FAMU-FSU College of Engineering
Department of Mechanical Engineering

PROPOSAL

EEL4911C/EML4511C– ECE/ME Senior Design Project I

Project title: FAMU-FSU RoboSub Project Proposal

Team #: 21

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Project Executive Summary

The main objective of the FAMU-FSU 2012 RoboSub Team is to participate in the AUVSI Foundation and ONR's 15th International RoboSub Competition. The competition is held in the TRANSDEC pool in San Diego, California and consists of a practice round, a first round, and a final round. Before the competition begins, each AUV will be inspected by the judges of the AUV competition to make sure that they do not pose a serious risk to TRANSDEC, other competitors, or the swimmers following the AUV. The judges will also be checking that the AUV is within the size, weight and density restrictions that have been set forth. Once the AUV has been cleared by the judges they will then allow the AUV to compete in the competition.

Each team is assigned a time slot for the practice round, and performance in the practice round will determine the order in which teams will proceed in later rounds. Then, all the teams that participated in the practice rounds will compete in the first round of the competition. The top scoring teams from the first round, generally the top five, go on to the championship round. Then, the top teams compete for first place with the top teams receiving awards for their placing. For each round, the AUVs will be expected to be able to pass through a gate, follow an obstacle course, drop markers into specified bins, shoot torpedoes at specific targets, pick up and surface with an object within an octagon, and then drop the object once the AUV has breached. All these activities will be performed while completely submerged unless permitted or required by the competition rules. The AUV is to be completely autonomous and may not have any communication with the team or any other source during the competition.

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1 Introduction

1.1 Acknowledgements

The 2012 FAMU-FSU RoboSub team would like to acknowledge the following individuals for their contributions to the project:

- Dr. Shih providing funding via a grant to complete this project
- Dr. Jonathan Clark for advising the team on questions we may have
- Dr. Harvey for advising the team on questions we may have
- FAMU- FSU COE Stride Lab for providing working and storage room in its lab
- Dr. Frank for instruction on how to present effectively and create thorough written documents

1.2 Problem Statement

The aim of this project is to develop an Autonomous Underwater Vehicle (AUV) to participate in the 15th annual AUVSI RoboSub competition in San Diego, CA in July 2013. Competition rules for the 2013 competition will not be released until November 2012, so all preliminary design considerations must be made with respect to rules from the 2012 competition.

The competition provides a set of goals for the AUV to complete and imposes numerous design limitations such as restrictions on the size and weight of the vehicle. According to the 2012 rules, the AUV will need to be able to follow paths, identify and pass through underwater gates, bump into colored buoys, pick up objects, fire torpedoes at specific objects, and other tasks. A comprehensive discussion of the various rules and restrictions can be found in the *Needs Analysis and Requirements Specifications* document released by the RoboSub team in September 2012.

As a complex mechatronic system, there are both mechanical and electronic subsystems that will need to be integrated for the AUV to be able to perform the desired tasks. This year's FAMU-FSU RoboSub team will be building on the progress made by the team from the previous year, and many of the base components are already present. One of the biggest hurdles for this year's team is to integrate existing mechanical and electrical components to create a fully-autonomous vehicle. However, upon analysis it was also determined that some components would need to be redesigned or replaced to meet desired performance goals.

The project can be broken into three major subsections: mechanical and structural components, electrical and electronic hardware, and intelligence and control. A generalized approach to each of the subsections will be discussed in the following paragraphs.

The mechanical design consists of a watertight hull that will contain the electronic components and a frame which will hold all external sensors and thrusters. The AUV had both of these components built by the 2011-2012 team, but are both going to be replaced to reduce weight and significantly improve accessibility to the electronics within the watertight hull. Especial attention will need to be paid to the buoyancy, weight, and stability of the new physical design. Desirable parameters include low weight (below 87 lbs.), buoyancy near neutral, and stability about all three axes of rotation.

The electrical hardware will remain similar to what was used last year, due to assumed similar power and processing requirements. A few of the boards used last year, including the main computer, have been burnt out and will be replaced. In addition, more microcontrollers will be bought for on-board control and spares. The power system proved challenging with the previous design due to the thrusters causing current spikes and burning out the electronics. As such, the new design will power the thrusters and the electronics using separate batteries.

The intelligence portion of the project is perhaps where most of the work will need to be done. The current AUV only has rudimentary motor control in the form of a demo program, and the computer vision has yet to be integrated into the control scheme. Programming will be done primarily in C++ and the specialized Arduino language. Controller design will rely on a model developed by the mechanical engineering sub-team. Before working on new code, all existing code must be tested in order to assess the functionality of present code.

1.3 Operating Environment

The operating environment for our AUV will be the TRANSDEC Anechoic Pool in San Diego, California July 2013. The TRANSDEC is a 300 ft by 200 ft by 38 ft deep pool containing 6 million gallons of chemically treated salt water to replicate ocean conditions, and is continuously circulated to maintain isothermal conditions. The AUV will be gently placed into the water by a crane using the sling attachment for the AUV. The TRANSDEC is an outdoor facility exposed to the elements, so there could be unforeseen weather conditions that could affect the operating environment. Since extensive waterproofing tests will have been performed and underwater currents are assumed to be minimal, the primary risk posed by uncontrollable environmental factors would occur during transportation of the vehicle. The team will take extra precautions to ensure the AUV's safety during transport.

The testing environment for our AUV will take place in the Morcom Aquatics Center pool, which unlike the TRANSDEC pool, is chlorinated. The likelihood of this affecting the operating capabilities is low. The only factor to take into account is the slightly higher buoyancy the AUV will have at the TRANSDEC pool compared to the Morcom pool.

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

The intended use for the AUV is to compete in the annual AUV competition hosted by the Association for Unmanned Vehicle Systems Integration (AUVSI) and United States Office of Naval Research (ONR). The competition will consist of the AUV submerging, passing through a gate, following a obstacle course, dropping markers into specified containers, shooting torpedoes into specified targets, grab an object from the floor of the pool, carry it up and surface into a designated area then drop the object. These are the only tasks that the AUV will be designed to be used for at the current time.

The AUV is autonomous, so the users will only be working to program and build the AUV before the competition, and it will operate itself through the competition. The intended users of the AUV are the team members who built it, and possibly future team members that become involved with the project later. These users are expected to have a basic understanding of engineering principles to understand the design of the AUV.

