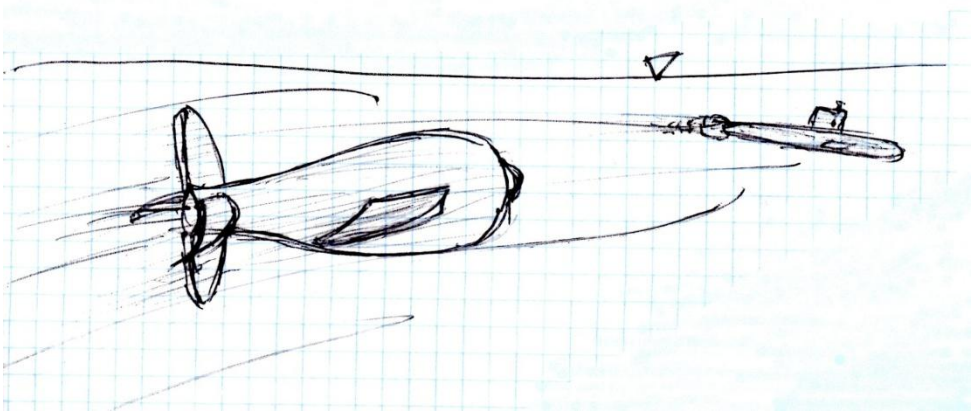
Memorandum

To: Professor Coburn Date: June 8th, 2014

From: Brian Martin

Subject: Senior Project Proposal/Primer Package

The following pages contain the required elements of the senior project proposal package as they relate to the senior project that I wish to launch. The specific section breakdown of this package is as follows:



Topic

Phase I (ME 325/L)

Design of an innovative underwater propulsion system based off of an annular screw concept

- Resulted in *SHEILA-D (Submerged Hydrodynamically propelled Explorer, Implementation: Los Angeles – Demonstrator).*

Phase II (EGR 481/482)

Design of an innovative, highly maneuverable, stealthy unmanned underwater vehicle with ISR* capabilities

**ISR here refers to Information, Surveillance, and Reconnaissance.*

Objective

The objective of this senior project is to develop an unmanned underwater vehicle (UUV) based off of an innovative propulsion system, merit of which was demonstrated through completion and testing of SHEILA-D (as defined above), an innovative propulsion system demonstrator developed through a ME 325/L project.

SHEILA-D (as developed in ME 325/L) was a Phase I concept demonstrator and, in as much, accomplished the goal of producing thrust through the propulsion mechanics that the project was designed to test. The senior project (as will be developed in EGR 481/482) will be Phase II of this effort and will focus on the design, building, and testing of the full solution, namely, the fully operational underwater vehicle (UV). The propulsion mechanism developed through SHEILA-D will either be directly used or adapted for use in the UV, as determined by the results of performance characteristic, flow field, and other types of testing that will be conducted during the Summer 2014 time period.

The senior project will be comprised of many subsystems, which must be integrated together in order to produce the fully operational vehicle; some of these subsystems are as follows:

- Propulsion system (as adapted from SHEILA-D)
- Maneuverability systems
    - Control surfaces
    - Control electrical systems
    - Control module
- Buoyancy system
    - Buoyancy control (mechanical components, etc.)
    - Buoyancy control electrical systems
    - Buoyancy control module

- Body
    - Streamlining
    - Subsystem housing
    - Structural support system
- Communications/Autonomy System
    - More than likely autonomous, not remotely operated, as this compromises stealth and limits the area of operations
    - \Possibly some sort of sensing and avoidance system

The above systems are those that have been selected as the focus of the Phase II effort. This list may be amended or added onto as the project progresses, but the main system decomposition (Propulsion, Maneuverability, Buoyancy, Body, Communications/Autonomy) will remain in place, but may be added to as any issues may arise over the course of the project.

In terms of engineering subject decomposition, the senior project goals will be assessed through the following major subjects/categories:

- Mechanical design
- Electromechanical systems
- Materials selection
- Fluid mechanics
- Heat transfer (see Challenges/Obstacles)

None of these subjects saw optimal usage in the Phase I effort, mostly on account of lack of time and proper funding. Both of these deficiencies will be corrected for in the Phase II effort.

