Deliverable 1: Needs Analysis and Requirements Specifications

EEL 4911C – Senior Design – Fall 2011 Deliverable

Team #4 (ECE) / Team #24 (ME)

Antony Jepson, Ryan Kopinsky, Hang Zhang
Department of Electrical and Computer Engineering, FAMU-FSU College of Engineering, Tallahassee, FL

Tra Hunter, Kashief Moody, Eric Sloan
Department of Mechanical Engineering, FAMU-FSU College of Engineering, Tallahassee, FL

Project Sponsor(s)

Project Advisor(s)

Dr. Bruce Harvey, PhD
Department of Electrical and Computer Engineering

Dr. Chiang Shih, PhD
Department of Mechanical Engineering

Reviewed by Advisor(s):

CONTENTS

1 INTRODUCTION

1.1 Overview of the RoboSub Project

The Association for Unmanned Vehicle Systems (AUVSI) desires to provide opportunities for students to experience the challenges of system engineering, to develop skill in accomplishing realistic missions with autonomous vehicles, and to foster relationships between young engineers and the organizations developing and producing autonomous vehicle technologies. As part of this mission, AUVSI has partnered with the U.S. Office of Naval Research (ONR) to design and host the RoboSub competition which requires students to design and build an Autonomous Underwater Vehicle (AUV) that is capable of navigating through an elaborate obstacle course while completing several specified tasks in a timely manner. The competition will be held in July 2012, and will be located in San Diego, California at the SSC SD TRANSDEC Facility which houses a large anechoic saltwater reservoir, to be used as the competition arena (Figure 1). The team's ultimate goal is to come up with a design that will win the competition and showcase the talent and dedication at the FAMU-FSU College of Engineering. It is further requested by the tournament directors that competing teams also submit a journal paper that describes the design of their vehicle and the reasoning behind their design choices, along with a video which will serve to introduce the design team and their approach to the event.

Figure 1: SSC SD TRANSDEC Facility Featuring the Anechoic Saltwater Pool

1.2 Team members

The team for this project is an interdisciplinary team consisting of Electrical, Computer and Mechanical Engineers. Table 1 lists the team members, their respective major, and their responsibility within the team.

Table 1: The RoboSub Team

Team Member	Major	Administrative Responsibility
Tra Hunter	Mechanical	Treasurer (ME)
Antony Jepson	Computer	Project Manager (Lead + ECE)
Ryan Kopinsky	Electrical	Secretary (ECE)
Kashief Moody	Mechanical	Secretary (ME)
Eric Sloan	Mechanical	Project Manager (ME)
Hang Zhang	Computer	Treasurer (ECE)

2 NEEDS ANALYSIS

2.1 Statement of the Problem

In order to successfully complete the aforementioned objective, the RoboSub will need to be equipped with several various sensory devices capable of detecting not only the surrounding environment, but also the dynamics of the vehicle itself. This intelligence information will need to be sent to the microprocessor for interpretation, ultimately yielding the desired output response from onboard subsystems. The responsibilities of these onboard subsystems will include stabilizing the AUV, propelling the vehicle in the proper direction in order to remain on the correct path throughout the course, achieving and maintaining the desired depth of the device underwater, and performing six specific tasks throughout the mission (as will be described below). Various requirements and constraints have been set forth by the tournament directors, which we must consider in our design. The tournament requires that an Autonomous Underwater Vehicle, journal paper, and a video from each competing team be submitted. A list of the required and desired capabilities of our AUV follows.