1.5 Assumptions and Limitations

The electronics housing will be made of 6064 aluminum and clear polycarbonate material in the shape of a box with the aluminum being the sides and base plates for the box and the polycarbonate for the cover of the box to allow for vision into the electronics housing. The housing will be made watertight through the use of a groove cut into the polycarbonate cover and a O-ring placed inside that slips onto the aluminum plate walls. Toggle clamps will be used to hold the cover on tightly.

There will be only one electronics housing for the AUV. The outer frame will be made from the 80/20 inch solid Aluminum T-slots used in the previous RoboSub. These components will be bolted together and water sealed properly. The cameras, marker dropper, claw, torpedoes, compressed air tank, thrusters, batteries, and actuators will be used from the previous year's sub.

For power distribution to the various electrical systems, off-the-shelf voltage regulators will be used and the electronics housing will be large enough to include all batteries required. For all tasks that require implementation of intelligence, we have assumed that the mission will be similar to that of last year. Until new rules for the contest have been received, intelligence to complete the 2012 mission will be implemented.

It is assumed that the rules for the 2013 competition will be very similar to those for the 2012 competition. This assumption will guide many of the design criteria until the rules for the upcoming competition are released. The weight must be under 125 lbs or immediate disqualification will occur, the robot must be fully autonomous, the robot must not exceed 6 feet by 3 feet by 3 feet. Additional limitations apply in the form of time constraints imposed by the senior design course schedule and budget limitation due to limited funding sources.

1.6 Expected End Product and Other Deliverables

The end product of this project should result in a completely autonomous unmanned submersible vehicle. It should be capable of submerging, entering through a gate, following a obstacle course via colored paths, dropping markers into specified containers, shoot torpedoes into specified targets, grab a specified object from the floor of the pool, carry it up and surface into a designated area then drop the object. The AUV is a competition based product and is only being built to complete these determined tasks.

Other expected products of the AUVSI RoboSub competition are a team website, a journal paper, and an introductory video of the team. The team website should consist of a layout of the team's work in building the AUV that is accessible to the public. The journal paper should be a technical paper explaining the operations of the team's AUV. The introductory video should be a short and riveting video to introduce the team and their competing AUV.

2 Concept Generation & Selection

2.1 Mechanical Design

The mechanical portion of the design consists primarily of a watertight hull and an external frame. The watertight hull will be designed to contain the electronic components and keep them safe from water damage.

2.1.1 Watertight Hull

Design possibilities:

- Use the current hull
- Keep current body, redesign end caps
- Design new box-like hull

Last year's RoboSub team left behind a working, waterproof hull. Reusing the current hull would save both time and money. Work on the rest of the components could start immediately without worrying about the hull failing.

By reusing the hull, however, problems from last year are kept alive. One of the main problems with this hull is access to the electronics. It takes 30 minutes to get inside the hull, and about 90 minutes to reassemble everything once work on the electronics is done. This presents a problem for various reasons. First, when the new software is ready for testing, the electronics are going to be moving in and out of the hull. Setting aside 2 hours just to disassemble and assemble the hull will lay a heavy burden on an already tight schedule. Second, at the actual competition teams are allowed 5 minutes before the runs begin to do any last minute changes. With the current hull, last minute changes would be impossible.

Since there are design aspects that greatly limit the functionality of the current design, it was ultimately decided to completely redesign the hull. A complete redesign would give the opportunity to create a design that would allow the electronics to be accessed in the small window of time permitted prior to running the AUV at the competition. The new design will include an advantageous feature of the old design: a way to see into where the electronics are in order to spot problems before they get out of hand.

2.1.2 Exterior Frame

The following design possibilities were considered:

- Keep current frame
- Redesign frame using parts from the existing frame
- Redesign frame not using existing parts

The current frame has a couple advantages that would make it useful in the coming competition. The frame has fairly low weight and the extruded aluminum provides a flexible design that permits quick and easy repositioning of thrusters and sensors to virtually any point on the frame. These characteristics are very appealing, and would undoubtedly be things that would be desirable even if the frame were to be redesigned.

There are some drawbacks to the current frame, however. The current frame is designed to fit the current watertight hull and not the redesigned hull. As a result, the existing frame will likely be too tall and not wide enough for the proposed redesign of the hull. In addition, the current design restricts the access to the interior of the watertight hull and must be partially disassembled before gaining access to the hull.

While the existing frame has desirable qualities, it was decided to redesign the frame. A redesigned frame would be the appropriate size for the new hull. With the redesign, it is hoped to keep many of the strong features of the old frame while optimizing it for the redesigned hull. The new frame will make access to the electronics easier and will ideally not have to have any part of it removed to reach the interior of the hull.

2.2 Electrical Design

Many parts of the electrical design last year are being reused in this year's AUV. However, there are also many designs from last year that are not practical and are being re-developed.

2.2.1 Electrical Power

Power Supplies

Last year's design used 2 batteries in series for a total of 32V output. This was very hard to regulate and control. To fix this, the design will use separate batteries for each subsystem.

Voltage Regulation

The voltage regulators from last year were custom made, but never worked as intended. Trying to regulate such a specific voltage from their once source was not working. With the change to the power system, the voltage regulators will only need to step down from 12V instead of 32V.

2.2.2 Electronics

Main Processing Unit (MPU)

In the previous year, a Zotac board with an Atom processor was used; however, that board has been destroyed. The design for this year uses the same concept but realizes the need for more processing power to control all the subsystems for the AUV. This unit will monitor and control each subsystem.

Subsystem Control

Using the same idea as previous years, the Arduino boards are perfectly suited for controlling each electronic subsystem. The motor control system is also being ported from last year's design as these devices still function as intended.

Vision

It is planned to use the same vision devices as were used last year as they are working.

3 Proposed Design

The proposed design of the AUV can be separated into four distinct sections: the mechanical design, the electrical system (including power sources and component wiring), the electrical components required, and the software system design.

3.1 Overview

The primary goal of this project is to create a fully autonomous robot that meets all requirements of the AUVSI RoboSub competition. In order to accomplish these goals, a complex system involving various electronics, sensors, and actuators will be employed on a watertight hull and frame system. Once built, the hull and frame will provide the physical structure of the vehicle, while the other systems will perform more dynamic tasks necessary for successful completion of the competition. These dynamic systems interact similarly to how is indicated in the block diagram below.

