December 19, 2010

School of Engineering Science

Simon Fraser University
8888 University Drive
Burnaby, BC
V5A 1S6

Re: *ENSC 440 Post Mortem for Clean Marine Systems Shoreline Oil Detection System*

To Whom It May Concern;

The following documentation outlines Clean Marine Systems ENSC 440 Post Mortem for their Shoreline Oil Detection System. The project has focused on combatting one of the world's most horrific man-made disasters: ocean oil spills. Clean Marine aims at detecting the oil spills coverage, providing real time alerts of effected zones.

This post mortem will summarize Clean Marine Systems project, discussing a few of the complications we hit, milestones we reached, as well as discussing future developments of the project. Additionally we will review our financial statement, and review our timeline.

The young and dedicated team of engineers at Clean Marine Systems has now proven they work well together, attributed to this project's success.

Sincerely,

James Kennedy

James Kennedy

Chief Executive Officer
Clean Marine Systems

Enclosure: *Clean Marine Systems Shoreline Oil Detection System Post Mortem*

CLEAN MARINE

Post Mortem

Shoreline Oil Detection System

James Kennedy, CEO
Ahmed Saleh, COO
Ned Tobin, CFO
Farid Mabrouk, CTO

Fall 2010

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Introduction

Clean Marine Systems came together 4 months ago with one common goal: create a project that will progress humans towards a cleaner and safer world, helping tomorrow look greener. We accomplished that. This post mortem will give a full overview of the project itself, discussing how we have deviated from the initial plans in building certain sections of the project, analyzing our budget, as well as discussing each engineers personal experiences.

The 4 hard working engineers that compose the team at Clean Marine have put in many hours of thought provoking work into this project, which we have learnt a lot from. We would like to share our thoughts on the whole project itself.

Current State of the System

Overview

The completed prototype of Clean Marine's Shoreline Oil Detection System consists of a pair of electrodes that detect the resistance of the water, which directly relates to the content of oil in the circuit. This resistance level is converted to a voltage which is then read by the microprocessor, where it interprets the voltage and transmits the necessary information based on that interpretation via the cellular wireless modem (SMS). The microcontroller also monitors the voltage level of the battery, which indicates the charge state to ensure over-charging does not occur.

The system's physical user interface includes a reset button that allows the system, or more specifically, the microprocessor to be reset after an alert has been received and acknowledged. There is also an LED that is lit when the microprocessor detects oil. The LED provides a more instantaneous way of observing the circuit is working as it should.

The electronics are enclosed in a waterproof container which contains the solar array, a 12V lead-acid batter, an analog sensing circuit, a microcontroller, and an SMS board with the antenna. This container is mounted on a wire grill, which is then mounted to a floating frame made of PVC tubes. The electrodes have been extracted out of the waterproof container via two small holes which then touch the surface of the water.

Testing

The sensing capabilities of the device have been successfully tested in the lab using seawater obtained from the Burrard Inlet, using light crude oil donated by a local refinery. The test procedure used is as follows:

1. Place the electrodes in a large container of clean seawater (large enough that the edges of the container do not contribute to conduction between the electrodes).
2. Power up the device and wait for startup notification via SMS message
3. Once notification is received, it can be observed (via onboard LED) that the sensing circuit is not detecting any oil presence by measuring the electrode voltage to be less than 1V.

4. Add a sufficient volume of oil to the seawater to see that the electrodes are insulated from the water.
5. Test the sensing circuit by measuring its output voltage. It should now be a value greater than 4V. Test the microcontroller by observing that the test LED should now be lit.
6. Once the microcontroller's average measurement threshold is exceeded (10 out of the past 19 measurements) then an SMS message should be received notifying the user of an alert.

The battery recharge control functionality has been tested successfully using a DC power supply to simulate various battery levels, and then using a Digital Multimeter (DMM) to test whether the BJT switch is open (charging inactive) or closed (charging active).

Deviation from Specifications

The project underwent many changes from the initial project proposal to the final product. We will outline those changes below, according to their relevant part of the system.

Electronics

Electronics is the brains of our project, although many other aspects were necessary. Integrating the electronics with the rest of the circuit required many component changes and/or alterations we will discuss.

Initially we were going to use a 6 V rechargeable lead-acid battery to power up the system, but after the purchase of the battery, we found that the battery wouldn't be able to provide enough power for the whole system. It turned out the cellular modem needs 1.2A for a reliable operation, as well the specifications for the microcontroller required ~7-12V input.

To solve the power requirement of our circuit we decided to then buy a 12 V rechargeable lead-acid battery with a 1.3 AH capacity. That way we made sure the system is fully powered up at all times, and also providing a longer fully charged time.

