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Monday, April 27th, 2006

Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
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Re: ENSC 440 Post Mortem Report for the GeoPreserver™

Dear Dr. Rawicz,

The attached document, *Post Mortem Report for the GeoPreserver™*, contains information about the current state of the GeoPreserver™, and its future. It also includes the personal experiences gained by each team member throughout the development process.

Our project team consists of five talented and innovative engineers with solid industrial experience. The team members include Jason Lee, Bryan Friesen, Jason Cho, Will Chan and Jeffrey Huang. Adam Smith of Innovative Technologies will work as a Senior Advisor and Consultant with our project. If you have any questions, please feel free to contact us at ensc440-onjin@sfu.ca.

Sincerely,

Jason Lee
Chief Executive Officer
OnJin Engineering

Enclosure: Post Mortem Report for the GeoPreserver™

Post Mortem Report for the GeoPreserver

Classification: CONFIDENTIAL

Project Team: Jason Lee
Jeff Huang
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Submitted To: Dr. Andrew Rawicz
Steve Whitmore
School of Engineering Science
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Issuing Date: April 27, 2006

Revision: 1.0

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Glossary

Geofence A virtual fence or geographical boundary used to trigger events once the fence boundary is crossed.

GPS GPS stands for Global Positioning System. It consists of 24 satellites controlled by the United States Department of Defense for the purpose of navigation and positioning.

IPX7 An IPX7 designation means the GPS case can withstand accidental immersion in one meter of water for up to 30 minutes.

MOB MOB stands for 'man overboard', signifying that a person has fallen off the ship into the water.

NMEA National Marine Electronics Association.

SPI Serial Peripheral Interface. A loosely defined serial transmission line that has synchronized data transmission intervals.

UART Universal Asynchronous Receive Transmit. Serial transmission line that is self-synchronizing so that data can be sent at any time interval.

USART A customizable UART that can function as a synchronous transmission line as well as an asynchronous line.

Revision History

Revision	Status	Publication/Revision Date	By:
1.0	• Created	Thursday, April 27, 2006	Jeff Huang

1.0 Introduction

OnJin Engineering has developed a prototype called the GeoPreserver™ over a 13 week period. Although we ran into numerous challenges and problems, through effective synergy we were able to combine our strengths as a team to complete the tasks within our given time frame. With several cutbacks and a great deal of learning in several aspects of our project, we applied the skills that we spent learning for the past four years to achieve our goal. Our project, the problems we faced, the budget, the timeline and our personal comments are outlined in this document.

2.0 System Overview

The GeoPreserver™ consists of two distinct modules: a Base Station, and numerous Personal Units. The Base Station will be mounted inside the bridge of the boat and will serve as the reference point for establishing the geofence and for determining when a crew member is overboard. The Personal Units will be worn by everyone on the boat at all times. These units will wirelessly transmit their geographical location back to the Base Station. The Base Station will then determine the position of each person. If a person is overboard, the system will be alerted to indicate a man overboard situation. The figure below illustrates the relationships.

