December 19, 2011

Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
8888 University Drive
Burnaby, British Columbia
V5A 1S6

Re: ENSC 440 Post-Mortem for SmartFlow

Dear Dr. Rawicz:

Please find the enclosed post-mortem document describing the design and implementation process of our company's product: SmartFlow. Our team at Smart Remote Communications (SRC) Telemetry Incorporated spent the past four months designing and constructing this product to allow clients the ability to control remotely located fluid tanks through the use of text messages via GSM enabled cellular phones.

This document addresses the current state of our prototype device, deviations from the originally proposed design, and possible further developments of the product in future iterations. Furthermore, budgetary and time management constraints faced during the past four months are also discussed. Finally, we conclude by discussing the personal and technical experiences that we have gained through work on building our finalized prototype of the SmartFlow unit.

SRC Telemetry is comprised of five undergraduate engineering students at Simon Fraser University: Yazan Shehadeh, Zhi-Yu (Mark) Zhou, Monir Pejgaleh, Shervin Asgari Pour, and Amit Verma. Should you have any questions or inquiries please do not hesitate to contact us at src.telemetry@gmail.com. Alternatively, you may contact me by phone directly at 778.709.5546.

Yours sincerely,

Amit Verma

Amit Verma
Chief Operations Officer
SRC Telemetry Inc.
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Enclosure: *Post-Mortem for SmartFlow*

Smart Remote Communications Telemetry Inc.

SmartFlow
Post-Mortem

Project Team:	Team Member Title:
Amit Verma	Chief Operations Officer
Mark Zhou	Chief Technology Officer
Monir Pejgaleh	Chief Financial Officer
Shervin Asgari Pour	Chief Marketing Officer
Yazan Shehadeh	Chief Executive Officer

Submitted to:

Andrew Rawicz – ENSC 440
Mike Sjoerdsma – ENSC 305
School of Engineering Science
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Issue Date:

December 19th, 2011

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1. Introduction

Over the past four months, the engineers at SRC Telemetry Inc. have worked diligently and with much enthusiasm in order to complete the prototype SmartFlow unit. Despite the few setbacks faced by the team during the final weeks prior to the demonstration date, SRC pulled together as a team and was able to work out the hardware problems with the GSM unit in time to demonstrate the prototype unit on December 16th, 2011. In addition to budgetary and time constraints faced, this document outlines some of the major challenges faced by the team, and the necessary changes that had to be made to the original proposal in order to develop the prototype SmartFlow device.

2. Current State of the Device

Presently, SRC Telemetry Inc. has successfully demonstrated the proof-of-concept on a working prototype of the SmartFlow unit. However, as evident during the demonstration, some minor issues with the pressure sensor are still present in the overall system built which need to be addressed prior to the construction of a marketable SmartFlow unit. Figure 1 illustrates the overall system block diagram of the SmartFlow prototype unit.