Mission Objectives

(As per the initial Mission Objectives sheet developed in April 2014)

Mission Objectives*

1. Fluid/smooth maneuvering
2. Higher speeds
3. STEALTH
    i. Thermal signature
    ii. Magnetic signature
    iii. Noise
    iv. Flow signature
    v. Cavitation
    vi. Inconspicuous
4. Little to no human interaction necessary

*These objectives were set out in the initial concept stage of this project and must be carried through to the final design/testing phases. Violation/endangerment/jeopardizing of these mission objectives is equivalent to a failure of the mission; as such, these mission objectives should be upheld throughout the project period and must be repeatedly referenced for compliance.

Operational & Design Objectives

The operational and design objectives will be more comprehensively assessed at the end of the Summer 2014 time period; a short list of initial operational objectives which are subject to alteration at the end of the aforementioned time period follows:

- Depth range of ~100-200 ft
- Speed of ~ 5 knots
- Size limited to approximately that of a scuba tank
- Weight which aims to increase thrust-to-weight ratio, but reduce the amount of positive buoyancy that the buoyancy control systems must overcome; the weight might possibly be used to induce neutral buoyancy at a prescribed depth
- Operational times of ~ 1 hour at full power
- Maximization of internal space for stowage of the sensor suite
- Eases of storage and transportation/portability
- Ease of maintenance/reduction in required maintenance

Partners

Brian Martin, Ketton James, Ben Saletta, Andrew Blancarte, Abraham Paucar

Team Member Profile Forms

Team UV Team Member Profile Form Date: 5/24/14

I. Academic Info

Team Member Name: Brian Martin Date Joined Team (MM/YY): 04/14

Major Curriculum Year: M.E. 09-10 Current Standing (i.e. 5th Year): 5th Year

Expected Graduation Quarter: Winter 2015 Interested in Higher Academic Degrees (Yes/No): Yes

If marked Yes, list any associated interests:

Fluid Mechanics, Materials Science, Aerospace Eng., Automotive Eng., Naval/Marine Eng.

II. Career Info

List any industries/fields/topics of interest:

Defense industry, all topics listed above.

List any jobs of interest:

Designing vehicles (sea, air, land, manned, unmanned, etc.) in defense industry.

III. Project Info

List favorite aspect(s) of your role in the project thus far:

Overall system design, fluid mechanics.

List the aspect(s) of the project that you are most interested in going forward:

fluids/performance characteristics, innovative subsystem & system solutions.

IV. Capabilities Info

List a few strengths that will help the team moving forward:

- Ability for/experience with innovation.
- Well read/studied.
- Extremely passionate about engineering & this specific project.

List at least one weakness/area you think you can improve in:

-Shy, so leading a team can be difficult. -Very busy, need to further improve time management.

V. Additional Comments

Hobbies: Wakeboarding, hiking/camping (& offroading), dogs, reading/learning, engineering projects.

Passion: engineering, defense industry, support for military, dogs, all things water based, this project.

If you have *anything* else you would like to comment on, please list here:

- hope to one day open my own small, special projects type engineering firm for projects like this one.
- Stoked about the future of this project & this team.

Team UV Team Member Profile Form Date: 6/2/2014

I. Academic Info

Team Member Name: KETTON JAMES Date Joined Team (MM/YY): 04/2014

Major/Curriculum Year: ME/2008 Current Standing (i.e. 5th Year): 6th

Expected Graduation Quarter: June 2015 Interested in Higher Academic Degrees (Yes/No): Yes

If marked Yes, list any associated interests:

SOLID MECHANICS AND/OR MBA

II. Career Info

List any industries/fields/topics of interest:

OTIS ELEVATOR, BECOMING STRESS ANALYST TO ELEVATOR DESIGN

List any jobs of interest:

~~[illegible]~~ JET TURBINE ENGINEER

III. Project Info

List favorite aspect(s) of your role in the project thus far:

INITIAL DESIGN/DESIGN REFINEMENT.

List the aspect(s) of the project that you are most interested in going forward:

FURTHER DESIGN REFINEMENT/INNOVATION

IV. Capabilities Info

List a few strengths that will help the team moving forward:

ANOTHER VIEW TO CREATE A SOUND DESIGN.

List at least one weakness/area you think you can improve in:

AVAILABILITY AND ANALYSIS

V. Additional Comments

Hobbies: RECREATIONAL SPORTS, & WORKING ON MY CAR.