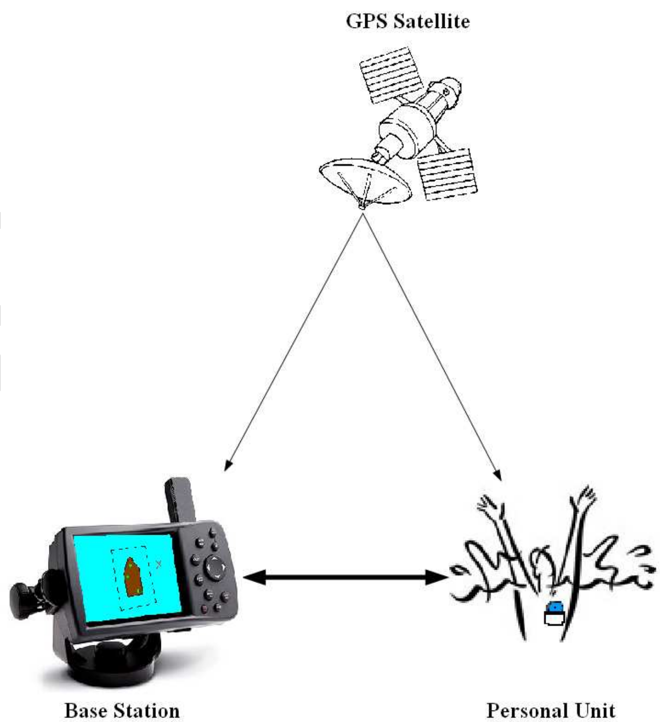

Figure 1: System Overview Diagram.

3.0 Implementation Issues and Problems

3.1 Hardware

The major impact on our project was time and funding. This lead to several cutbacks and deviations from our original ideas for implementation, but overall, our proof of design prototype worked out quite effectively. Although we had been a bit more ambitious in our plans for the project, we later realized the impact that our short 13 week time frame left us. As a result, we had to lower our goals. The major design changes are outlined in the following section.

Our initial intention was to create a prototype that supported multiple units. There was to be two personal units with a single base station. However, due to the realization that the construction of prototypes would be extremely lengthy and the algorithms used to implement the sampling of data were complicated, we decided to simplify the scenario to one personal unit and one base station. Furthermore, due to the fact that we blew one transceiver we only had one transceiver to work with. Our algorithms were then designed around receiving information from a single personal unit thus simplifying our coding and firmware which reducing a lot of the development time.

The final prototype of our project was also intended to be wearable and small. However, the final size of our prototype was much larger than the anticipated final design. This was primarily due to the fact that we never laid out a final schematic and did most of the hardware construction as time progressed. We did not have the time to draw out a schematic and most of our hardware members knew what was going on so we felt that it was not necessary. Therefore, when we were building the protoboards, everything was spaced out since we left plenty of room for error. Also, we used DIP mount ICs thus increasing the surface area that was used. In our final design, a printed PCB with surface mount ICs would be used, thus greatly reducing the final prototype size.

The battery and power consumption of the prototype was also never thoroughly tested. It was our intention to provide a module that would last for a specific amount of time; however, due to our time frame we simply sought a route that would power our units for testing. Battery consumption therefore was much greater than anticipated since we did not take into consideration power saving modules, and purchasing high quality batteries that would last for extended periods of time. Furthermore, the low power mode on the GPS and PIC was never enabled. This was because for the GPS, the CR2032 backup batteries would need to be implemented and we never found time to do this. Furthermore, for the PIC, more firmware coding would be required to implement sleep features thus we also did not do this.

The implementation of the firmware from the design specifications was also simplified. Instead of using the SPI to UART chip on the base station, we decided to place all the components on the RS232 multiplexer. Therefore, we eliminated a lot of the MAX232 buffers from our design since they were no longer needed. From testing and debugging we found that a lot of the components produced appropriate voltage levels that did not require a driver or buffer. Our final block diagram of the system for the base station is shown in Figure 2.