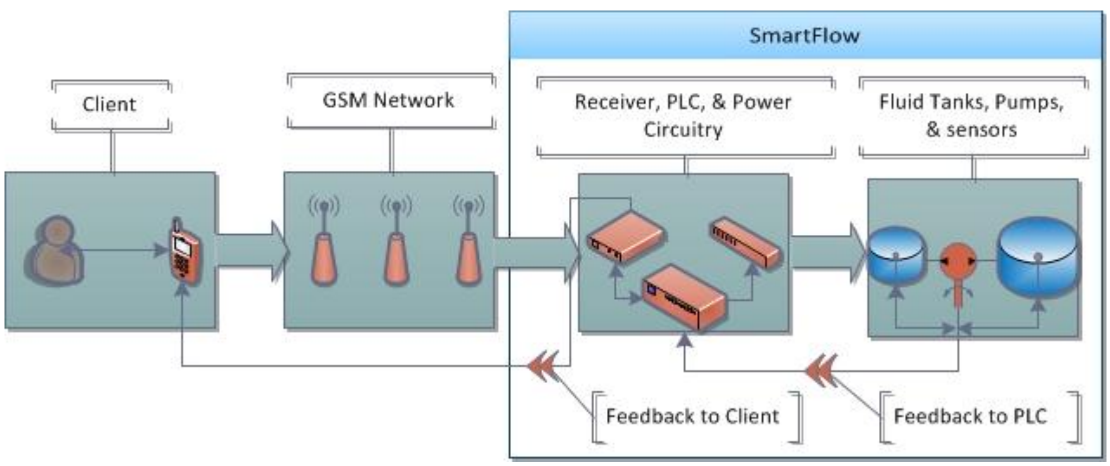

Figure 1 - SmartFlow System Block Diagram

2.1. Level and Pressure Sensors

This product needs one level sensing sensor in order to indicate the water level in a tank and for the user to be able to reach a desired level. The first idea presented was to build a level sensor tank that is divided into 10 points along a rod that has the same length as the tank. Each point consisted of NAND gates which triggered at logic high or low. This idea wasn't ideal for this product since the output was discrete and the readings were unreliable. The pressure sensor used in this product, the PTD25-20 pessure sensor, is shown in Figure 2 below.

Some technical difficulties were faced with using this sensor; the low output voltage range was one limitation that was faced which restricted the desire to have different levels being reached in the tank.

Since the output of this pressure sensor was current and not voltage, running the output current through a resistance in order to get voltage outputs caused the output measured by the PLC to be linear voltage. The main issue and the reason for inconsistent measurements was caused by the high pressure measuring range ($500\ PSI$) which was much larger than the actual pressure in the tanks ($1\ to\ 2\ PSI$), this lead to the sensor to sense and show inaccurate readings since the pressure in the tank was equal to the error in pressure readings for the sensor.

Figure 2 - PTD25-20 Pessure Sensor

2.2. Pumps

The SmartFlow unit is composed of two main units which are integrated together to form the overall prototype of the device: the power unit and the PLC communication unit comprising of the PLC, pressure sensor, and the GSM module.

The power unit is comprised of two water pumps, two level float switches, two tanks, and two contactors. The communication part is comprised of sensor, PLC, and GSM. The pump and its protection system are currently in good state, they perform their functions as per expectations. Pump speed can be varied as per the required flow rate needed to draw the correct output voltage values from the pressure sensor, while minimizing the effect of errors. The main pump located at the bottom of the in the in-flow tank is protected from dry running by using a level float switch which cuts power to the pump should the volume of water fall to a minimum allowable height. In addition, overfilling of the storage tank is also protected by using a second float switch at the very top of this tank, thus allowing for the cessation of pump operation should the water level increase to the maximum allowable height.

2.3. Float Switch Operation

The float switch operation is successful when placed in series with the tanks. The operation principle is quite simple and almost acts like a sensor. As show in diagram below, the float switch is equipped with a powerful magnet which actuates the magnetic reed as the float rises or lowers the liquid level. These float switches are vertically mounted on the tanks and provide a consistent accuracy of $\pm\ \frac{1}{4}$ inch.

