April 13, 2011. In addition to the aforementioned documentation, a final design review will be delivered. This document will include all engineering design work (drawings, schematics, bill of materials) required to build additional AWQuSam prototypes.

10 References

United States. Federal Communications Commission. Memorandum Opinion and Order. *Private Land Mobile Radio Services*. 2002. Print. WT Docket No. 98-182.

The Apalachicola Estuarine System Site Characterization, A River Meets the Bay. December 2008.

"Calculating Temperature and Conductivity" *Sea-Bird Electronics*. Feb. 2010. Web. Oct. 2011. <http://www.seabird.com/pdf_documents/ApplicationNotes/appnote31Feb10.pdf>.