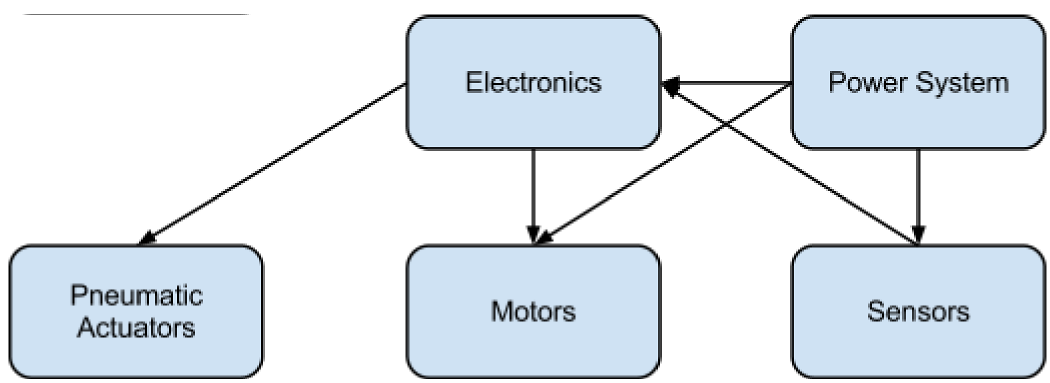

Figure 1. Top-level block diagram of the systems involved in the operation of the AUV.

3.2 Mechanical System

3.2.1 Watertight Hull

The decision that was taken is to redesign the hull. The new design will consist of an aluminium box with a lid. This box is going to be shorter, in terms of height, and wider than the previous hull. The logic behind the box is that since most of the electrical components are of a box-like shape, a box-shaped hull will allow more efficient use of the space. The new design will not be as hydrodynamic as the current cylindrical hull, however, hydrodynamics are not expected to be a significant issue at the low operating speeds of the AUV. Holes will be made on the sides of the hull where SEA CON connectors will run from the electronics inside to the motors, sensors, and other components that operate outside the robot.

The lid for this box will be made of a clear polycarbonate that allows the electronics to be seen at all times. This is a built-in safety feature, as with electronics there is always a risk of fire. With an opaque lid, once the hull was sealed no smoke would be seen or smelled until the box was opened. A figure illustrating the proposed design for the hull and lid is below.

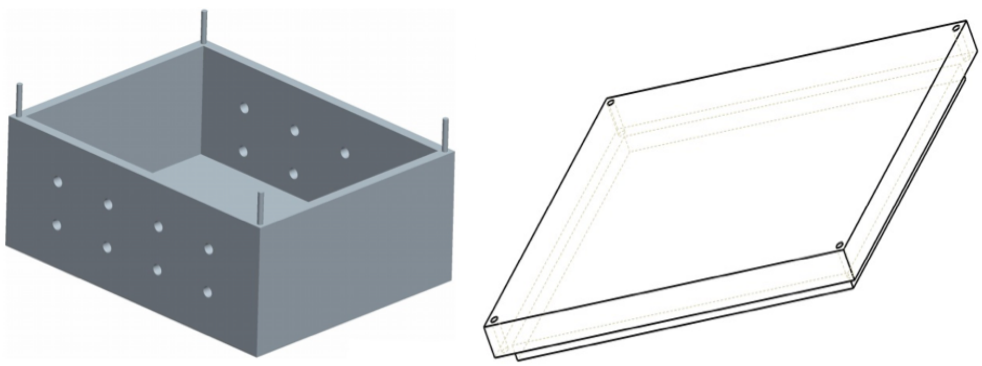

Figure 2. A basic CAD model of the watertight hull and lid.

3.2.2 Frame

The whole hull will be mounted onto a frame made from the same material as last year's frame. The design for this is rather minimalist with the purpose of saving weight while still being functional. The frame will run along the sides and the bottom of the hull, leaving the lid unblocked. This will be done so that the lid can easily be removed to access the electronics without having to tamper with the frame. The frame will run rails from front to back underneath and along the sides of the AUV. This will help with placing the different components as it will allow for adjustability to account for appropriate weight distribution. The goal is for the robot to be perfectly balanced and having rails for the components will help with this. A preliminary design for the frame is shown in the figure below.

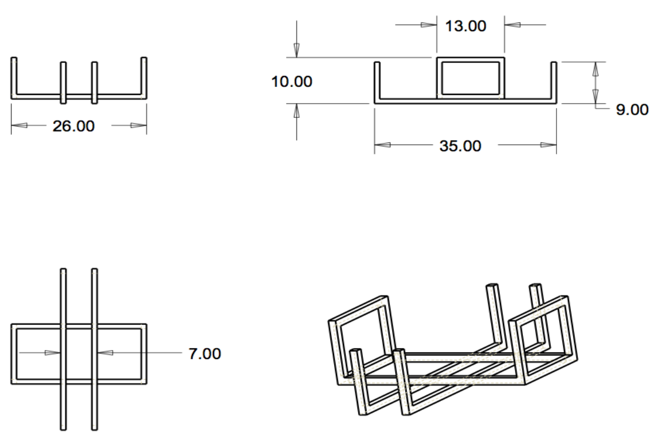

Figure 3. A basic CAD model of the frame. Measurements are based on initial estimates and do not reflect actual design specifications.

3.3 Electrical System

The AUV will be powered by 3 separate power sources. The separation of power sources is intended to stabilize each electronic system so that fluctuations caused by the thrusters are not harmful to the other systems.

- The first power source are the two Lithium-Ion batteries from the previous years design. These batteries are rated at 14.8 V with a 30A maximum discharge rate each. They take ~10 hours to charge. This system is intended to power only the thrusters.
- The second power source is only for the main computer. This battery supports 19V and has a maximum discharge rate of 3A. With a rating of 4AH, it can support the main CPU's power for upwards of 3 hours.
- The final power source is a 12V battery intended for the remaining electronics. This would power all of the electronic subsystems that need external power. This battery has a 4A max discharge rate which can easily handle the power requirements for the current design.

Component	*Maximum Current Consumption*	*Average Current Consumption*
Zotac PC Board	3.5A	1.5A
Arduino(s)	.75A	.5A
IMU	.075A	.060A
Thrusters	12A	3A

Table 1. Current consumption of electrical devices.