To power the microcontroller we initially decided to buy a DC step-up converter to use directly from the battery. We soon found out that the step-up converter (IC) we wanted to buy would not provide enough power for other components of the system, mainly the cellular modem. The DC step-up converter was only able to yield 200 mA output, since the microprocessor itself needs 200 mA, this solution wouldn't work.

Another power problem was initially with the 6V rechargeable battery, we planned to put the two solar panels in parallel to charge up the battery. Since each solar panel gave ~7V in full light, this was perfect. But, after we purchased 12 V battery, we needed to put the solar panel in series to get enough voltage. We then designed our circuit to be charged up at a rate of 220mA, which is constant current rather than constant voltage.

To monitor the battery charging circuit to properly charge the battery, we initially planned to use a bipolar junction transistor (BJT). As it turned out, we needed a MOSFET in series with the battery to provide this function. Once we had this we used the microcontroller to assert a 5 V or 0 V to the gate of the MOSFET, thus turning the MOSFET on or off which directly controlled the power charging.

We bought the Arduino Mega 2560 processor board to use as the main active component in our prototype, but during integration with the analog circuit we over powered it , which rendered the board no longer useable. To solve this problem, we were able to get an Arduino Mega 328, which is the same family, but a less feature rich version.

Frame Construction

The frame went through a few re-incarnations in the lifecycle of this project. At the start, a small Pelican Case was going to be used, but this turned out to be too small. What we did learn from this first version was that it was a very good idea to install the solar panels on the inside of the box to have the least amount of components exposed to the harsh ocean environment as possible. To this end, a larger, clear box was used to house the majority of the unit's electronics, including the battery.

At the start, fabric straps with plastic buckles were going to be used, which would allow us to remove the unit at any time to do minor adjustments. But, it appeared that this solution wasn't tight or sturdy enough since the straps could be loosened or tightened at will. To avoid this, plastic quick ties were used. We feel that the plastic will last much longer in the ocean and also reduce the growth of unwanted marine vegetation that would accumulate on the fabric material.

Holding the grill above water that had the clear case mounted onto it, we used plastic PVC tubes. Initially metal clamps were going to be used to hold the grill to the tubes. This would have provided an extremely strong hold so we could be sure there would be no loss of components, but this also was exposed metal, would over time would rust, and possibly cause the metal grill it was holding to be pinched and start rusting itself. It was also an expensive choice. To avoid this we used plastic quick tie straps. We feel these wouldn't promote decay or vegetation buildup like the metal solution.

The electrodes were a very crucial part of the circuit, and thus had to be carefully designed. Initially we had planned various contraptions to float along the water, or to even attach the electrodes to the floating main unit to avoid the problem of sea animals wanting to play with the floating electrode unit. In the end we decided that the electrodes needed to float away from the main unit to allow it to properly track the water. This would also prove an easier solution for giving a product demo. From here, we envisioned many different configurations from blocks of wood, to tennis balls, to fishing bobby, and foam hockey pucks. The final design used compact foam and a sheet of plexi-glass to hold the electrodes on, while keeping them just touching the water's surface.

Budget and Time Constraints

Budget

In our project proposal, we had initially predicted that our budget would need to be at approximately $440.00, which was, as it turned out, fairly accurate. Table 1 describes our budget, comparing our estimated budget, with actual costs.

Item	Budgeted Estimates	Actual Cost
Microcontroller Kit	$50	$72.74
Cellular modem	$150	$143.09
Electronics components	$10	$35.88
Prototyping Boards	$10	$7.00
Electrodes	$20	$0.10
Enclosure construction materials	$50	$65.15
Battery system	$50	$34.10
Incidentals	$100	
Total CAD $	**$440**	**$357.96**

Table 1 Budget

Table 2 is a complete breakdown of the costs, where you can see the total cost of the complete unit came to $357.96.

Item	Price
Arduino microprocessor	$72.74
modem	$143.09
4x PVC Tubes	$23.70
Large Waterproof Box (2nd)	$28.00
Cable Ties and Glue Sticks	$13.45
Solar Cells (2) , ICL7662 regulator inverter	$35.88
various electronics	$7.00
1st Battery (6V) Lead Acid	$12.88
2nd Battery (12) Lead Acid	$21.22
Total	**$357.96**

Table 2 Detailed Budget

We sought out funding from SFU's Student Society Fund (SFSSF), where we received a bursary of $350.00. As you can see from the total cost of our unit from table 1, this bursary nearly perfectly covered the whole cost of production.

