

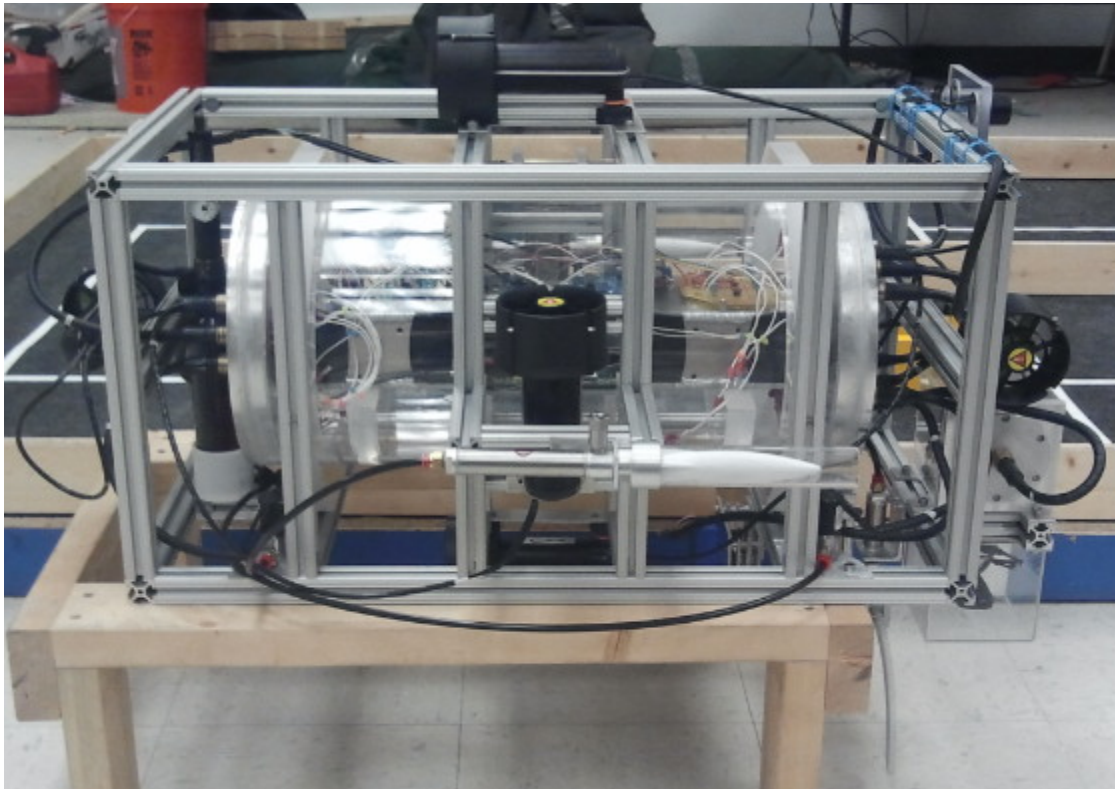
EML 4551C Senior Design

Project: RoboSub Needs Analysis and Requirements Document

Team # 21 Date: 25 September 2012

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RoboSub 2012



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Project 21– Specifications and Requirements

9/25/2012 Rev. 1 Original Document

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1 Introduction to the Project

For this senior design project the students have been given the task of designing, building, testing, and competing in the Autonomous Underwater Vehicle (AUV) competition. The AUV competition is sponsored by the Association for Unmanned Vehicle Systems Integration (AUVSI) and the United States Office of Naval Research (ONR). The purpose behind the AUV competition is to allow students a chance to not only design but build and test an autonomous vehicle. This allows students to see the difficulties faced in trying to create a autonomous system, along with the challenges faced when moving a project from the design phase to the build and testing phases. The competition will be held at the TRANSDEC Anechoic Pool in San Diego, California July 2013 (see figure 1). The TRANSDEC is 300 ft by 200 ft by 38 ft deep containing 6 million gallons of chemically treated salt water, to replicate ocean conditions, and is continuously circulated to maintain isothermal conditions. During competition the TRANSDEC is split into 2 sides, one for competition and one for practice runs. The AUV competition requires that the AUV designed and built by the students be able to autonomously negotiate an obstacle course while completing certain objectives. The rules for the 2013 AUV competition will not be released until November 2012, so all analysis will be based upon the previous year's competition until this year's competition rules are released.