3.3.1 Voltage Regulation

Many of the devices used on the AUV require different voltages. This will be possible by using voltage regulators to step down or step up voltages to each individual device. The power source for each electrical component is supplied by the 12V battery. Many of the components in the current design require 5V of power. To achieve this, the Pololu step-down voltage regulator has been chosen with high efficiency.

Pololu Step-Down Voltage Regulator D15V35F5S3 :

- input voltage: 4.5 V to 24 V
- typical continuous output current: 3.5 A (Actual continuous output current depends on thermal dissipation.)
- output voltage selectable as 5 V or 3.3 V
- 700 kHz switching frequency

- 15 mA typical no-load quiescent current (150 µA typical quiescent current with EN=0 V)
- integrated over-current shutoff
- small size: 1.68" × 0.46" × 0.3" (43 × 12 × 8 mm)
- weight without header pins: 0.1 oz (3 g)

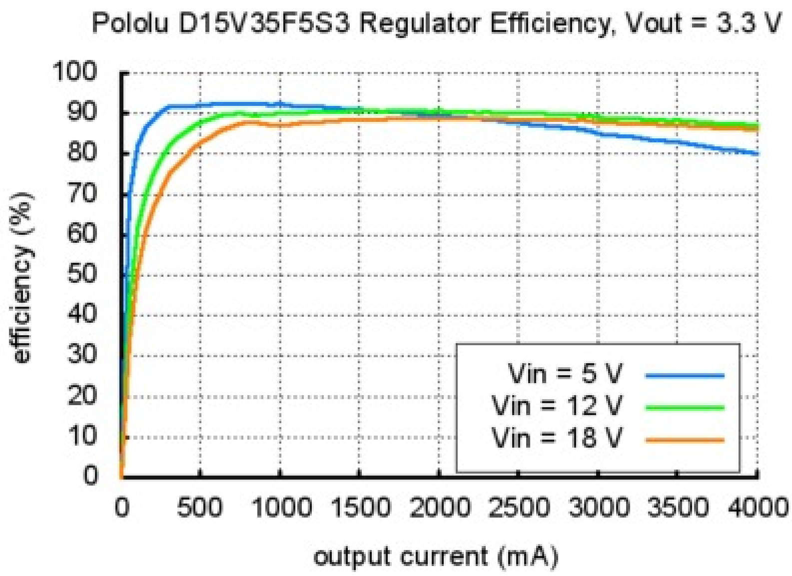

Figure 4. A plot of the Pololu voltage regulator efficiency versus output current for various input voltages.

3.4 Electronics

The hardware required to control an AUV is comprised of a main control unit and many subsystems. Each subsystem is an entity within itself that could be self sustaining except it needs correct instruction from the main unit. Below is a basic block diagram illustrating how the electronics communicate with each other and other subsystems.

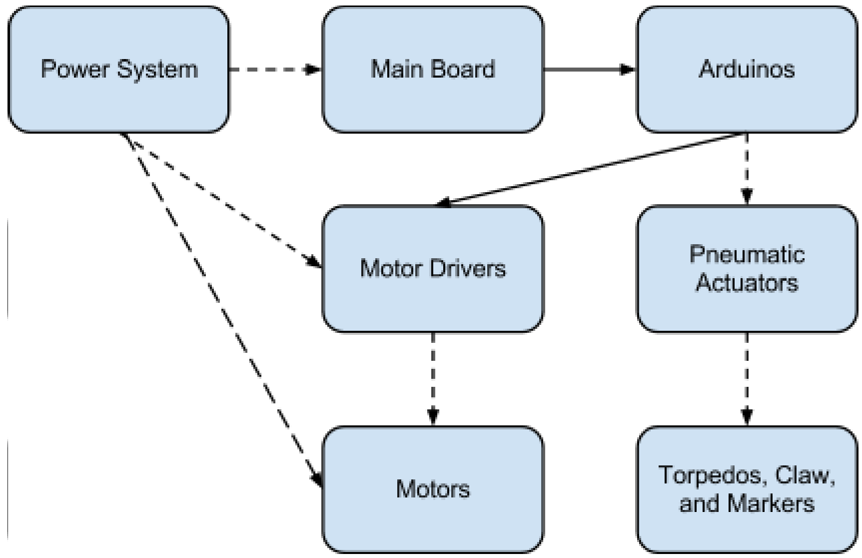

Figure 5. A simple block diagram of the proposed electronics system with its interactions with external systems indicated by dashed lines.

3.4.1 Main Processing Unit (MPU)

This unit is intended to handle all major communication between each peripheral device. Essentially this will handle data from all subsystems and output communication to each of those subsystems. The selected device for this is the Zotac Intel Core i3-2330M ZBOXHD-ID82-U.

Detailed Specs:

- CPU Intel Core i3-2330M Processor (2.2 GHz, dual-Core)
- Chipset Intel HM65 Express
- Memory:2 X 204- pin DDR3-1333 SODIMM Slots, Max Capacity of 16GB
- Hard Drive: Supports 1 X 2.5-Inch SATA 6.0 GB/s Hard Drive
- Ports: 4 X USB 2.0 Ports (1 front, 2 rear, 1 top); 2 X USB 3.0 Ports; 1 X Wi-Fi Antenna Connector; 1 X DVI Port; 1 X HDMI Port; 1x?Optical S/PDIF Out; 1 X RJ45 LAN Port; Audio I/O Jacks
- Carder Reader: 6-In-1 Card Reader, Supports MMC/ SD/ SDHC/ MS/ MS Pro/ xD
- LAN: Integrated Gigabit Ethernet Controller; 802.11n/g/b Wireless LAN; Bluetooth 3.0

The benefits of using this device are myriad. Firstly, it is intended as a lower power and low heat media PC, thus it is designed to produce as little heat as possible while producing enough power for the image processing required of the AUV. Secondly it powers it's own hard drive straight from it's motherboard, without needed external power. Thirdly, it doesn't require a 24-pin ATX like many iTX and Micro-ATX motherboards require. It is essentially a laptop system only requiring 19V DC to power itself. Lastly, it has 6 USB ports to power and communicate with each camera and Arduino.