Timeline

For this project, we had just under 3 ½ months to design, build, and test our prototype system. Given the scope of the project, this was a very short amount of time, and while we attempted to choose a project with an appropriate scope, it still proved difficult in getting everything finished on time.

Weekly meetings as a team helped us to keep very good track of the project's progress throughout the entire term. These meetings focused on briefing the entire group on what each member had completed in the past week, and what they planned to achieve in the coming week ahead. We also used the meetings to organize responsibility for deliverables that were required for the ENSC 305 assignments.

To track our long-term progress, we used an online project management service called Basecamp. This allowed us to record meeting minutes for each meeting, track what needed to be done to accomplish each milestone, and discuss any issues that we were having.

Completing our timeline in this manner allowed the entire team to stay focused on goals, and work collectively towards the end result: a working Shoreline Oil Detection System.

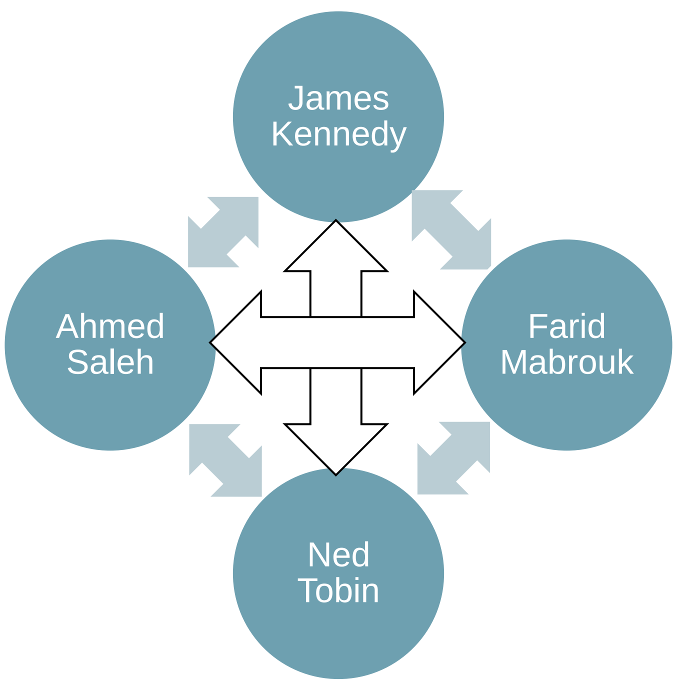
Group Dynamics

One reason that made Clean Marine a very effective group was that the group members complimented each other. One member would be strong in hardware and another would complement that strength in software.

The team had great management and kept very organized which helped reduce any controversy due to stress. Any conflicts that we did have, we dealt with in a very civilized, professional, and open manner. When problems arose we all stepped up and tried to tackle it together as a team. In part due to our weekly meetings, we were always updated on any change and aware of each other's progress.

The team's relationship and respect for each other is very positive; very rarely would there be any agitations between any of the members. No one complained about the work load that was assigned to them, and everybody participated in all of the tasks to help create the atmosphere a creative team requires.

We found that the most beneficial fact about the team was that all the members were motivated with shared one common goal: "Integrating the Shoreline Oil Detection System as an innovative product with industry standards, while protect the environment for our future."



Personal Experiences

James Kennedy – Chief Executive Officer (CEO)

For this project, I worked mostly as Project Manager and Software Developer. Since most of the design work was done collaboratively, I was involved with various other areas of the project as well. I took on these roles due to my past professional experience as a Web Developer which had taught me a lot about working with teams and making sure things stay on schedule. I feel that as a team we were largely successful in achieving what we wanted in this project and creating something that we can take pride in.

In the role of Project Manager I was responsible for creating and maintaining the PM documentation, scheduling deliverables, and keeping everyone up to date on our progress. In order to successfully handle these responsibilities, there were a few tools I used. Firstly, to handle PM documentation, I used an online PM service called Basecamp. This allowed everyone to make their own updates on their progress, and discuss any issues that they were having. Secondly, I used weekly in-person meetings to make sure that everyone knew what they were working on and getting everything done. We also used these meetings to work out any issues that had come up during the week, and give any suggestions that we had for our colleagues.

As the Software Developer for our team, I was responsible for planning, designing, and executing our software. In order to implement our software on the platform we chose, the Arduino Mega prototype board, I had to learn a new set of C++ libraries (Arduino and AVR libraries). This was a great experience working with low-level programming on limited hardware resources. The software development went fairly smoothly, but we had one major issue after destroying our prototype board due to a power supply problem. In order to do the demo, I had a very short time to revise our code to work with an even more limited piece of hardware, an older Arduino 328. Fortunately, both microcontrollers use the same set of libraries, so it was just a matter of removing a few features which relied on the better hardware we had originally used.