2.2 Required Capabilities / Needs

Autonomous Underwater Vehicle

Section / Requirement ID	Capability Definition
RC2.2.1	The vehicle must operate autonomously (no external/ remote control).
RC2.2.2	The AUV, and any parts connected to it, must submerge and remain submerged once the vehicle has embarked on its mission.
RC2.2.3	All electronics must be preserved in a waterproof environment.
RC2.2.4	The AUV must have a remote kill switch (in case of an emergency) which, when activated, causes the vehicle to rise to the surface of the water.
RC2.2.5	The vehicle must be slung on a harness or sling of some type for safety purposes during transportation.
RC2.2.6	The device should have onboard subsystems which enable the AUV to successfully complete the course tasks.
RC2.2.6.1	[Gate] The AUV should pass through the gate.
RC2.2.6.2	[Buoys] The AUV should strike two of the three buoys (Red, Green, and Yellow) in the given order.
RC2.2.6.3	[Box Crossing] The AUV should navigate through a box defined by PVC and imaginary sides (i.e. not all sides have physical boundaries).
RC2.2.6.4	[Drop-in-bin] The AUV should drop two markers in the correct bins (four total bins). Each bin will have a distinct symbol or object which will need to be sensed and deciphered.
RC2.2.6.5	[Torpedo] The AUV will need to fire two torpedoes (at a "safe" speed) through certain cut-outs of a PVC structure.
RC2.2.6.6	[Surface-and-Recover] Guided by a specific acoustic ping signal, the AUV must position itself under a designated octagonal region on the surface of the water. After the vehicle has completely surfaced within this designated region, the AUV must successfully recover a specified object. Thereafter, the AUV must navigate to the second octagon. After the vehicle has completely surfaced within the second designated octagonal region, the AUV must release the object.