3.4.2 Arduino UNO

Each serial device needs a “bridge” to communicate with the MPU. The Arduino UNO is a perfect solution to handle this communication. Essentially each Arduino will control a peripheral: motor driver, actuators, hydrophones, etc. This will take the serial communication from each subsystem and allow control over USB from the MPU.

- Operating Voltage : 5V
- Input Voltage : 7-12V
- Digital I/O Pins : 14 (6 Provide PWM output)
- Analog Input Pins: 6
- DC Current per I/O pin: 40mA
- DC Current for 3.3V Pin: 50mA
- Flash Memory: 32KB
- SRAM: 2KB
- EEPROM: 1KB
- Clock Speed: 16MHz

The greatest advantage of using an Arduino is its versatility. Each Arduino will have its own subsystem process. This will allow that subsystem to be controlled by the Arduino, without always needing outside assistance from the MPU. This will not only take process power off of the MPU, but also decrease unnecessary communication between every device.

3.4.3 Motor Controller

To control each thruster an L298 dual H Bridge driver is selected for interpreting the PWM signal from an Arduino. Essentially, each thruster is given a duty cycle range to accompany the necessary voltages the thruster requires to speed up and slow down. To control this, an Arduino will send PWM signals to the motor driver, where it will then take the voltage from the batteries and adjust the voltage output according to the duty cycle designated by the Arduino controllers.

- Operate at 6 to 26V
- 4A Total Drive Current
- Requires 5V for board power
- Motor Direction indicator LED’s
- EMF Protection diodes

3.4.4 Vision System

The vision system will use last year’s Logitech C615 Webcams, which are perfectly functional and work in OpenCV. OpenCV is an image processing library used by many high ranking teams from previous years’ competitions. It works in C++ on multiple platforms including Windows, Linux, Mac and even Android. This will increase the efficiency in image development while also making programming easier for detecting and tracking throughout the project. Each webcam is powered via USB from the MPU so no external power is required for them. One will be placed facing the floor of the pool to track the orange tape on the floor of the pool. The other camera will be the “eyes” of the AUV and it will be facing straight in front of the vehicle to interpret the units surroundings.

3.4.5 Air Release Actuators

These actuators are used for controlling the marker dropper, the claw grabber, and the torpedos. Each actuator requires a 7V input to "actuate." This will be controlled by an Arduino, however the voltage input will be taken from the 12V battery designated for the electronics.

3.5 Software System

The software system will be composed of three distinct modules that perform the required tasks, and potentially a fourth module which will be responsible for checking the work of the other three modules. Figure 4 shows the general layout of each of the components, and each component is described in detail in the subsequent sections.

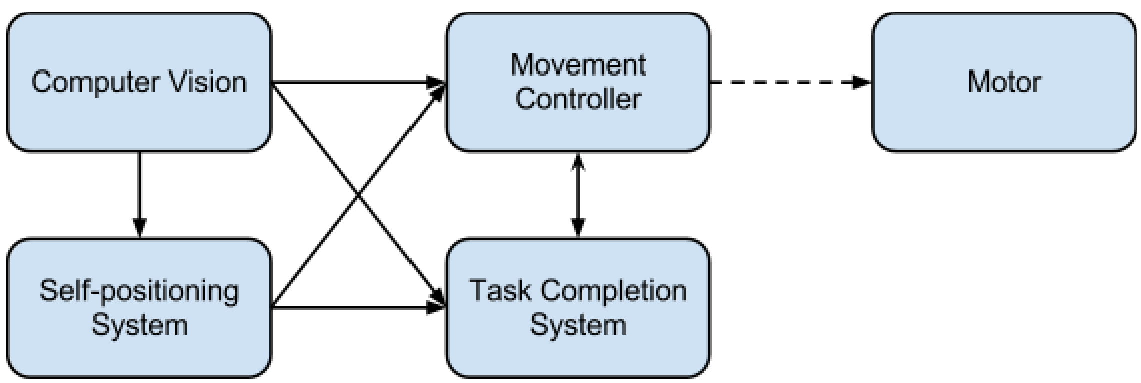

Figure 6. A simple block diagram of the proposed software system with its interactions with external systems indicated by dashed lines.

3.5.1 Computer Vision:

This subsystem will analyze the data from the cameras and output its findings in a form that is easily manipulable for the other subsystems. The team's preliminary communications protocol dictates that the computer vision module output the angle and distance to the next target. This system will therefore identify shapes and colors along the course and determine their location. In order to achieve the flexibility of identifying different course objectives, the computer vision system should use a state machine to differentiate between different targets to search for, such as finding a path instead of a gate.

3.5.2 Movement Controller:

The movement controller will accept information regarding the distance to its next target, as well as its angle with respect to the sub. It will then direct the output of the thrusters to reach the target position as nearly as possible, while accounting for the drift and inertia inherent to underwater movement. The mathematical model of the controller will be worked out separately, and then implemented in software.

3.5.3 Self-Positioning System:

The self positioning system will use the IMU and the computer vision data to determine where the AUV is with respect to its destination. The self-positioning system can then provide this data to the movement controller or to the task completion system to allow for intelligent corrections. The output protocol has not been decided yet, as it is pending further development of the artificial intelligence system in the sub. This module will decide whether the main system believes a task to have been completed.

3.5.4 Task Completion System:

This system is not required for the operation of the sub, although it may be useful in allowing the AUV to account for unexpected situations. As such, this system has been deemed optional, and will only be implemented if the team has time to do so. This system will examine the outputs of the three main operational modules and determine if they are in agreement with each other. This system may also attempt to determine whether other tasks have been completed, such as ascertaining whether an object has been picked up, a gate has been passed, or a marker has been dropped.

In its final implementation, the task completion system should have the final say on the completed status of the current task, and on whether a task should be paused and continued later if it cannot be completed at this time. For debugging purposes, the team may also choose to implement a tracking system to monitor which tasks have been completed; such a system would also be maintained by this module.

4 Statement of Work (SOW)

4.1 Project Management

This year's RoboSub team consists of members with various backgrounds and skills; this is appropriate for such a multifaceted engineering project. The team has a project manager and team leaders for each major component of the mechatronic system and the design process. In addition to the project lead, there is a designated leader for the following subsystems and design phases:

- Electrical (hardware)
- Mechanical design
- Programming and intelligence
- Testing and prototyping

The leaders in charge of each subsystem are responsible for ensuring that there is a general direction to the design process of that subsystem. They are also responsible for holding sub-team meetings for their respective subsystem and ensuring that their portion of the project stays on schedule.