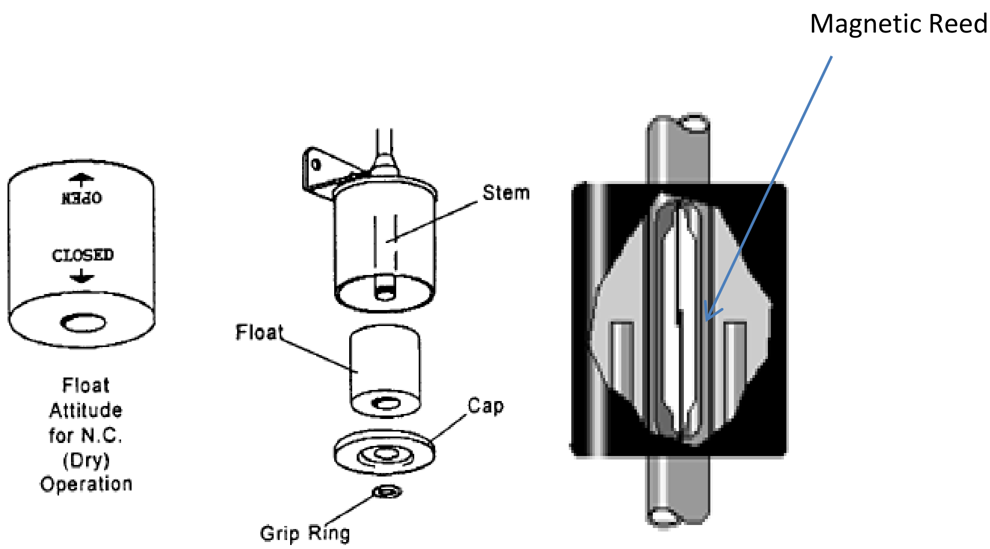

Figure 3 - Float Switch with the Enclosed Magnet and Magnetic Reed

2.4. Contactors and Relays

In order to create the proper connections between the two pumps and the float switches, a contactor and a relay have been used; ensuring that the pumps do not run simultaneously at a time. Furthermore, the source tank was equipped with three devices: pump 1, upper float switch, and the bottom float switch. As explained above, the bottom float switch was used to make sure that the pump did not run dry. Therefore, the bottom float switch was connected in series with the pump via a contactor. The relay in turn was connected to pump and to the float switches so that each pump could function simultaneously without interrupting each other's connections. Also both the contactor and the relays were connected to circuit-breaker to break the contacts during short circuit events.

2.5. Issues with the Power Circuit and Proposed Solutions

The initial power circuit design is rejected due to the following issues:

- Compatibility and complexity: The power circuit design failed to provide the accurate voltage required for communication with the PLC unit. Additionally, the power circuit, as shown in Figure 4, became very complex and harder to understand and to debug. The issue was resolved by having only one $24V$ relay which connected the float switches in series with pump.

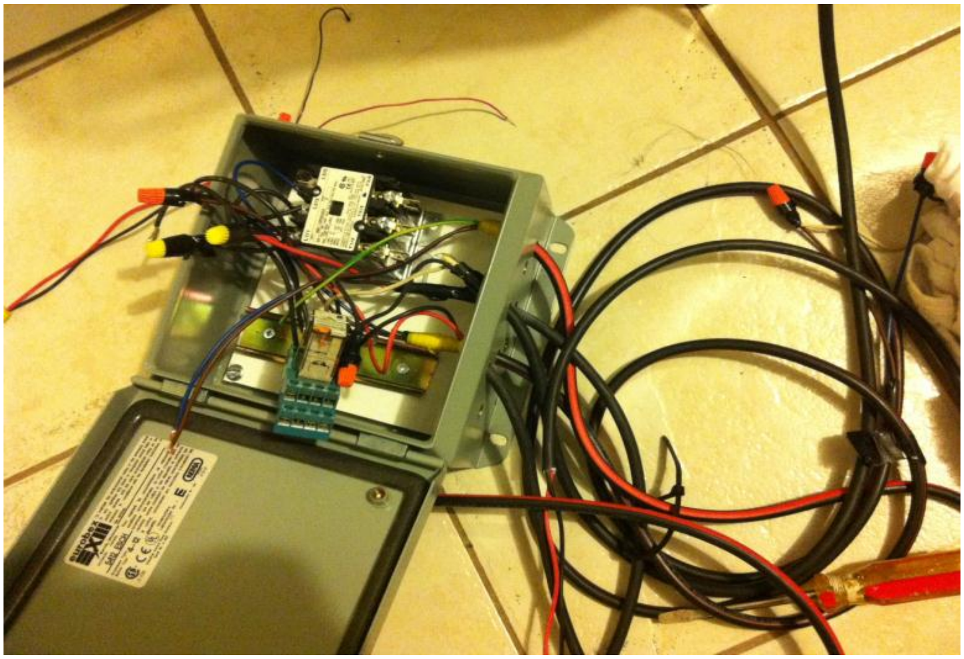

Figure 4 - Initial Power Circuit

- Redundancy and fail safe: In order to increase the reliability of any design, it is important to add additional safety features. This is to ensure that in adverse conditions, the system fails safely and gracefully. Therefore, the power component design was further simplified to make more area for additional safety features. Also, the new design ensures that if one component fails or burns out, it does not cause the entire system to fail drastically. Figure 5 illustrates the final power circuit utilized in the circuit along with the PLC and the GSM module.