Passion:

LEARNING NEW THINGS. TAKING ON ANY NEW CHALLENGE.

If you have *anything* else you would like to comment on, please list here:

Team UV Team Member Profile Form Date: 5/27/14

I. Academic Info

Team Member Name: Ben Saletta Date Joined Team (MM/YY): 04/3/14

Major Curriculum Year: ME 10-11 Current Standing (i.e. 5th Year): 4th Year

Expected Graduation Quarter: Spring 15 Interested in Higher Academic Degrees (Yes/No): Yes

If marked Yes, list any associated interests:

Ocean Engineering, Fluid Mechanics

II. Career Info

List any industries/fields/topics of interest:

Ocean, Sustainability, Biomimicry, innovation

List any jobs of interest:

Ones that Pay Money. Design Engineering

III. Project Info

List favorite aspect(s) of your role in the project thus far:

Finding creative solutions to problems & working around obstructions

List the aspect(s) of the project that you are most interested in going forward:

Simplifying & Controling Navigation.

IV. Capabilities Info

List a few strengths that will help the team moving forward:

Creative Problem Solving, Some practical experience with electrical controls

Some welding experience.

List at least one weakness/area you think you can improve in:

I tend to over Invest in Myown Ideas.

V. Additional Comments

Hobbies: SCUBA Diving, Rock Climbing

Passion:

Underwater exploration,

If you have *anything* else you would like to comment on, please list here:

Team UV Team Member Profile Form Date: 5/27/14

I. Academic Info

Team Member Name: Andrew Blancarte Date Joined Team (MM/YY): 04/14

Major/Curriculum Year: M.E 2008-09 Current Standing (i.e. 5th Year): 6th Year

Expected Graduation Quarter: Winter 15 Interested in Higher Academic Degrees (Yes/No): No

If marked Yes, list any associated interests:

II. Career Info

List any industries/fields/topics of interest:

Product Development, Medical Equipment, robotics.

List any jobs of interest:

Testing and/or Quality

III. Project Info

List favorite aspect(s) of your role in the project thus far:

I really enjoyed the manufacturing phase of our project and testing.

List the aspect(s) of the project that you are most interested in going forward:

Arduino coding, controls, electronics.

IV. Capabilities Info

List a few strengths that will help the team moving forward:

Willing to commit large amounts of time. Very hands on.

List at least one weakness/area you think you can improve in:

I would like to be more involved with design calculations.

V. Additional Comments

Hobbies: Working on Sheila-D, Driving my Camaro, Spending time w/the family

Passion:

Passion for Success :)

If you have *anything* else you would like to comment on, please list here:

Team UV Team Member Profile Form Date: 5/26/14

I. Academic Info

Team Member Name: Abraham Paucar Date Joined Team (MM/YY): 04/14

Major/Curriculum Year: ME / 2009 Current Standing (i.e. 5th Year): 5th Year

Expected Graduation Quarter: Spring 2015 Interested in Higher Academic Degrees (Yes/No): (Yes)

If marked Yes, list any associated interests:

Materials / Stress Analysis

II. Career Info

List any industries/fields/topics of interest:

Materials, Stress analysis

List any jobs of interest:

anything

III. Project Info

List favorite aspect(s) of your role in the project thus far:

Design of SHEILA, stress calculations

List the aspect(s) of the project that you are most interested in going forward:

Controls and programming

IV. Capabilities Info

List a few strengths that will help the team moving forward:

Stress analysis, machine design, experiance w/ Arduino programming

List at least one weakness/area you think you can improve in:

Design suggestions

V. Additional Comments

Hobbies: Music, Dance, Sleeping, Hiking, Jesus

Passion:

If you have *anything* else you would like to comment on, please list here:

Schedule/Timeline

The following schedule is subject to change and **will** be changed in the coming months as the amount of work completed over Summer Break (06/16/14-09/25/14) will be reflected in a much more polished schedule which will be developed in mid to late September 2014. As such, the schedule below is a *very* rough picture of the objective timeline.