The project manager serves as a liaison between sub-teams and works to make sure that the team as a whole is making sufficient progress and that all work done is compatible with the overall design. The project manager is also responsible for deliverables and presentations and is expected to divide up tasks and make sure that the team is prepared for senior design course milestones.

There are also roles that have been assigned to take care of financial management, record-keeping, and public relations. While not involving actual design work, these roles are essential to proper team functioning.

- Financial management and budgeting
- Public relations
- Secretary
- Webmaster

4.2 Mechanical (ME) Responsibilities

All dependencies refer to ME tasks, unless otherwise indicated. The parenthetical sections indicate the following information: (<responsible parties>, <time to complete>).

Responsible parties legend:
- $: Treasurer
- C: computer software team
- E: electrical hardware team
- L: Project Lead
- M: Mechanical team
- T: Testing Engineer

4.2.1 Electric Housing($,M,T)(3-4 weeks)

1. Prototyping(**1 week 2 Days), (2 weeks allowed for hold ups)**
    a. Size Prototype(**2 Days**)
        - Purchase particle board sheets
        - Cut to size
        - Put together
        - Check with ECEs to make sure there is enough space
    b. build scaled prototype with materials to be used in final design (**1 week**)
        - Purchase scaled down materials
        - Weld plates together and tap holes for secants
        - test lid and secants for water tightness
2. Final Design(**1-2weeks**)
    a. Purchase Parts
        - Aluminum Plates (unless new material chosen after prototyping)
        - Polycarbonate top plate
        - clamps/latch to hold top plate
        - O-ring
    b. Machine parts

        - drill holes for secants
        - weld plates together
        - cnc top plate for o-ring groove
        - attach clamps/latches to hold top plate
    c. Final test
        - Check final design for water tightness

4.2.2 Body Frame($,M,T)(2 week)

1. Prototype(**1 week**)
    a. sizing prototype
        - dismantle previous frame
        - finalize frame design in ProE
        - Use size prototype from electric housing to begin building new frame
        - Purchase new framing material if inadequate old material
    b. Weight distribution prototype
        - using size prototype begin laying out other components for Sub
        - check with ECEs about placement of Cameras, and their relations to the torpedoes, claw, etc to make sure reasonable for coding.
2. Final Design(**1 week**)
    a. Put finished electric housing and frame together
        - check weight distribution with all components attached
        - test in water to see buoyancy in water, and make preparations for use in seawater

4.2.3 Other Components($,M,T)(4 days-4 weeks)

1. actuators and air container(**1 day-1 week**)
    a. Test actuators and air container
        - if still work then can use
        - if not working then must be replaced
2. Claw(**1 day-1 week**)
    a. Use actuators to test claw
    b. if broken then must be redesigned, otherwise will be reused
3. Torpedoes(**1 day-1 week**)
    a. Use actuators to test torpedoes
    b. if broken then must be redesigned, otherwise will be reused
4. Marker Dropper(**1 day-1 week**)
    a. Use actuators to test Marker Dropper
    b. if broken then must be redesigned, otherwise will be reused

4.2.4 Build practice course($,M)(1-2 weeks)

1. Plan for the course released in November by AUVSI
    a. Once plans released research can go into each individual part of the course
2. Course Construction

a. purchase necessary materials for construction
b. build each part of course

4.2.5 Controller Design($M)(2-3 weeks)

1. Come up with design for controller (talk with Dr. Clark)
2. Purchase parts (if necessary)
3. Put final design into production

4.2.6 Help ECE with testing and Debugging($MTCEL)(see ECE for deadlines)

1. Help finish writing code
   a. Help where the ECEs need help
2. Test code
   a. Take RoboSub to FSU aquatic center
   b. run tests checking that each part works together
   c. debug and run code again
   d. repeat process c. until code works
   e. If parts damaged during testing must be replaced

4.3 (ECE) Electrical Responsibilities

All dependencies refer to ECE tasks, unless otherwise indicated. The parenthetical sections indicate the following information: (<responsible parties>, <time to complete>, <dependencies>).

4.3.1 Power System ($CE)

1. Component Acquisition and Testing **($E, 2 months, none)**
   a. Purchases **(1 month, none)**
      - Batteries
      - Voltage Regulators
      - Extra Arduinos
      - Main Computer
      - Cables
      - Voltage stepper (for Arduino – actuator communication)
      - Breadboard, wires, LEDs (for Arduino testing)
   b. Confirm functionality of current components **(2 weeks, none)**
      - Arduinos **(1 day, I.1.a)**
      - Thrusters **(1 day, none)**
      - Batteries **(1 day, none)**
      - Cameras **(1 day, none)**
      - Sensors **(1 week, none)**
   c. Confirm functionality of purchased items **(1 week ,I.1.a)**

        - Batteries **(1 day, I.1.a)**
        - Voltage regulators **(1 day, I.1.a)**
        - Extra Arduinos **(1 day, I.1.a)**
        - Main Computer **(1 week, I.1.a)**
2. Wire together components, confirm correct current/voltage supplied **(3 days, I.1)**
3. Test system operation time **(1 day, I.1)**
4. Modifiable mounting system **(2 weeks, none)**
    a. Design system **(3 days, none)**
    b. Test system component by component **(2 days, I.1-2)**
    c. Implement system **(3 days, I.4.a-b)**
    d. Make any necessary corrections to mounting and layout to achieve design specs **(1 week, I.4.a-c, ME.1, ME.2)**