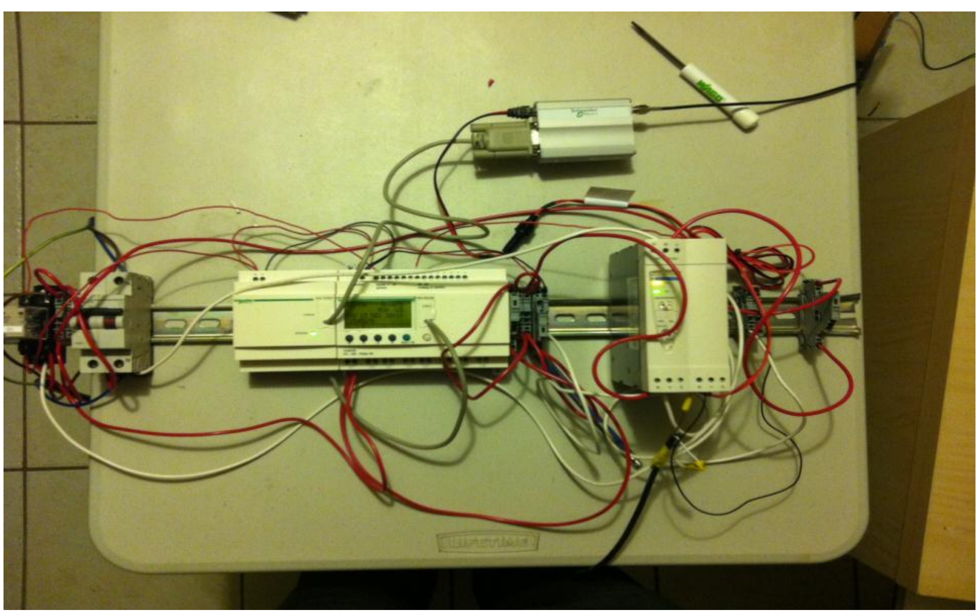

Figure 5 - Finalized Power Circuit

2.6. GSM Module

The GSM was one of the core components for the project. This is due to the fact that being able to control the tanks via text messages was the motivation behind the idea of this project. On one side, the GSM connects with the communication module that connects it with the PLC. From the other side, a wireless antenna is required to have a two way communication with any authorized user. Without the GSM component, the team would not have been able to communicate any messages to or from the PLC unit with any clients using the product.

The team faced a few problems with the GSM module; the arrival of the GSM unit at the middle of the semester caused a lot of trouble for the team towards the end of the semester. This was because the GSM that the team received was not connecting properly with the communication module. Although SRC engineers followed the given instructions step by step, the GSM would not connect and the LED only displayed a yellow color indicating no connection could be established.

Before going any further, the team had a meeting to discuss the issue and to try to find the reason behind this negative reaction. SRC engineers decided to contact Schneider Electric to find out if this was a common problem and whether the team could go about fixing it. They mentioned that they test all their products before sending them out, so they avoided the possibility of the GSM having a hardware issue. They also provided the team with debugging procedures to follow in order to find out where the problem was. This required buying a cable to connect the GSM with a personal computer so as to get access to the device and to troubleshoot the problem.

However, after following the given instructions yet again, the team was not able to resolve the outstanding issues with this module as everything seemed normal; the only conclusion the team could make was due to the possibility that there was a hardware issue with the product. As a result, SRC's Chief Executive Officer contacted Schneider Electric and ordered a second GSM module. Luckily, once the new module was received and connected with the communication module, the LED turned green indicating that indeed the issue was with the hardware. This is when we realized that the old GSM had hardware issues and sent it back to Schneider.