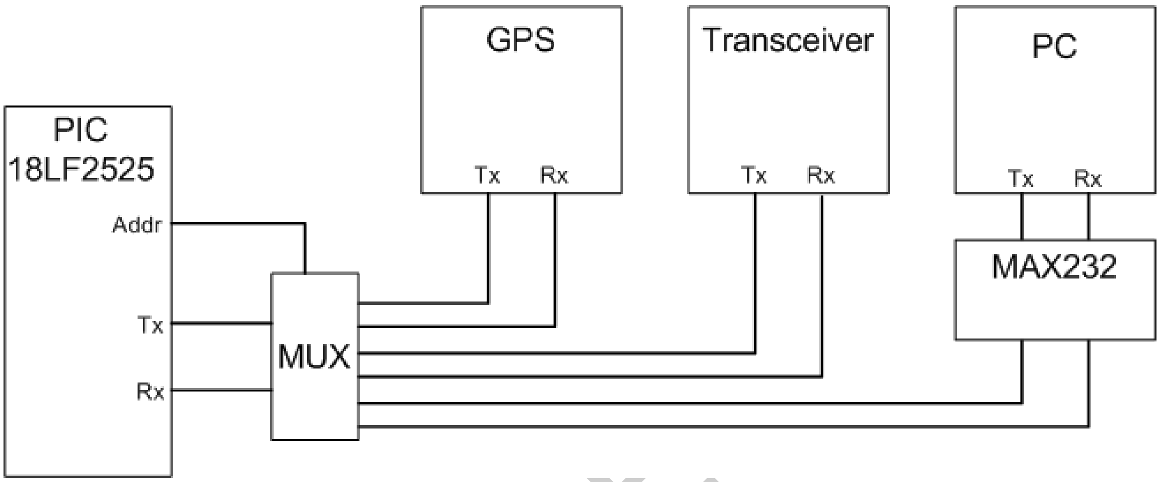

Figure 2: Base Station Block Diagram

3.2 Software

Due to the same limitations as the hardware, we had to cut down on a lot of the features that were initially designed. We had a very short timeframe to complete our software, thus a lot of the high level features of the initial designs were generally tossed out.

High level features from our initial design specifications that we scrapped included: creating a database for crew information, all operations related to associating a person to the personal unit, registering a personal to a base station, setting a permanent dock location, and assigning a name to that dock location. These items were scrapped both because they were relatively unimportant to the concept of the project, and because we only had one personal unit for our prototype. Therefore, it was not necessary to differentiate between other personal units.

The dock feature changed from storing locations in a database to just having the user set their current ship location to a dock. At this point, if the personal unit went off the ship, the system would not alert the crew. However, if the ship undocked or moved a set distance away from the dock, then the dock feature would deactivate and the system would operate normally. The final product will likely incorporate a database so that multiple docks can be added, but for the prototype, this was not necessary.

3.3 Problems

We ran into numerous problems during the development of our product, which was expected as this is the case for most design processes. The major issues are outlined in the following section.

The pitch on the components was not standard, and was very difficult to implement on our protoboard and use in our breadboard designs. We had to manually drill holes in PCB and solder wires onto a header and make wired connections from the breadboard to the GPS unit and the transceiver. When we implemented the protoboard, we also had to manually drill holes for a 0.2mm pitch in order to implement the GPS and the transceiver. At first these problems seemed extremely difficult, but we learnt how to work around them pretty easily.

Furthermore, during our hardware prototyping, a lot of the time we crossed wires, or made bad connections which ended up blowing up some of our components. For example, we fried two transceivers and had to get them replaced. Also, during the prototyping stages, we never made a final schematic and our schematic continuously changed with time. This resulted in de-soldering and re-soldering connections as time passed by. This was because we slowly removed features, or added others as we tested our prototype. Although this was extremely time consuming, we soon became adept at prototype construction.

Due to all these problems, the time to construct the hardware was much longer than anticipated. This delayed our timeline, but we maintained a steady work pace. We fell behind schedule not due to laziness but because of problems we encountered in our construction. As we ran out of time, a lot of firmware and software patches were implemented to simply work around problems rather than fix them. For a final prototype, all these problems would need to be solved, and a more realistic timeline should be followed allowing for errors in hardware construction.

One major problem in writing the software was boat drift. This problem involved determining what direction the boat was facing. The direction of the boat is important for our system because the personal unit locations are displayed relative to the direction of the boat. This makes it most useful to those onboard the boat so that a rescue operation can be carried out. GPS packets provide the ship's course information (which gives the boat's direction). However, if the boat is not moving significantly in any particular direction (i.e. less than a couple knots per second), then the course may vary by as much as +/- 40 degrees. This causes a lot of jitter in the position of personal units. One resolution we attempted to solve this was to average the courses. However, this caused our system to be inaccurate in real testing, and made our course unreliable, so this idea was scrapped. The final workaround involved setting the initial ship heading to 0 degrees.