Another issue that we had was in regards to one of the hardware devices we purchased. We used a cellular modem which was interfaced with the microcontroller to send SMS messages as alerts. The first cellular modem we received was faulty, but it took me 15-20 hours of diagnostics before this was determined. Since none of us had worked with a device like this before, we were not aware of how to quickly diagnose it. Once I received our replacement modem, I was able to test it and have it working in about 5 minutes, since I then knew exactly what to look for.

In the end I found this project to be a great learning experience, and I think we developed some really cool ideas for how to detect seawater contamination. I also gained a few new points to stick in my resume if I ever need to: embedded device design, serial hardware programming, and Git version control experience. Despite the issues we had, I think that we achieved a really good level of completion.

Ahmed Saleh – Chief Operating Officer (COO)

Before coming into this course I was very skeptical of the members I would end up with. Fortunately, I had nothing to worry about. I ended up with 3 great intelligent guys. Not only did I learn a lot about myself, I also learned a lot from them. Since we were aliens to each other it was hard to come up with a project idea at the start. We didn't know each other's skills. But, after weeks of deliberating and debating we finally chose the best project that compliments us, as well as potentially being very profitable in the market.

This project has taught me a lot about the interaction of a team. Of course, with any team, there were a lot of disagreements. Instead of looking at these disagreements in a negative perspective, I believe that they led us to think outside our own comfort zone, which is important when you are working in a team with 4 different brains. This, in conclusion, led us to a working and innovative project. One aspect that we all shared and valued is the dedication and motivation that will all put in. We all had one common vision, and that was to protect the environment.

I was the COO of the team, Chief Operations Officer. At the beginning stages of the project I was working closely with Farid Mabrouk (CTO) with the hardware design that he had envisioned. We tested a prototype of the design and determined that we can move forward and use this design. I also worked with James Kennedy (CEO) with the software aspect of the design. There was one stage of our project where we were all getting a little bit concerned. After James vigorously attempted to make the cellular modem to work, which is a big aspect in our project, it was handed over to me to give it a tackle. After long hours, it was determined that it wasn't us that were in fault, it was simply a faulty product. With little time in place, I had to deal with the customer service of the company and made a quick order of a new modem. Thankfully, the new modem worked right away. Another scary moment that happened to us was during our testing stages. We had too much trust on the voltage regulator that was on the processor, which led us to overpowering it with too much current, and of course with 1 week before the demo we had no processor. I had to call in a favor to one of my friends, in order to borrow a processor.

At the end of the day, we succeeded. We had a working product that with a few adjustments can be exposed to the competitive business market. I am honored to have worked with this great group of guys. If I were to go back in time to change anything, keeping in mind of the problems that arose, I would not change anything, because without these problems my learning curve wouldn't be a curve, simply a line.

Ned Tobin – Chief Financial Officer (CFO)

As the CFO for Clean Marine, I have learnt that there are a lot of elements that can turn the financial books in the wrong direction. One is buying parts that turn out to not be needed. It would seem, however, like this may be a natural progression for a project to trend, since at every milestone along the way new problems are found.

Working in a group I always learn better ways of how to work well with team. As with all projects, my ideas might not be the same ideas that another group member has, but the key is to realize that both ideas could be great ideas, and that I need to respect all the engineers own ideas.

This project was great practice for me to learn how to be comfortable working with extremely competent engineers who are very knowledgeable. It was nice being able to rely on each member of the team to pull their own weight. It felt like a well-oiled machine. It was really great to see how well the team complimented each other.

Being in charge of the construction of the prototype, I learnt the value of quick-ties. They allow the product to be held together and tidied up to make it look professional and clean, something a good engineer I believe should pride themselves in.

Assisting in the electronic construction, as well as being the CFO, allowed me to be part of parts buying. I learnt that even if you have an idea of what you're going to buy, when you get to the store you need to make sure that you have your data specifications of all the other parts that you'll be integrating with. This ensures you know for certain that you're new parts will integrate seamlessly into your circuit.

Farid Mabrouk – Chief Technical Officer (CTO)

During the last four months, I have been actively involved in the design and development of our oil spill detection system. I consider myself lucky for having the chance to work with three dedicated and hardworking young engineers, which made the whole project both an exciting and learning experience. Regardless of the differences and disagreements we had about ideas concerning design or implementation, we all shared a common goal that was the realization of a dependable and durable product that can defeat any other similar competing systems in the market; in other words, we all believed in success and worked hard to achieve it.