Figure 1. Aerial image of TRANSDEC Anechoic Pool

2 Overview of the Design Team

- **Treasurer: Santiago**
 - Responsible for keeping track of the team budget and expenditures - latest version should be posted in a place accessible to all team members, preferably Google Docs
 - Solely responsible for making and approving purchases
 - Create and maintain list of desired components or donations to request from sponsors
- **Secretary: Lead – Sondra; Backup – Alex**
 - Responsible for attending all meetings, and obtaining notes from other members on smaller “huddles” if they pertain to the project as a whole
 - Type up or otherwise post minutes to be available to all members and on website
- **Project Manager and Coordinator: Kyle**
 - Responsible for keeping team on track, first point of contact if intra-team problems arise
 - Responsible for breaking project down into manageable assignments to give to the team
 - Keep track of deadlines for department tasks and other tasks that may arise.
 - Make sure that all submissions are delivered on time
 - Point of contact for advisors, and so must stay abreast of general team progress
- **Webmaster: Alex**
 - Maintain back-end of team website
 - Provide team members with ways to edit and provide content to website as desired or necessary
 - Integrate team feedback as feasible
 - Ensure that website content is updated regularly for viewing by advisors
- **Lead Program Designer: Darryl**
 - Responsible for dictating all of the communication protocols between each component.
 - Responsible for programming the master controller that interfaces with all of the components.
 - Liaison between other teams and the programmers to ensure system compatibility
 - It is preferred, but not required, that this person be intimately acquainted with the majority of the code, i.e. writing at least one component, knowledge of all languages used, etc.
- **Testing Engineer: Stuart**
 - Responsible for designing test course to check overall system operation in conditions similar to competition
 - Responsible for ensuring testing equipment is built to correct parameters
 - Confirm acceptable operation of RoboSub components as they are built
- **Electrical Systems Lead: Alex**
 - Responsible for designing electrical system for maximum manageability and stability
 - First point of contact in group for electrical questions and concerns
 - Ensure that all components are able to operate correctly in the electrical system
- **Mechanical Systems Lead: Gregory**

- Stay abreast of developments in mechanical systems
- Liaison between mechanical group and other teams to ensure compatible designs
- Approves mechanical designs if they are built
- **Publicity Lead: Darryl**
 - Responsible for organizing group liaisons with potential sponsors
 - Responsible for setting up ways for the group to raise project awareness and solicit funds
 - First point of contact for potential sponsors and other interested parties
- **Media Development: Alex**
 - Organizes media development in group
 - Approves media developed by group for use as publicity material
 - First point of contact for other media-related tasks that may arise
- **General Team Tasks:** In addition to the roles above, every member must be actively involved in at least one of the following capacities at all times:
 - Programming
 - CAD Design
 - Fluid Dynamical Design
 - Design and manufacture of practice course and test setups
 - Completion and review of required documentation
 - Other roles TBA upon more information
- **Dynamic**
 - More responsibilities may be created if needed
 - Team members may resign from their responsibilities if necessary and be replaced by other member(s) as agreed upon by the team. Resigning from a responsibility should not reflect badly on the member, unless it demonstrates a lack of commitment to the project.
 - If a member is not fulfilling their responsibility adequately, the team may elect to “fire” the member from that responsibility given a unanimous decision of the other members. The team must agree upon a way to account for the missing position. Being “fired” from a position is highly undesirable, and team members should resign from their position on their own if they cannot handle the tasks involved.

3 Needs Analysis

3.1 Overview of the Project

The goal of this project is to produce an Autonomous Underwater Vehicle (AUV), or RoboSub, that will complete the tasks outlined in the competition document. The requirements for the 2013 competition have not yet been released, but the requirements are expected to be very similar to the 2012 requirements outlined below.

According to the 2011 RoboSub Final Mission document,

“The fundamental goal of the mission is for an AUV to demonstrate its autonomy by completing an underwater Ides of TRANSDEC mission. The vehicle will be able to commence in training (dock/release buoys), pass over an obstacle course (PVC pipe to pass over), enter the gladiator ring (drop markers), Et tu Brute? (shoot torpedoes through a cut-out), feed grapes to the emperor (manipulate a cylinder), and finally collect the Laurel wreath and crown the emperor (find a pinger, grab an object and move/release the object).”