Any course change would require that the ship be moving greater than 2 knots. As long as the Base Station was moving greater than 2 knots, the system would recognize the course data from the GPS. However, if the Base Station slowed to less than 2 knots, the last recorded course data would be retained. The assumption here is that the Base Station is now stopped and is facing the course that was last recorded.

4.0 Budget

Table 1 below shows the projected budget for the GeoPreserver™ back in January 2006.

Table 1: Projected Budget.

Equipment	Est. Cost
Evaluation Board	$200.00
Processors	$150.00
GPS Modules	$300.00
Transcievers	$150.00
Supporting Components	$100.00
Misc. Test Equipment	$200.00
Office Supplies	$100.00
Manufacturing	$200.00
Total Cost	**$1,400.00**

The above budget includes all the main components of the system, the supporting components, and other necessary equipment needed to complete this project. A more detailed breakdown of each section is provided in our actual costs table below. Some of the supporting equipment can be obtained from Simon Fraser University, and is also included in the table above.

After doing some research on each component, we realized some components may be purchased at lower prices, at the cost of quality; however, these lower cost parts still provided enough features for our needs. Table 2 below outlines the estimated budget we spent on our components.

Table 2: Actual Budget (Estimated Values).

Equipment	Est. Cost
Evaluation Board	$0.00
Processors	
- Microchip 18F2525	$0.00
GPS Modules	
- Laipac OEM GPS Modules	$310.00
Transcievers	
- XBee/XBee Pro OEM	
RF Modules	
(Total)	$300.00
Supporting Components	
- Power adapters	
- Connectors	
- Regulators	$100.00

- Buffers	
- Others purchased from Fred	
Misc. Test Equipment	
- Microchip ICD2 Development Kit	$310.00
- Transceiver Development Board	$100.00
Office Supplies	$0.00
Manufacturing	
- Enclosures	$30.00
Total Cost	**$1,050.00**

As we can see, our actual budget of $1050 is lower than our projected budget of $1400. The cost of the transceivers includes the blown up ones, so if we excluded them, our total cost would be lower.

5.0 Timeline

A Gantt chart comparing our projected vs. actual timeline for the project is shown below.