4.3.2 Intelligence Wiring and Code Development (CEM)

1. Computer Vision **(6 months, none)**
    a. Test existing code **(1 month, none)**
        - Determine current functionality **(1 week, none)**
        - Determine modifications necessary for:
            - Path planning **(2 weeks, none)**
                - Shape locating **(1 week, none)**
                - Color identification **(1 week, none)**
    b. Implement path planning **(5 months, II.1.a)**
        - color identification **(1 months, II.1.a)**
        - shape location **(1 months, II.1.a)**
    c. Develop communications protocol **(1 day, none)**
        - Send to self-positioning system, movement controller
        - Inputs: Camera data
        - Outputs: direction to next target; distance to next target
2. Movement Controller **(CM, 5.5 months, none)**
    a. Test existing code **(1 week, none)**
    b. Determine functionality of existing code **(1 week, none)**
        - Any control more intelligent than “motor on, motor off”?
            - Indication of speed?
            - Braking?
    c. Develop communications protocol for inter-device comm **(1 week, II.1.c)**
        - Inputs: Self-positioning system, Computer Vision Distance
        - Outputs: Thruster speeds (4x8 bit array)
    d. Implement ME controller design in code **(1 month, ME.7)**
    e. Design testing procedure **(1 week, none)**
    f. Test functionality of ME controller design **(2 months, II.2.d)**
3. Motor Control **(2 weeks, I.1)**
    a. Wire motor drivers from Arduinos to thrusters **(2 days, I.1.a)**
    b. Arduinos: write code to convert input to PWM speeds **(1 week, none)**

        - Inputs: 4x8 bit array, [-128 – 127]
        - Outputs: PWM values
            - -128 is maximum allowed reverse duty cycle
            - 127 is maximum allowed forward duty cycle
            - 0 is off; 1 is minimum allowed duty cycle
4. External Hardware Actuator Control **(2 weeks, none)**
    a. Wire voltage stepper (ie power FET) from Arduino to actuators **(1 day, I.1)**
    b. Arduino code **(1 week, none)**
        - Inputs: On/off, device
        - Outputs: Logic high/low to correct voltage steppers
    c. Testing full system **(1 week, II.4.a-b)**
        - Arduino logic outputs (part of I.1)
        - Voltage stepper functionality (part of I.1)
5. Self-Positioning System/ Mission Control (depending on program architecture) **(CM, 1 month, I.1.b)**
    a. Design method to read IMU data and direction to target data to feed into movement controller **(CM, 2 weeks, II.2.c)**
        - MEs will determine data needed by controller
        - CEs will determine data format
    b. Inputs
        - IMU data (velocity, orientation, gravitational forces)
        - Direction with respect to target
6. Task Completion System **(CM, Unknown, II.4-5)**
    a. Ensure that the speed of the robot is what the controller expects
        - Inputs: IMU, controller anticipated velocity
        - Outputs: T/F (are the two values within n units of each other)
    b. Make sure unit picked up an object or deployed a marker where it thought it did

4.4 Test Plan

Test plans for ensuring our AUV works proper will include several different processes. A watertight test will first be implemented to ensure the electronics housing will protect the electronic components. A test of the components such as thrusters, the claw, cameras, the beacon dropper, and the torpedoes can be performed without a trip to the testing pool by instead having a bucket of water to simulate underwater conditions.

Once the AUV is fully assembled and the autonomous system needs to be tested, trips to the Morcom Aquatic Center will be made to place the submersible into water to operate. Colored duct tape, colored PVC piping, and other objects will be used to mimic competition components that the AUV will interact with. Swimmers will be in the water with the AUV to ensure all is working properly during testing operations. Video, pictures, and data will be recorded about the AUV’s testing to better enhance it and establish its performance.

4.5 Documentation

Much of the documentation will be in the form of deliverables submitted to the Mechanical Engineering department and the initial, midterm, and final presentations.

Additional documentation provided by the RoboSub team will consist of the following in order of expected frequency of update:

- Personal blogs
- Team website with meeting minutes and documentation
- Weekly presentations to technical advisor
- Biweekly reports to program advisor
- Formal presentations to committee

5 Risk Assessments

There are several types of risk when attempting to accomplish the team's goal of completing a fully autonomous underwater vehicle. These risks could be absolute downfalls to project and could cause failure to compete in the competition in July. These risks can be prepared for and in most cases prevented by taking simple steps to ensure the success of the AUV project.

1. Failure of the watertight seal into the electronics housing during testing or competition.
    a. Water leakage into the electronic component area would destroy very expensive electrical components.
        i. Prevention: properly seal all possible leakage points and do testing of the case before electrical components are inside the housing.
2. Burnout of electrical components during operation
    a. Without proper calibration and planning electrical components and Arduino boards could receive too much voltage and become fried.
    b. This would result in time wasted ordering a replacement component
        i. Prevention: by doing proper electrical calculations and component testing nothing should be damaged.
3. Incompletion of programming the guidance system
    a. Creating an effective and working program to be able to autonomously perform the tasks in the competition may be too difficult of a task to complete.
        i. Prevention: Have the entire team set a steady pace of working on an effective program to have plenty of time to finish it.
        ii. Prevention: A more authoritative figure could be sought after to help if the problem seems over our heads.

4. Uneven distribution of weight inside the AUV while in water
    a. An imbalanced submersible would not operate well underwater and possibly burnout one of the thrusters while trying to re-establish it's positioning.
        i. Prevention: Evenly distribute weight throughout the AUV so that it is balanced evenly in the water.
5. A loss of a team member on the project
    a. For unforeseen reasons and circumstances a team member may have to leave the team and be unable to continue working on the AUV
        i. Prevention: Be able to divide up that team member's roles to others to ensure they get accomplished
        ii. Prevention: Be familiar with the tasks he/she was responsible before an untimely departure.
6. Running out of funding for the project
    a. If our project costs are larger than our project budget, the team won't be able to purchase needed components to continue building the AUV.
        i. Prevention: Carefully budget ourselves and set aside extra funds to rely on if we need them.
        ii. Prevention: Approach potential project sponsors in order to gain more money for the project.

6 Qualifications and Responsibilities of Project Team

The 2012 FAMU-FSU College of Engineering RoboSub Team consists of seven exceptional senior engineering students. With four mechanical engineering and three electrical engineering students on the team, the team's complementary background is adequate for accomplishing the tasks laid out in this document.

6.1 Electrical Team Qualifications

The electrical team have skills in the following areas:

- circuit design and analysis, enabling sound design of the RoboSub power distribution system
- electronics implementation; heuristic skills acquired from experience soldering and wiring circuits
- programming, allowing for ease in developing algorithms and implementing them in software

Many students on the team have programming experience and will be contributing to the completion of the programming tasks outlined. The software development will be managed by Darryl McGowan and Sondra Miller. Darryl and Sondra are FAMU electrical engineering students with a wide range of programming experience from coursework and extracurricular experiences. With courses in C, C++, FPGAs, and Microprocessors along with experience coding and developing algorithms in various experiences, they are more than equipped to satisfy the software development needs of the RoboSub.