3. Budget and Time Constraints

The overall final cost was slightly over the projected budget because many factors: The first factor was that we needed to replace some of the original designed components such as our fluid level sensor so cost was much higher than we originally anticipated.

Another factor of over-budget was that we needed to replace the GSM unit because the first one had a hardware fault. As this occurred during the very last few weeks before the final deliverable, we had no time to repair it and as such could only replace it with a new one, so our cost was almost doubled for that particular component.

One last factor in the overshooting of our budget was our slightly change in design which aimed for better electrical safety. As we were developing our system, we realized that we needed some better electrical protection for many of the components including GSM modem, the PLC, the fluid pump, and any human operator because the device used a $110V$ power supply. Nevertheless, the overall spending is well within our anticipation and expectation, and all members are happy to have individual spending within an acceptable level. Table one illustrates a breakdown of the estimated and actual costs incurred.

Table 1 - Estimated and Actual Costs

Components	Number of Components Required	Estimated Cost	Actual Cost
GSM modem development board:	$1 + 1$ replacement	$350	$700
Liquid level sensors:	1	$60	$200
Overload sensors:	2	$120	Borrowed
Relays and contact switches:	4	$120	Borrowed
Water pumps:	2	$60	$26
Liquid tanks:	2	$40	$25
Pipes, hoses, and valves:	2	$150	$15
SIM card with SMS service:	1	$70	$22
Taxes and shipping (12%):	–	$200	$119
Contingency (15%):	–	$150	$0
Total:		$1390	$1120

Figure 6 illustrates the Gantt chart used during the duration of the four months. Apart from the issue with the GSM module, the Team was mostly able to follow time deadlines set forth in this chart.

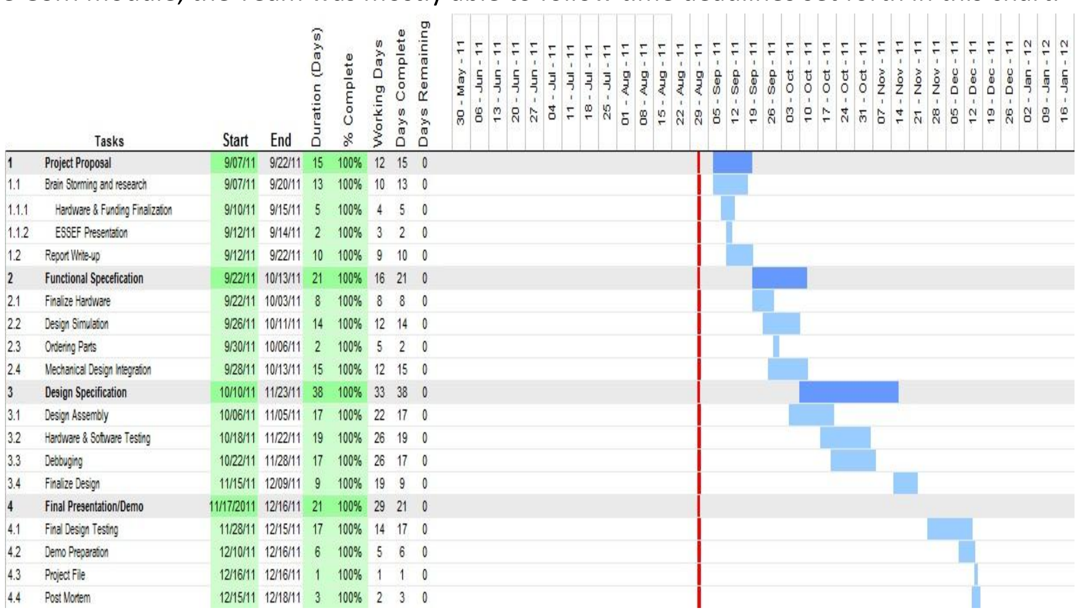

Figure 6 - Gantt Chart Schedule

4. Future Plan

To further enhance the functionality, stability and durability of our product, there will be many possible improvements made on our current existing prototype.