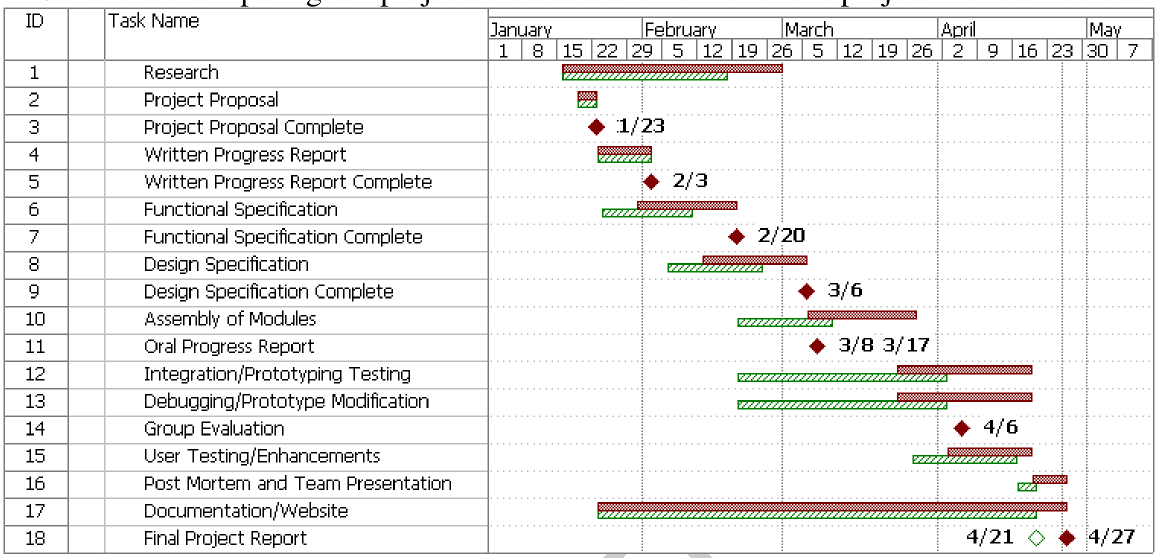

Figure 3: Comparison between Predicted and Actual Timeline.

Figure 2 above illustrates the comparison between our projected timeline made back in January 2006, and our actual timeline finalized in April 2006. The green bar (bottom bar) represents our projected timeline, and the red bar (top bar) represents our actual timeline. The diamonds represent the deadlines of a particular task, such as the project proposal, and the functional specifications. It is shown that we started to fall behind schedule at around the time of our functional specifications. This led to further delay of our other tasks, and shorter periods to complete them.

6.0 Personal Comments on the Project

6.1 Jason Lee

As part of OnJin Engineering, my primary role was the interface design of the system. Furthermore, I was responsible for delegating tasks and ensuring that our team was working efficiently and on important tasks. I worked mostly with the Microchip microcontroller and the integration of the GPS module, and the transceiver with the microchip. I designed and wrote the firmware code for the PIC to enable the components to communicate effectively with each other. Furthermore, I helped with the hardware construction and the design of the interfaces between each component.

In the initial stages of the project, the challenges were apparent. It was a rather challenging project to undertake within a 4 month period. With some setbacks and some cutbacks we were able to design a fully functional prototype in the 4 month span. The main challenges that I faced were learning how to program and use the PIC effectively, but the purchase of a development kit greatly reduced the learning curve. By using online resources and manuals I was able to learn how to program the PIC within a few weeks and effectively integrate the components with each other. We ran into a lot of trouble with communication pins on the USART, but with the debugging skills we learned in our previous ENSC courses, I was able to figure out the problems with time. I learned how useful small patches and workarounds were for a prototype but eventually a more optimized code for the firmware will need to be implemented.

At times, the group was pessimistic and we all thought that we weren't going to finish, but I am proud to say that we were able to complete a great project within a very short time frame. I found that I appreciated working with my team more everyday as the hard work and perseverance showed as time came by. With our many late nights and countless hours spent working on the project, we came much closer as a team and worked effectively with each other. I was able to develop specialize in an area I was truly interested while learning a little bit about other areas of the project throughout the time span. It was truly a worthwhile experience.

6.2 Bryan Friesen

My main task on this project was to help design the hardware. Specifically, I was responsible for choosing a GPS module, and learning how it worked. I was also in charge of constructing the prototypes. The hardware was tested initially on breadboards, and then soldered onto protoboards. Another task I had was to do most of the drawings we used in our documents. I enjoyed all of these tasks since I consider myself to be a hands-on type of person.

When Jason Lee proposed the idea for this project, I wondered if it would be feasible for 5 engineering students with very little practical experience to make it. When it was decided that GPS would be used for locating the units, I again questioned whether we could do it. However, after lots of research on OEM GPS modules, PIC's, and Transceivers, I began to realize that everything we have learned so far in our ENSC courses would actually come in handy. Other than minor setbacks such as the pitch on the GPS and Transceivers, and RS232 voltage levels, I didn't have much trouble building the prototypes. To solve the problem I had with the pitch, I manually drilled the hole into the side of the protoboard. Once the units were built, they worked pretty much as we intended them to.