In addition, the following competitive limitations will also apply to our robotic submarine

- Weight and size constraints
 - The device must fit within a 6’x3’x3’ box or be disqualified.
 - The device must weigh less than 125 lbs or be disqualified.
 - If the device weighs more than 84 lbs, the team will be automatically penalized during the competition.
 - Bonuses are given to all devices under 84 lbs
- Equipment parameters
 - All deployed markers must fit within a 2”x2”x6” box. They must weigh no more than 2 lbs in the air.
 - Exceeding these requirements by more than 10% will result in disqualification.
 - Exceeding these requirements by less than 10% will result in a penalty.
 - Torpedoes: Size specifications and requirements are identical to those of the markers. Torpedoes must not travel fast enough to cause a bruise on personnel upon impact.
 - The RoboSub must have an accessible kill switch that disconnects the batteries.
 - The RoboSub must have sling connectors for ease of transport and weighing.
- Operation in competition
 - The RoboSub will have 15 minutes to complete all tasks during the competition. All activities undergone at this time must occur autonomously; if desired, the AUV may survey the arena (autonomously) during this time. This time does not include deployment and recovery time.
 - The team will have no more than five minutes to outfit the AUV before it must perform. The AUV will be mounted on a crane or placed on the dock at this time, and cannot touch the water.
 - The team is never allowed to touch the water.
 - The AUV may not communicate remotely with any personnel or off-board computers while performing.
 - The AUV must not surface except for in the designated PVC ring.
 - The AUV may complete the objectives in any order, except for the gate which must be completed first.

3.2 Statement of the Problem

The goal of this project is to design and assemble an AUV (autonomous underwater vehicle) which can reasonably compete in the AUVSI competition. In order to fulfill this goal, the AUV must be able to complete a substantial portion of the course, which is summarized below as a list of capabilities.

Note that the capabilities below represent specific requirements and functionalities of the final design, but do not limit the designs that may be employed to meet these requirements. However, the RoboSub must comply with all rules and constraints while achieving the functionalities below.

Required Capabilities

CAP-001: The RoboSub must autonomously complete all objectives.

CAP-002: The RoboSub must pass through a gate. (First task)

CAP-003: The RoboSub must follow a path constructed of flat PVC through the course. (Path)

CAP-004: The RoboSub must strike colored buoys in a predetermined order. (Training)

CAP-005: The RoboSub must be able to pass through a rectangular PVC gate. (Obstacle Course)

CAP-006: The RoboSub must successfully drop markers into bins. (Bins)

CAP-007: The RoboSub must shoot torpedoes through circular targets at a speed that will not endanger judges. (Et Tu Brute)

CAP-008: The RoboSub must follow an acoustic pinger, surface inside a PVC octagon at the top of the pool, pick up and securely hold a PVC rig (wreath), navigate and surface to another octagon near the surface, and then redeposit the rig on a predetermined resting place. (Laurel Wreath & Emperor's Palace)

3.3 Operational Description

Since the requirements of the contest state that the AUV must operate autonomously, minimal user interaction will be required. Once a starting signal is received, the AUV will commence the completion of contest objectives, with no interference physically or wirelessly from an outside source.

The AUV will have a kill switch that can be manually activated. If possible, this kill switch should also be remotely accessible.

4 Requirements Specifications

Section 4 describes the various requirements and constraints that will determine the nature of the final design. Requirements have been grouped into functional requirements, non-functional requirements, and constraints. Functional requirements represent specific behaviors and technical details regarding the design. Non-functional requirements are less specific, but can still be used to judge the performance of the AUV. Requirements have been converted to engineering specifications and compared with the primary competition in a House of Quality included in Appendix A.

4.1 Functional Requirements

These specify desirable behaviors of the AUV and specifications. They dictate how tasks should be performed and how certain components must be designed. Some requirements may make reference to specific dimensions, measurements, etc.