4.1. Mobile Application

To provide user a cleaner interface with easier access and control, we plan to develop mobile applications on various platforms including Apple iOS for the IPhone and Google Android for corresponding compatible devices. Instead of sending abstract control commands, a user can select and send control commands in a more intuitive method; a user can also obtain real-time status feedback from sensors and motors using a better GUI, instead of abstract text description. The main limitation of such apps is that most mobile operating systems restrict the access to automation on text message sending and receiving, so the design of such an app may involve using packet service such as mobile internet access instead of circuit switching such as the SMS service.

4.2. Better Control and Status Commands

To help a user and an operator better understand and use the system, we plan to modify many of the current system control logic and response/feedback logic so more informative status messages are sent back to the user; doing so will allow a client to receive crucial information in a shorter time period and thus reduce the likelihood of errors.

4.3. Enhanced Security Features

We plan to move our existing security protocol from simple phone number checks to MDS5 checking, so the message is encrypted from the system level and any unauthorized devices or messages will be filtered out and leave our system as secure as possible.

4.4. Sensor and Electrical Components Upgrade

Many components used in current system are simply a scaled down models lacking the essential functionalities. For example, the pressure sensor is not sensitive enough for our current operation, so we plan to have it replaced with more appropriate one such as an optical sensor.

5. Closing Thoughts and Personal Reflections

The following section discusses the personal skills gained and also offers some of our thoughts on the project, the team, and the personal challenges that we have faced.

5.1. Yazan Shehadeh – Chief Executive Officer

The starting stages of this project were extremely crucial due to the fact that we had to choose a project with certain features. Complexity, the amount of time we have, and our budget were the main factors when choosing our project. Due to my experience with PLCs, ladder logic programming, and my past co-op positions, I suggested that we do something creative that required the use of the PLC. Seeing oil tanks in isolated areas and considering human error motivated me to choose the innovate idea of controlling oil tanks via text messaging and receiving the statuses of the tanks.

I considered the idea of the project with my partners that were both interested and excited about it. That motivation and excitement were needed to start the work on this time consuming project. We were lucky to have a dynamic team with all kinds of needed skills. Despite all the stressful times and the all-nighters of trying to meet the deadlines we have created for ourselves so we can finish on time, I can say that I am extremely satisfied with the amount of information I have learned during the semester and our final outcome.

Through this experience, I have gained a wealth of knowledge and improved many great skills throughout the semester. I was also able to create a network of people from the companies I purchased some of our products from, creating more future job possibilities. This is especially important for me because through working on this project I found that I have a great interest in ladder logic programming. I also have a much better understanding of everything we worked with, whether it be sensors, pumps, power, GSM, etc. As the CEO of the company, I have gained strong leadership skills with an excited team that is very forthcoming and open to communicate. This led to accomplishing the initial goal of the project in a friendly and positive way.

5.2. Monir Pejgaleh – Chief Financial Officer

Working on this project taught me how to manage my time and be able to analyze and abstract all collected data, and be able to find the source of error to reach a goal.

I have also gained more experience working with different types of sensors such as temperature, water level and pressure sensors. I contributed a big amount of time trying to understand the functionality of each sensor, compare them to each other and be able to choose the best option while keeping the price and this projects goal in mind. It was also helpful to ask my instructors for guidance and help to make sure we are on the right track .I was also able to work on building the control circuit which in return helped me gain more experience with contactors, relays, and circuit schematic drawings.

In addition, I found that in order to get better results, a lot of research and brainstorming is needed. It was not easy to come up with an idea that was somehow new and never thought of before. Knowing that similar ideas were out there and people are trying to improve it gave us the motivation to be able to finish this project and add a feature (text message controlling) that was not included in the products built by other companies.

This group achieved a great way of working on and writing technical documents since we would start by brainstorming and writing down all the main ideas, then we would divide the work in between us and make sure that each member is working on a part that is in his expertise. Once every part was done and added together, we would have one person review everything and attach all parts together so it looks as one piece of document.