Everyone has heard the horror stories about ENSC 305/440, but I'm happy to say that I think we avoided almost all of it. As a group we worked well together, and got through any problems that we ran into. When one member was down because something wasn't working the way they had hoped, someone else was there to step in and give them a hand. I am proud of the work we did, but more importantly, I am proud to be a member of OnJin Engineering. I look forward to working with this same group of guys in the future.

6.3 Jason Cho

I was responsible for transceiver component of the system. My job was to research the possible transceivers which would fit our needs, learn how they worked, and choose the best one. I was also involved in the integration of the hardware components, and the making of the prototype with Jason Lee and Bryan Friesen. In addition, I also was in charge of creating the company website.

In choosing a transceiver for the system, many possibilities were presented; however, because we only had 4 months to complete this project, and had limited funding, in the end, we were unable to purchase higher quality transceivers. Each transceiver had its own positives and negatives. I tried looking more at the positives, and turning the negatives into positives. An example would be the pitch of the transceiver we chose, which had a 2mm pitch. Instead of turning the transceiver down, we adapted to the 2mm by drilling holes on the protoboard and purchasing connectors which were used to connect onto the protoboard to allow connection of the transceiver to the rest of the circuit. Upon integrating our hardware components with each other, we managed to blow up a couple of transceivers. This held back our project a bit, as we were unable to test our design; however, due to the availability of the transceiver, we were able to obtain new ones in a hurry. In the end, we were able to produce a working prototype.

When this project first started, I had trouble seeing the big picture of the project, and as the semester progressed, the picture became clear as pieces of the puzzle fell together. After taking ENSC305/440, I can now truthfully say that ENSC305/440 is my favourite course taken at SFU. I am really happy with the results we were able to achieve in a limited time frame, and I am just glad to have worked with such a talented group of guys.

We were always there in support of each other, especially when someone falls behind. As deadlines approached, we'd gather ourselves and work hard together to meet our goal. This course allowed all of us to feel like real engineers, and allowed us to apply our knowledge gained in courses taken previously. I am very proud of my team, and I look forward to further developing this project in the future.

6.4 Will Chan

I was responsible for GUI development for our project at OnJin Engineering. My main contributions to the prototype were designing the GUI's display, its overall look, and its features such as button input. I was also the chief designer of the software's system and functionality as a whole. I initiated the ideas for how the software and hardware will interact, the use of threads, as well designing and implementing the classes used to store and retrieve data for both Base Station and the Personal Unit.

In designing the GUI for this project, I chose to use MFC libraries to implement the display and the buttons. I had never used MFC before and it was a challenge to both learn the library and implement it at the same time. One particular challenge was drawing the display onto the GUI. I chose to use a dialog based program and there were no direct references or examples on how to approach this problem. However, after playing around with the code for a bit, I managed to solve this issue and the software progressed progressively afterwards. Other issues included the necessity for the completion of the hardware before real-time testing of the software could be accomplished. Due to some incidences (blown transceivers) mentioned earlier, this testing was pushed back. However, it was good to see that we could pull together as a team to mitigate this issue and complete testing before our deadline. Also, since timelines were crunched, it was a challenge get to know the entire system inside and out. Due to specialization of duties, we all become experts at our own domains. This is good for completion of a project in a short time frame; however, I would have still liked to learn more about how the PIC was programmed, or how the transceivers were utilized, and so on.

ENSC 305/440 has been the most enjoyable course that I have ever taken at SFU. I enjoyed our team dynamics and working with the core of talented and hard-working individuals at OnJin Engineering. Everyone truly pulled together during crunch time to complete their respected tasks and to meet our deadline. I learned a good deal of how to manage the scope of our project, at least on the software side, and am proud to see that our planning for the software had resulted in relatively seamless integration with hardware. This resulted in a few minor fixes in a few of our algorithms during real-time testing. This course really leveraged my ability as an engineer and with working in a team environment to meet a common goal. I am looking forward to developing this product further with my team-mates and to explore its potential.