Date		Description	Tasks	Notes
Start	End			
06/16/14		1st Phase II (Intro) Meeting	Phase I debrief, financial assets, project organization, concept	
06/16/14	09/25/14	Summer Break	Concept, preliminary calcs, preliminary drawings, parts search, redesign (post parts search)	Meetings every other week (possibly more often in September)
09/25/14	12/13/14	Fall 2014	Redesign (post parts search), complex calcs/analysis, manufacturing start	At least weekly meetings
12/13/14	01/06/14	Winter Break	Manufacturing/assembling	At least weekly meetings
01/06/15	**03/21/15**	Winter 2015	Manufacturing/assembling, testing, final analysis, report preparation	At least weekly meetings **Project Deadline: 03/21/15**
03/21/15	06/30/15	Spring 2015	Polishing, presentation preparation	Meetings every other week
06/30/15		Project Symposium	Project presentation	Set sights on Showcase

Challenges/Obstacles

As with any project that ventures into the unknown and attempts to accomplish what has not been done before, this project is born into a nest of challenges and obstacles, a relatively short list of which follows (as classified into one of four categories).

Design

Many of the same design challenges as were faced in the Phase I effort will continue to represent obstacles in the Phase II effort; but, as always, obstacles exist to be overcome. Some of the challenging areas that will be carried over from the Phase I effort include:

- Sealing/waterproofing
- Streamlining/reduction of drag
- Efficient use/transmission of power to produce thrust
- Proper structural support

Along with these continuing challenges will come a whole slew of new challenges, including:

- Navigation (communication/autonomy)
- Maneuverability (directional control)
- Buoyancy control
- Heat transfer (for electronics cooling and reduction of thermal signature)

- Materials selection (for corrosion control, weight control, cost control, manufacturability, reduced thermal, noise, magnetic, signature)

Analysis

Just as was the case in the Phase I effort, virtually any analysis that will be done in the Phase II effort will have to be adapted from a wide variety of theories, which will need to be integrated together to provide the formulas and methodology needed for the analytical portion of this project. This is the case because of the innovative nature of the project. Some of the topics which relate to the analysis that will need to be performed, but which literature cannot be found or does not exist for, include:

- **Annular screw flow**
- Highly dynamic/acrobatic movement of an underwater vehicle
- Stealth on the small scale of this project
- Small scale buoyancy control

Some areas in which literature exists, but is not readily applicable to this project include:

- Sealing/waterproofing of a system subjected to great hydrostatic pressures
- Streamlining/drag reduction for a relatively high speed/highly dynamic, small scale UV
- Control surface design for a relatively high speed/highly dynamic, small scale UV

Lastly there are some areas in which literature has recently become more available with the recent upswing in popularity of underwater vehicles; therefore, these subjects represent less of a challenge with respect to analysis, but will still be time consuming in their adaptation. These areas/subjects are as follows:

- Navigation (more specifically, autonomous underwater vehicles (AUVs) have recently come into the spotlight; however, none of these vehicle are high speed nor high mobility, so this may lead to some interesting challenges)
- Materials selection for weight, cost savings, and corrosion control with respect to ocean-going vehicles (although current literature is unlikely to discuss stealth considerations)

Manufacturing

This specific subset of complications revolves around the fact that in order to fulfill all of the challenges listed in the Design section (as well as *many, many* challenges that were not listed there), many custom parts will have to be manufactured, as Commercial Off The Shelf components (COTS) will simply not fit the needs associated with this project. In addition to this, as was seen in the Phase I effort, many of the tolerances must be held quite tight in order to produce optimal results.

Financial

This is truly the most limiting of all of the challenges that will be faced in the Phase II effort. As was noted before, the mindset of this team is that obstacles exist to be overcome. This is a highly talented, capable, motivated, determined, and innovative team, but these assets cannot be fully taken advantage of without proper funding.

The Phase I effort amounted to $769.74 and produced a demonstrator that was almost completely constructed by hand and which had loose tolerances, numerous inefficiencies, far less-than-optimal materials (truthfully, it was a materials engineers worst nightmare), and was not aesthetically pleasing. In order to produce meaningful results in Phase II, the project simply cannot be funded by the team itself; the team must obtain financial backing.

The lower limit of funding necessary will more than likely be in the $3k-$5k range in order to accomplish what this team has set out to do. There does not exist an upper limit to the amount of funding that the team can receive, as no funding will go to waste. Any extra funding will be used to further the project in as many ways possible or to complete more comprehensive, more polished testing.

Preliminary assessment of achievability of objectives

Mission Objectives

The mission objectives as set forth are all within the realm of achievability. With the Phase I effort, these objectives were at the very least partially addressed, with some of them actually achieved with some degree of success (cavitation, flow signature, thrust which will lead the way to high speeds). As noted in the Mission Objectives portion of the Objective section, failure to meet these objectives will not be tolerated, and as such, they will remain the top project priorities.