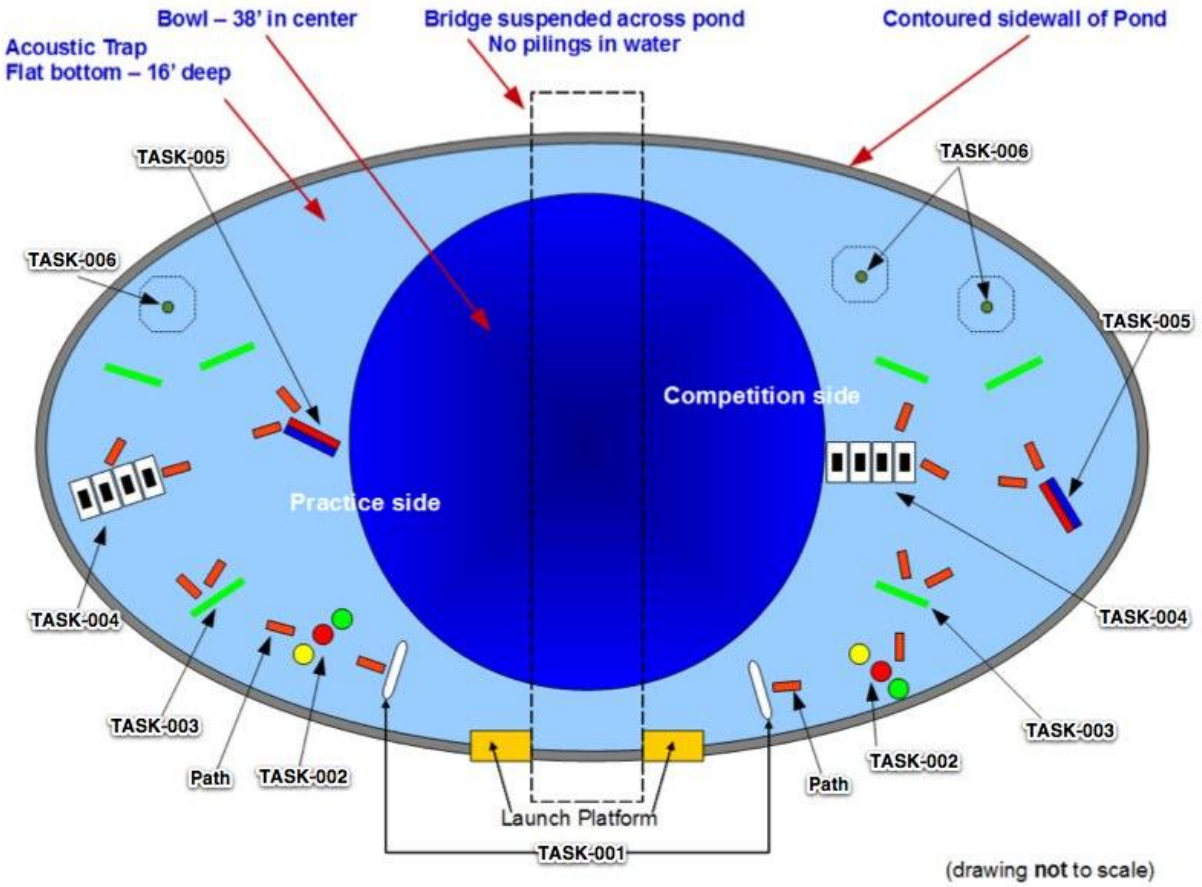

Figure 2: Schematic of the competition task layout. Note: This is based on the previous year's layout since the official 2012 competition rules have yet to be released. Only slight (if any) variations are expected.

Journal Paper

Section / Requirement ID	Capability Definition
RC2.2.7	The journal paper should clearly and concisely describe and illustrate each aspect of our AUV design, as well as the reasoning behind the design choices.
RC2.2.8	Student resumes should be included in the journal paper submission.

Video

Section / Requirement ID	Capability Definition
RC2.2.9	The video should introduce our design team and our approach to the event.
RC2.2.10	The video should be clear, concise, and informative, while conveying strong team cohesiveness and enthusiasm about both the design and competition.

2.3 Desired Capabilities / Wants

Section / Requirement ID	Capability Definition
DC2.3.1	The AUV should have onboard obstacle (i.e. shape, color, and audio) recognition and path tracking capabilities while underwater.
DC2.3.2	The vehicle should be able to sense its relative position, velocity, acceleration, and orientation while underwater.
DC2.3.3	The device should be able to interpret the input sensory information and output the proper mechanical function.
DC2.3.4	The AUV should be able to efficiently and effectively dissipate heat away from the electronics and into the environment (i.e. the flowing water) in order to maintain an acceptable internal/operating temperature.
DC2.3.5	The AUV should be built to maintain positive buoyancy when the motors are shut off so that the activation of the kill switch will naturally cause the device to surface.
DC2.3.6	The AUV should be as lightweight as possible while not compromising any functionality in order to obtain maximum points.
DC2.3.7	The AUV should have remote control capabilities (for testing).
DC2.3.8	The AUV should have a data logger (for testing and debugging).
DC2.3.9	The AUV should be able to send relevant data to a remote computer.
DC2.3.10	The AUV should be symmetrically designed in order to make the device easier to model and control.
DC2.3.11	The AUV should be aesthetically appealing, including the ability to see the onboard electronics via a transparent roof.

2.4 Operational Description

The device will be lowered into the salt water pool by tournament officials at a designated launch platform. Thereafter, the program will be initiated by simply pressing a start button, and the AUV will be deployed on its mission. During the mission, the AUV must navigate through the competition course by following a colored PVC path on the bottom of the pool. Along the journey, the vehicle will encounter each of the six different obstacles mentioned above, at which point the device will need to perform a specific task. The AUV will use various sensors to acquire information regarding the color and shape of the surroundings, as well as the relative position, velocity, acceleration, and orientation of the device. This intelligence will determine the proper output functions required from the propulsion, stability, and task-specific systems in order to keep the AUV headed along the correct path, maintain the desired orientation (which would

otherwise deviate due to disturbances), and properly complete each task. Following the completion of the mission, the tournament officials will retrieve the device.

3 REQUIREMENTS SPECIFICATIONS

3.1 Functional Requirements

Autonomous Underwater Vehicle

Section / Requirement ID	Requirement Definition
FR3.1.1	The vehicle must be able to complete all of the required tasks.
FR3.1.2	The vehicle must bear a clearly marked kill switch that a diver can readily activate. The switch must disconnect the batteries from all propulsion components and devices in the AUV.

Documentation

Section / Requirement ID	Requirement Definition
FR3.1.3	A journal must be provided.
FR3.1.3.1	The journal paper must be no more than 10 total pages long.
FR3.1.3.2	The journal paper must include an abstract of no more than 250 words.
FR3.1.3.3	The journal paper must be printed on 8 ½" x 11" paper with margins of at least 1" on all sides, and all text must have a font size of at least 12.
FR3.1.3.4	The journal paper must be received in pdf format via email by a specified deadline.
FR3.1.4	A video must be provided.
FR3.1.4.1	The video must have a duration of 3 – 5 minutes.