6.5 Jeffrey Huang

My main role in the team was to do the lower level programming in C++, and coordinate the communication between hardware and software. I was also the main editor for the documentation. As part of my work, I searched the Internet for a library that would make setting up the serial port communications easier, and searched for various algorithms to do tasks such as checksum comparisons and distance determination between 2 geographic points.

The challenges I faced throughout the project were numerous. I found it frustrating to pore over documents repeatedly throughout their creation for formatting issues, grammar, and other details. I found that I needed to pass on the document to others to edit as well, because at some point I could not bear to read it anymore. From the coding standpoint, I had some initial difficulty compiling programs with the Serial Library, although I managed to figure it out later. Another issue I had was trying to make the code as neat as possible. While this is an excellent idea for any project, especially if you're planning on working on it in the future, I found that at crunchtime, code neatness will suffer, and quickfixes become increasingly useful and necessary to get the job done. One item worth noting is that because I knew what type of input our system was getting from the serial port, I could simulate it using a test driver; thus, most early software testing was accomplished without the need of functioning hardware.

The team dynamics worked out pretty well for us. Will and myself generally worked independently from the rest of the 3 in the group. Personally, I felt the need to know what everybody was doing, and I wanted to learn what the rest were learning too; however, with only 4 months to get the project done, specialization is certainly necessary to get the job done in a timely fashion. Most of the team ended up working on the project regularly, which helped us from falling too far behind our timeline. By applying our engineering skills that we've acquired through the years in the program, I believe the project has increased the competence level of everyone on the team, and made us feel more like engineers.

7.0 Future Work

7.1 Continuing with the GeoPreserver™

There is still a lot of work to do with this project. If we were to decide to take this product to market, a significant investment in both time and money would be required. On the product development side of things, we would need to incorporate functionality for multiple personal units, and upgrade a number of components in the system for better performance. Low-power operation of all components would need to be implemented, and all the code would need to be optimized. The base station would also need to be designed into an embedded system, as opposed to being tied to a PC as it is currently for the prototype. When the development work is done, the product would need to be patented, certified, and designed for manufacturing. These steps will be very costly to accomplish.

On the bright side, by continuing with this project, we could adapt our technology to other markets. We initially targeted the fishing industry with our project, but we could easily extend the design to accommodate tracking passengers on cruise ships. Other potential applications include aiding tour guides in tracking lost tourists, and parents tracking their children's whereabouts.

7.2 Other Projects

For future projects, we would certainly do well to transfer our knowledge gained from this project. From a time standpoint, we would improve our timeline projections. By including our course midterms or other events into our scheduling, we can better gauge our productive abilities on a weekly basis. Also, regular meetings are necessary to keep all members both accountable for their progress, and knowledgeable about everyone's status. Meetings in the early stages will generally be longer than in the design and development stages because details need to be discussed. Design and development meetings can be shorter because everyone is working on their own components, and less collaboration is needed, assuming the product has been designed well.

Another part of keeping a project on track is to have contingencies in place in case something goes wrong. Contingency funds should be allocated so that replacement parts can be obtained. Spare parts for critical components should be on hand or quickly obtainable, especially when breadboarding circuits, since wires can be easily crossed, causing parts to spontaneously combust.

8.0 Conclusion

We have come together as a team over the past 13 weeks. We all had individual specialties and knowledge that, when compiled, were able to effectively produce an excellent product. Through this time, we applied our knowledge and our expertise that we have learnt in the past four years in engineering science at Simon Fraser University. The GeoPreserver™ has shown our ability to work as a team and produce a proof of concept prototype. Although we faced challenges and problems, we found ways to work around them and finish our project within the timeline. ENSC 305/440 presents a challenge to students where many cannot complete in the allotted timeframe. It is a common trend for students to extend their projects into the next semester. But OnJin Engineering, with our excellent time management, work ethic and technological expertise, was able to excel in all facets of our project and meet our deadline.