Also, all electrical engineering students have had coursework and experience with electronics and hardware. Alex Smith, an FSU electrical engineering student, will be coordinating the electronics hardware development effort. Alex has excelled in electronics and power fundamentals coursework. He also has a wealth of experience building personal computers which allowed him to become familiar with the challenges of power distribution, heat dissipation, and assembly of electrical components and boards.

6.2 Mechanical Team Qualifications

The mechanical team brings a wealth of knowledge in a breadth of topics. The group's knowledge includes:

- aerodynamics and fluid dynamics, aiding in computational analysis of the effects of water flow on the AUV's movement;
- thermodynamics, aiding in the computational analysis of heat dispersal through the sub;
- programming of mechatronic devices, aiding in the design and structure of the software for autonomous movement;
- materials, aiding in the materials selection process for the hull and AUV body.
- control system theory, aiding in the design of the RoboSub motor controller

Gregory Robertson, an FSU mechanical engineering student, is the team's Mechanical Systems Lead. Gregory's focus is in fluid dynamics, and he also has a solid foundation in a broad range of mechanical systems topics. He has experience designing mechanical frames and systems, and has a family background in building mechanical structures.

Santiago Franco, another FSU mechanical engineering student, is the team's Treasurer and a strong member of the mechanical design team. Santi's knowledge of fundamental engineering procedures make him a qualified team treasurer. Furthermore, Santi's focus in materials gives him an understanding of the effects and benefits to be assessed in the materials selection process.

Stuart Royal, our third FSU mechanical engineer, is the team's Testing Coordinator and another strong member of the mechanical design team. Stuart is focusing in fluid dynamics, along with Greg, and can provide both computational flow analyses and other kinematic computations. He has experience in hands-on assembly of frames and systems, and is enthusiastic to design and implement a test course to assess the AUV's capabilities.

Kyle Miller is our FAMU mechanical engineer. He is the Project Lead, will be largely responsible for the movement controller design, and is also a strong programmer. Kyle has had experience as a group leader in a number of other projects that he has completed throughout his academic career, and was enthusiastic to take on the challenge of coordinating the efforts of the team. His focus is in control systems and gas dynamics, and he also has strong interests in both fluid dynamics and materials. Kyle's strengths allow him to provide solid support in a number of tasks, making him a strong addition to our team.

7 Schedule

A tentative schedule has been attached to this report in the form of a Gantt chart. Due to its size, the chart is not included here, but can be found after the conclusion of this report.

8 Budget Estimate

The actual team budget is summarized in the following chart.

Proposed Budget		
Total Funds	$2,200	
	Funds Allocated ($)	% of total budget
EE	880	40
ME	880	40
Prototyping/testing	220	10
Emergency	220	10

Table 2. Proposed allocation of discretionary project budget.

Currently, an initial list of needed items that are needed have been generated. Pending items desired by the electrical team consist of the following items:

- Zotac ZBOX HTPC with 8GB RAM Intel i3 processor @ 2.2 GHz ($400)
- 16/19V Li-ion laptop battery ($60)
- 12V battery for electronics ($130)
- 2 Arduino Unos ($50)
- Pololu voltage regulator ($15)
- Various wires and breadboards ($19)

The mechanical team anticipates the required materials for the new body will cost (shipping is not included):

- Aluminum baseplate box enclosure ($182.71)
- Polycarbonate lid ($94.69)
- 6ft O-rings ($6)

Current pending mechanical engineering costs for the prototype of the lid and housing for the electronics are $114.59. Electrical prototypes will be implemented using the components for the final design.

Travel expenses for the group are expected to be approximately $500 per person. An external fund of $4,000 has been allotted for travel alone, and the mechanical and electrical engineering departments are anticipated to be able to provide additional funding if necessary.

If the goal of receiving more funding from outside sponsors is achieved, each part of the budget will receive more money based on the percentages that have been set. This allows for all parts of the RoboSub to benefit equally from the newly acquired funds.

Costs for implementing the project as a whole are modeled in following table. Only the expenses portion of the budget is directly managed by the team. These initial estimates extend only over the duration of the current tasks. The assumptions are as follows:

- The electrical tasks will be handled by the electrical team only, and the mechanical tasks will only be handled by the mechanical team
- $30 per hour base salary for personnel, and a 12-hour work week for the duration of the tasks
- Fringe benefits (only on personnel) at a rate of 29%
- Overhead rate of 45% of the direct costs (personnel and expenses)
- Equipment costs are the sum total of equipment costing over $1000
- Expenses will only include the purchases allotted thus far, rather than our budget proposal for the group's discretionary funds

	Cost
Personnel	$40,834.29
Fringe Benefits	$11,841.94
Overhead Costs	$20,432.83
Equipment Costs (not included in total)	$0
Expenses	$4571.99
TOTAL	$77,680.96

Table 3. Proposed budget based on university cost estimates.

9 Deliverables

The anticipated outcomes of the project can be broken down into the following categories and individual outcomes:

1. AUV
    a. Have a fully-functioning AUV capable of competing in the 2013 RoboSub competition
    b. Compete in the 2013 RoboSub competition
2. Deliverables
    a. Code of Conduct
    b. Needs Analysis and Requirements Specifications

    c. Project Plan and Product Specifications
    d. Conceptual Design
    e. Team Evaluation Report
    f. Final Design Deliverable Package Report
3. Presentations
    a. Conceptual Design
    b. Interim Design
    c. Final Design

10 References

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http://higherlogicdownload.s3.amazonaws.com/AUVSI/fb9a8da0-2ac8-42d1-a11e-d58c1e158347/UploadedImages/PDFs/RoboSub_Mission_Final_2012.pdf

2. McMaster-Carr http://www.mcmaster.com

3. Amazon http://www.amazon.com/Zotac-i3-2330M-2-2GHz-Barebone-ZBOXHD-ID82-U/dp/B008G9WB1I/ref=sr_1_1?s=electronics&ie=UTF8&qid=1349295946&sr=1-1&keywords=ZOTAC+ZBOX+ID82

4. Pololu http://www.pololu.com/catalog/product/2110

For additional information and references, please see the team website. http://coeRoboSub.wordpress.com