3.2 Non-Functional Requirements

Section / Requirement ID	Requirement Definition
NFR3.2.1	The vehicle must be battery powered.
NFR3.2.2	All batteries must be sealed to reduce the hazard from acid or caustic electrolytes.
NFR3.2.3	Batteries may not be charged inside of sealed vessels at any time while on the

	site of the competition and/or while engaged in the competition.
NFR3.2.4	The open circuit voltage of any battery (or battery system) in a vehicle may not exceed 60 VDC.
NFR3.2.5	All propellers must have a shroud with a minimum 2" spacing between the propeller and the back of the shroud.
NFR3.2.6	The AUV must fit within a 6' x 3' x 3' (1.83 m x 0.91 m x 0.91 m) box.
NFR3.2.7	The AUV must weigh less than 110 lbs (50 kg) in order to be eligible for competition, but must weigh less than 84lbs (38 kg) in order to avoid deductions.
NFR3.2.8	Each marker and torpedo must fit within a 1.5" x 1.5" x 6" (3.81 cm x 3.81 cm x 15.24 cm) box.
NFR3.2.9	Each marker and torpedo must weigh no more than 1.5 lbs (0.68 kg) in air.
NFR3.2.10	The vehicle must be capable of completing the competition course in the allotted 15-minute time frame while sustaining sufficient battery life.
NFR3.2.11	The vehicle must be buoyant by at least one half of one percent (0.5%) of its mass when it has been shut off through the kill switch.

3.3 Constraints

Section / Requirement ID	Constraint Definition
C3.3.1	The device should not have any sharp corners/ edges in order to prevent damage to test environments (e.g. FSU Morcom Aquatics Center).
C3.3.2	Each team is apportioned 20 minutes for competition—5 minutes for preparation period, and 15 minutes for performance period.
C3.3.3	The cost of the UAV cannot exceed the donated funding amount, including the additional travel expenses (currently $7,433).

4 PRELIMINARY TEST PLAN

4.1 Capabilities Test Plan

Autonomous Underwater Vehicle

- The waterproof capability of our AUV will be tested by deploying the vehicle underwater in the FSU Morcom Aquatics Center, having the vehicle dive vertically to the maximum depth of the test pool, remain at this maximum depth for twenty minutes, and then surface. The AUV will be analyzed for any leakage, and the assessment of this capability will result in either a pass or fail.

- A simulated environment will be constructed in the FSU Morcom Aquatics Center, where the mission will be deconstructed by tasks. Each task will be individually tested, and

thereafter, the transition between tasks will be tested by progressively expanding the replicated environment. The determination of successful completion will simply be based on a pass/fail criterion in the ability of the AUV to accomplish each task and transition to the following task in the reconstructed obstacle course.

4.2 Requirements Test Plan

Autonomous Underwater Vehicle

- Following construction of the final prototype, the AUV and the torpedoes will be weighed to ensure that they meet the respective weight requirements set forth. Theoretical weight measurements of both the device and the torpedoes will also be made in Pro/E in order to ensure that the expected actual weight will be acceptable.

- The dimensions of entire AUV and the torpedoes will also be measured to verify that they meet the respective size requirements set forth. Theoretical size measurements of both the device and the torpedoes will also be made in Pro/E in order to ensure that the expected actual dimensions will be acceptable.

Journal Paper

- The journal paper will be proof-read to ensure that the requirements set forth have been met.

Video

- The video will be timed to ensure that the duration is within the required range.

4.3 Constraints Test Plan

Autonomous Underwater Vehicle

- A checklist will be created to verify that all the constraints have been met following the completion of the AUV.

5 REFERENCES

[1] *AUVSI_Rules_2010*. San Diego: AUVSI Foundation, 2010. PDF.

[2] *AUVSI_Rules_2011*. San Diego: AUVSI Foundation, 2011. PDF.