Definitely, this final year project is going to be one of the most memorable experiences of my academic education. It came at the right time, just after I finished all of the required engineering courses for graduation, which gave me the opportunity to put my theoretical knowledge into test and to prove my hands-on capabilities. The project was both a combination of analogue and software design, which allowed me to integrate all of my Electronics Engineering knowledge. On top of that, it also allowed me to put all the theory I learned in Business and Economic courses into practice. These last two courses proved to be very helpful in the marketing, profit and cost analysis of our designed product.

The project was a systematic process. It consisted of several steps that we moved through: brainstorming, writing the functional specification, writing design specifications, design, building the prototype, testing, and finally implementation. The important thing about this was that at each stage I had the chance to learn and develop new skills. For example, at the brainstorming stage I learned how to contribute effectively with new and good ideas about products to consider for the project, and also learned how to research for documentations and useful information related to each product I proposed.

Like in any teamwork environment, disagreements over certain aspects of a project and how an implementation of such an aspect should happen. Another skill I learned in this project is how to convey my opinions and ideas clearly and how to convince my teammates about my ideas on how I envisioned something. Listening and accepting other's ideas were much needed skills. So overall, I learned how to be an active team player who is willing to do anything for the sake of his team within my abilities.

Time management and the ability to meet deadlines was another skill that I learned in this project. All my teammates were very punctual on deadlines and that had a positive effect within the team.

At Clean Marine I am the Chief Technical Officer and this position gives me the chance to do all the technical aspects involving the design and implementation of the oil detection system. I designed, tested and implemented the analogue circuitry of the system: sensing circuit, system power supply, and solar panels charging circuit. While doing this, I had to communicate any of the design aspects above with James Kennedy and Ahmed Saleh who were involved with the software design of the system; I also had to communicate with Ned Tobin who was in charge of the physical design of the device. During the entire process, I was an active and contributing team member and I was open to any concerns coming from my other teammates and I am glad we ultimately as a team managed to achieve our goal, which is a dependable oil detection product.

Future Plans

From this project we have learned many valuables lessons, which we will definitely all carry forward onto any future projects. Evaluating our project for future development, assessing which areas are rather unreliable, we have come up with some ideas in which we could improve the Shoreline Oil Detection Circuit.

We found out that the testing stage for the system we allotted the shortest amount of time of all project stages. Definitely, if more time was given, we could have done rigorous testing on the unit. Testing the unit for long periods in the ocean and seeing how low long the electrodes can last without becoming badly corroded is essential for the product development. This would also gave us the chance to monitor the sensing accuracy of the electrodes in various weather and water conditions, allowing us to monitor how the readings are changing over time. In addition, having the unit deployed into the ocean for some time would have allowed us to see how long it takes for algae to grow on the electrodes. In summary, extensive testing in the ocean would have given us a clear idea about:

1. What frequently the system should be maintained?
2. How reliable is the material used in the electrodes?
3. Will debris from the ocean interfere with the device?
4. What is the best material for the electrodes to yields accurate results?
5. How reliable is the battery with the charging circuit?
6. Are the solar panels capable indeed of delivering the needed power to the battery to ensure proper charging at all times?

For production equipment that will be used for solutions for real problems, reliability is a big issue. To ensure we meet the reliability requirement we and our clients both demand, it is essential that a redundant system of electrodes are used, so that if one electrode malfunctions, it won't render the device out of commission. Ideally, we would mount the electrodes on all four sides of the frame to combat this, but as mentioned above, extensive testing needs to be performed to prove this solution is reliable.

Instead of using solar energy to power up the system, wave power could have been an ideal and very effective solution. Solar energy is highly dependent on the weather, which is a major problem with the competitors and alternate solutions for detecting oil in the ocean. The coastlines around the world are subject to very frequently changing weather conditions. The device is deployed in the ocean, which is full of waves that can be used to generate power for the system at all times and seasons and at very low cost.

Conclusion

Clean Marine's first group project has been a success. All members of the team work well together, clearly showing their strengths. Our team is very well balanced in each of the respected areas of development, which makes the company very effective. Future development with this team can only become easier, more creative, and more efficient.

With regards to the Shoreline Oil Detection System, we all feel it was the best product we could have produced given our time and budget constraints. There are many development areas that we can focus our attention on in the future, which is where and how we will be able to keep Clean Marine Systems constantly innovating.

James Kennedy

James Kennedy
CEO

Ahmed Saleh

Ahmed Saleh
COO

Ned Tobin

Ned Tobin
CFO

Farid Mabrouk

Farid Mabrouk
CTO