Operational & Design Objectives

The depth range listed above is very attainable with proper water proofing and sealing, which will be a major component of the Phase II effort. The speed is well within the range of capabilities that the propulsion system will be able to provide for. Size, weight, portability, internal sensor suite spacing, and maintenance concerns will all be addressed in a highly redundant, iterative manner throughout the duration of the project. Lastly, SHEILA-D had a full power operational time of about 30 minutes (as determined through power calculations) and thus scaling this up to 1 hour will be a challenge as a result of all of the new subsystems, but is certainly doable as the team has already learned quite a bit about providing the necessary power since the conclusion of the Phase I effort.

Challenges/Obstacles

While all of the aforementioned challenges and obstacles might amount to what would be normally viewed as an insurmountable barrier, this is not an average team.

The design challenges can and will all be overcome. SHEILA-D was developed in just over a month and represented something that had never been done before. This team now has 9 months (Summer 2014, Fall 2014, Winter 2015) to complete the rest of the design; this is well within this team's operational capabilities. Overcoming the design challenges is simply a matter of finding time (which we have plenty of) to do so and being motivated enough to do so. The latter is a non-issue for this team.

The analysis challenges are simply stimuli to encourage more learning outside of the class room, which is exactly what this project is all about. It was known going into this project that these challenges would push all of the team members outside of their comfort zones, and thus this is not a deterrent. The team has already begun researching, picking out textbooks, and extending their knowledge for the Phase II effort; the Team UV library currently consists of 13 textbooks, 2 guides, 3 magazines, 36 technical papers, and 2 videos all relating to the Phase II effort and this list is quickly growing.

The manufacturing challenges are simply something that must be worked through in a highly introspective, well-measured manner. This is to say that the trigger will not be pulled on any manufacturing until all possible kinks will be thought out; in addition to this, in order to reduce costs and maintenance, while increasing usability, these challenges will have quite a chunk of time dedicated to them.

Lastly comes the financial hurdles mentioned earlier. In order to remedy this situation, two main means of funding are being looked into:

- Crowd-funding (Through websites like KickStarter, Indiegogo, Smallknot, and RocketHub)
- Sponsorships (Through local companies providing funding, products, or services)
    - One team member was previously part of Formula SAE and thus has experience with this type of funding
- Donations
    - Another team member is part of Cal Poly Pomona's effort to receive school donations/funding and thus is familiar with this kind of funding and is currently looking into tax write offs or other benefits for donators
- We are open to just about any source of funding; however it should be noted that the reason we are not considering research grants as much as these other sources is due to restrictions that may be incurred with respect to the project as well as possible issues with creative rights, as this project is 5 years in development conceptually and the team is in no way willing to risk loss of creative rights.

Proof of 300 level coursework completion

Senior Project Eligibility Check Sheet

Senior Project Eligibility Check Sheet

Project Duration: Fall 2014-Winter 2014 Project Advisor: Dr. Todd Coburn Email: tdcoburn@csupomona.edu

This page provides verification of completion of all 300 level courses prior to start of the senior project for each team member involved.

300 level courses required to graduate as a Mechanical Engineering undergraduate at Cal Poly Pomona are as follows (as appears on the 2009-2010 curriculum year curriculum sheet):

1) ME 301: Thermodynamics I
2) ME 302: Thermodynamics II
3) ME 311: Fluid Mechanics I
4) ME 312: Fluid Mechanics II
5) ME 313L: Fluid Mechanics Lab
6) ME 315: Engineering Materials
7) ME 316: Intermediate Vector Dynamics
8) ME 319: Stress Analysis
9) ME 325/L: Machine Design
10) ME 340: Modeling of Systems
11) ME 350L: Materials Science & Selection Lab

Student	Senior Project Eligible (Yes/No)	Remarks	Professor Verification	Date
Brian Martin	Y			6/3/14
Ben Saletta	Y			
Ketton James	Y			
Andrew Blancarte	Y			
Abraham Paucar	Y	Student will be taking final 300 level class Fall 2014 (ME 350L) and thus will register for EGR 481/482 Winter 2014.		

Additional Notes:

Prepared By: Brian Martin