REQF-0001: The RoboSub must be under a maximum weight of 125 lbs, preferably lighter.

REQF-0002: The entire AUV shall be no larger 6' long, 3' wide, and 3' high.

REQF-0003: The AUV must contain and employ an inertial measurement unit (IMU). (may be a potential solution, but not a requirement)

REQF-0004: The AUV must be able to perform all competition tasks autonomously.

REQF-0005: The AUV must have all equipment required to complete the tasks on-board during the competition.

REQF-0006: Markers and torpedoes used by the AUV cannot be larger than 2"x2"x6" and weigh more than 2 lbs in air. They must also bear the team name or emblem.

REQF-0007: The AUV must be able to be supported in a sling for weighing and transportation purposes.

4.2 Non-functional Requirements

The non-functional requirements can be used to judge the performance of the AUV, but do not necessarily mention specific behaviors or design criteria.

REQNF-0001: The RoboSub should have a low hydrodynamic drag.

REQNF-0002: The RoboSub should be visually appealing.

REQNF-0003: The RoboSub should be of a modular, easy to maintain construction to impress the contest judges.

REQNF-0004: The RoboSub should accommodate easy access to all interior components and electronics

4.3 Constraints

The constraints below are limitation imposed by the rules of the 2012 AUVSI competition. These restrictions will dictate how certain components and systems may be designed in order to be eligible to compete.

CONS-0001: The torpedoes being used should be operated at a “safe” speed, that would not cause injury to a person.

CONS-0002: The markers and torpedoes used in the competition must be able to fit within a 2"x2"x6" box and weigh no more than 2 lbs in air.

CONS-0003: The dry weight of the submarine must not exceed 125 lbs.

5 Preliminary Test Plan

The following subsections provide a framework for the testing of AUV systems. Subsection 5.1 details the tests that will be employed to demonstrate the AUV’s competence at completing desired tasks and capabilities. Subsection 5.2 outlines how the team will verify the AUV meets the requirements set forth in earlier sections. Finally, subsection 5.3 covers how the team will demonstrate that all constraints are satisfied by the design.

5.1 Capabilities Test Plan

The device will be placed in a freshwater pool at the Florida State Aquatics center in order to verify basic functionality. The competition will take place in salt water, so the team will design the device accordingly to operate in the appropriate environment. The most notable difference will be the buoyancy required; since salt water is more dense than fresh water, the device is expected to sink more rapidly during freshwater testing. All evaluations of the completion of objectives will be made according to section 6.3 in the previous year’s contest rules.

CAP-001: The RoboSub must autonomously complete all objectives.

A test course will be designed and assembled at the Florida State University Morcom Aquatics Center. The course will mimic the obstacles that will be present at the competition as nearly as feasible without causing damage to the pool.

CAP-002: The RoboSub must pass through an obstacle course.

Among the equipment used in the test course will be a gate which mimics the construction of the gate at the competition. The AUV must pass through the gate. Ideally, the AUV will travel in a straight line through the gate.

CAP-003: The RoboSub must follow a path constructed of flat PVC through the course.

A PVC trail will be constructed. Any coloration or distinguishing features used in the competition will be mimicked; for example, the team presently anticipates using a fluorescent orange paint or tape to color the path. The AUV will be launched in the freshwater pool and is expected to follow the path reasonably well, after accounting for differences in color in the competition pool. If the color is expected to differ greatly, the team will test the computer's response to the correct color

in a component test and use code optimized for the freshwater color during test runs.

CAP-004: The RoboSub must strike colored buoys in a predetermined order.

Buoys will be constructed to match the size, color, and shape of the competition buoys. If color is a significant issue, it will be handled in the same manner as for CAP-003. Ideally, the AUV will directly strike each buoy in the intended order.

CAP-005: The RoboSub must be able to pass through a rectangular PVC gate.

A rectangular PVC gate will be constructed to mimic the competition gate as nearly as possible. The AUV is expected to be able to pass through the gate after correctly identifying it. If coloration is an issue, it will be handled as for CAP-003.

CAP-006: The RoboSub must successfully drop markers into bins.