Interpersonally, I have learned that I need to be a good listener, understanding and welling to do what is best for the group. Since each person has an idea of how things should work, I believe that gathering those ideas and picking the best parts out of all of them would be the best strategy to achieve the desired goals.

5.3. Zhi-Yu (Mark) Zhou – Chief Technology Officer

I learned many valuable lessons throughout this course. One of the most important aspects is teamwork. Although I did not have much issue with any of the team member, we do have disagreement from time to time on various design differences. I learned that by handling and overcome those differences correctly; we can all benefit from the eventual outcome and learn a great deal of compromise and tolerance.

I also learned a lot on software development, especially the one using ladder diagram and C. Also I had many previous experiences with both of them, working on an actual project feels and handles much differently than any of my previous experiences.

Finally, I took a great lessons on how to handle the most unexpected when working on a project evolves multiple people and distributed components. For instance, in the beginning of the project, I already divided the input/output voltage for the PLC so I thought we could easily integrate all electrical and sensor components easily together; but unfortunately, the pump motor requires a relay connection instead of a voltage driven output, and sensor input requires Amp instead of Voltage. I learned how to correctly and effectively adjust the project and its associated setting to any new issue as the project moves on. I important thing is to communicate with other members in the group so each should know any used protocol used by their component so everybody else will design their parts complying to them.

5.4. Amit Verma – Chief Operations Officer

The initial idea was proposed by our CEO, Yazan and provided me an overview of the project. I explained him my past work experiences in the area of power and energy. Hence, I was assigned the duty of building the power components comprising of pumps, safety and electrical components. Initially, I found my duty challenging as I never had enough hand on experience with high power components. However, as the time progressed I gained experience in high voltage circuit analysis, protection relays and mechanical torque. In addition, this project also improved my hand on skills. Lastly, the most important learning areas gained from this project were team work, creativity and improved work ethics.

5.5. Shervin Asgari Pour – Chief Marketing Officer

As the chief marketing officer for SRC Telemetry Incorporated, I was responsible for researching existing market technologies and in proposing various design enhancements that could potentially cut down on the current costs of the prototype unit. A cheaper, equally safe, and functioning product was always my vision behind SmartFlow. During my last co-op with Creation Technologies, I was part of the Product Cost Engineering Support team; as such I was able to use my knowledge of the market and of the various distributers and manufacturers in order to save up on many of the essential components utilized in the production of the SmartFlow unit.

Furthermore, I gained a lot of experience in implementing an idea from inception to completion. I was very satisfied and motivated to work hard in order to complete the project in time for the proof-of-concept demonstration. Additionally, the time management, technical writing, and the level of professionalism that I have gained will definitely be applicable to my future employments.

The research into possible markets for our product was also done in part by me, although we knew from the start that we wanted to market SmartFlow to remotely located storage vessels used in the oil and gas industries, I was able to find other uses for our product that could be achieved with some minor tweaking. As an example, consider a typical house and its temperature-controlling unit, the thermostat. A disabled person on a wheelchair may not be able to control the humidity and the temperature level of their home freely as most thermostats are strategically placed on walls at a height that is accessible while standing. By using our company's product, life can become a little simpler for such a person, allowing them the freedom to control the humidity and temperature levels by simply sending a text message, rather than asking for help.

I strongly believed in our product from the very start, and I know that it could prove to be very beneficial to not only the oil and gas industries, but also to the general public. I thoroughly enjoyed working with my partners throughout the last four months and I shall never forget the many sleepless nights endured to ensure the completion, testing, and debugging of SmartFlow.

6. Conclusion

The team at SRC Telemetry was able to show the proof-of-concept of SmartFlow during the demonstration held on December 16th, 2011. As detailed throughout the past four months, our product is to be marketed towards the oil and gas industries, in order to cut down on the costs incurred by those companies (such as transportation costs to and from such remotely located oil fields). As discussed above, SmartFlow could also be marketed towards the elderly or the disabled should the team decide to take that route instead.

The team was presented with a majority of challenges throughout the entire four months, but the level of professionalism shown by each team member contributed to a positive proof-of-concept demonstration.