Bins will be constructed for the test course to mimic the competition bins. The AUV will drop markers into the bins, both during a full test course run and during runs of individual tasks. All code will be optimized for the colors expected at the competition; if the AUV is unable to properly recognize freshwater colors, the issue will be handled as in CAP-003. Ideally, the AUV will drop the correct marker in the correct bin. At minimum, the AUV will drop a marker in a bin.

CAP-007: The RoboSub must shoot torpedoes through circular targets.

Circular targets identical to the dimensions of those in the contest will be constructed. Ideally, the AUV will be able to shoot a torpedo through the target at some predetermined distance at a speed that would not bruise a human. At minimum, the torpedo should hit the target.

CAP-008: The RoboSub must pick up a PVC rig (wreath) in a way that the rig is secure and then surface inside a PVC circle at the top of the pool, and then redeposit the rig on a predetermined resting place.

5.2 Requirements Test Plan

REQF-0001: The RoboSub must be under a maximum weight of 125 lbs, preferably lighter.

The AUV will be weighed on a scale. The weight on the scale should be less than 125 lbs. During the development and redesign phase, the weight of each added component will be tallied for a weight estimate.

REQF-0002: The entire AUV shall be no larger 6' long, 3' wide, and 3' high.

The dimensions of the AUV will be measured with a tape measurer. Also, all designs that do not conform to this requirement will be rejected.

REQF-0004: The AUV must be able to perform all competition tasks autonomously.

All capabilities testing will be conducted with the AUV performing autonomously. If human interaction is necessary for objective completion, all, or at least some, objectives will not be deemed achieved.

REQF-0005: The AUV must have all equipment required to complete the tasks on-board during the competition.

The equipment used such as the torpedoes and markers must be securely maintained on-board the AUV until the designated time in which these components are used.

REQF-0006: Markers used by the AUV cannot be larger than 2"x2"x6" and weigh more than 2 lbs in air.

The markers of the AUV will be measured and weighed to ensure that they meet this testing requirement. All designs that do not conform to this requirement will be rejected.

REQF-0007: The AUV must be able to be supported in a sling for weighing and transportation purposes.

The AUV will be transported to the test area using a handcart and support frame. Better means of transporting it can be looked into if the need arises.

REQNF-0001: The RoboSub should have a low hydrodynamic drag.

A more hydrodynamic flow design shall be created for the AUV body. Considering the test result calculations of the flows when thrusters are running in water will determine if modifications to the design will be required.

REQNF-0002: The RoboSub should be visually appealing.

Aesthetic changes to make the AUV visually appealing will be secondary to the main goals of the testing and competition.

REQNF-0003: The RoboSub should be of a modular, easy to maintain construction to impress the contest judges.

A container component shall house the electronics, with a minimal as possible amount components of the AUV jutting out past the main body of the sub.

REQNF-0004: The RoboSub should accommodate easy access to all interior components and electronics.

The housing of the AUV will have components that allow easy access to the electronic hardware components and wiring. A window of 5 minutes should be the maximum time it takes to open, tamper, and again seal the housing of the sub.

5.3 Constraints Test Plan

CONS-0001: The torpedoes being used should be operated at a “safe” speed, that would not cause injury to a person.

The team will test the torpedo speed and power by having an individual at a safe distance catch the torpedo and judge it’s power. Adjustments will be made to the the torpedo system if the torpedos travel below or beyond a “safe speed.”

CONS-0002: The markers and torpedoes used in the competition must be able to fit within a 2"x2"x6" box and weigh no more than 2 lbs in air.

As referenced in REQF-0006, these components will measured and kept to the strict design requirements.

CONS-0003: The dry weight of the submarine must not exceed 125 lbs.

In reference to REQF-0001, the AUV shall be measured with a scale and adjusted to be within this constraint.

6 References

1. AUVSI Foundation Website - 2012 Mission and Rules

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

2. Transdec Wikimapia website- Transdec details

<http://wikimapia.org/1362997/TRANSDEC-Anechoic-Pool>

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Appendix A

Title: RoboSub House of Quality
 Author: Franco, McGowan, Miller, Miller, Robertson, Royal, Smith
 Date: 9/24/2012
 Notes: This graph is included to illustrate the House of Quality design methodology. The RoboSub project has a clear list of engineering requirements in the competition guidelines.

