April 18, 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 a Blood Flow Speed Measurement Probe

Dear Dr. Rawicz,

Our team at VeloStream Technologies Incorporated has successfully designed and built a blood flow measurement probe. The enclosed document, *Post-Mortem for the VivaceFlow Blood Flow Speed Measurement Probe,* provides details about the current state of our device, deviations from our previous documentation, future plans for our device, discussion of our budget and timeline, and a personal reflection from each team member.

Our team is comprised of five undergraduate students from Simon Fraser University: Connie Drewbrook, Wyatt Gosling, Kaveh Naziripour, Jedsada Sahachaiwatana, and Elizabeth Steiner. If you have any questions or concerns regarding our design specifications, please do not hesitate to contact us at velostreamtech@googlegroups.com.

Sincerely,

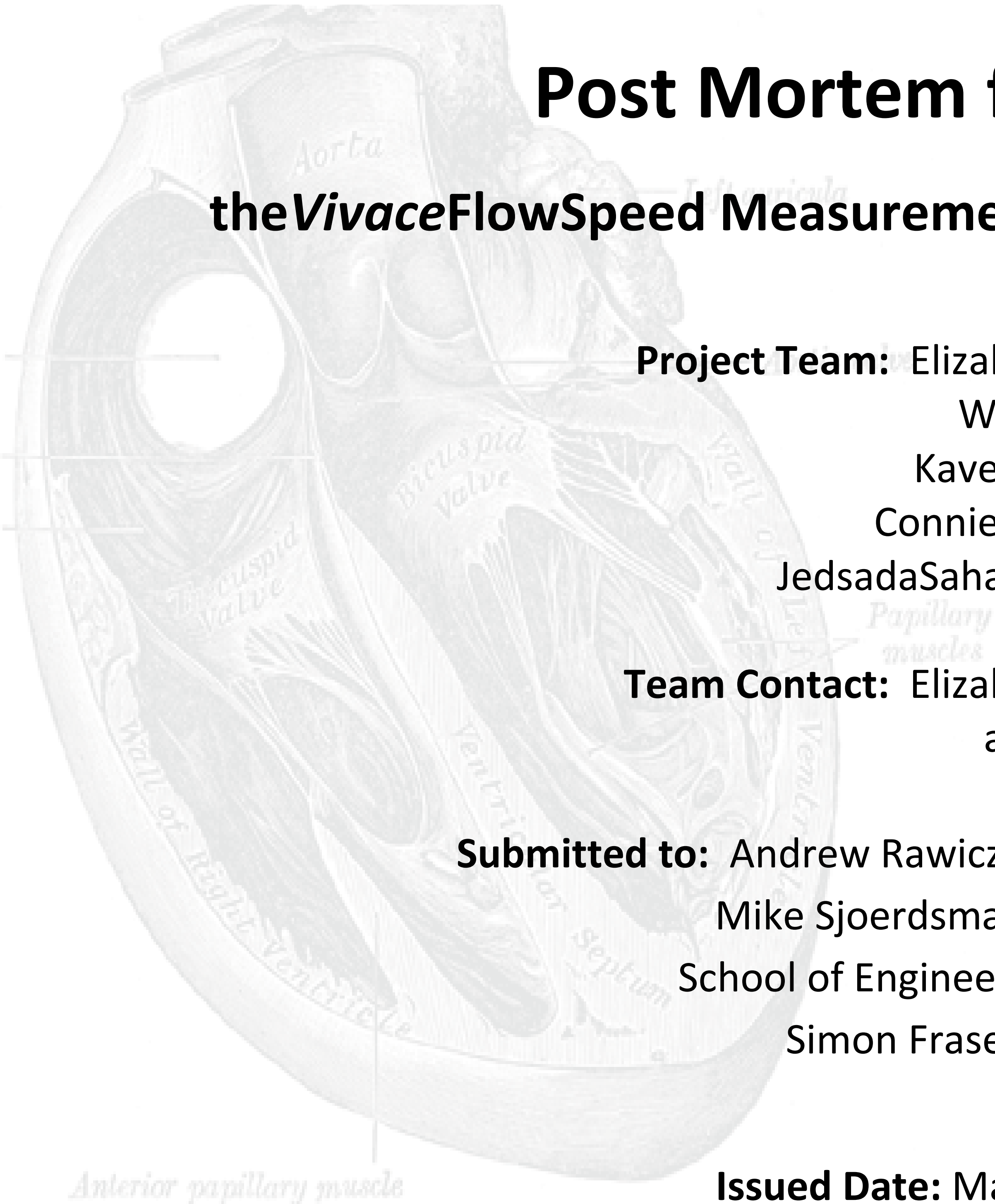
E Steiner

Elizabeth Steiner
Chief Executive Officer
VeloStream Technologies Inc. Suite 2106 - 8888 University Drive
Burnaby, BC V5A 1S6

Enclosure: *Design Specifications for the VivaceFlow Blood Flow Speed Measurement Probe.*

velostream

VeloStream Technologies Incorporated



Post Mortem for the

the*Vivace*FlowSpeed Measurement Probe

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Glossary

ADC	Analog to Digital Converter
COM	Serial port interface available on PCs.
C#	A programming language developed by Microsoft
DAQ	Data Acquisition
GUI	Graphical User Interface
In Vivo	A experiment or procedure is performed inside a living organism
.NET	A software framework developed by Microsoft
Saline	Water containing significant concentrations of salt
Thermistor	A resistor whose resistance varies with temperature
Wheatstone Bridge	A circuit used to measure an unknown resistance

1 Introduction

Over the past semester, VeloStream Technologies has been working diligently to design and build the VivaceFlow Blood Flow Speed Probe, and have successfully completed a prototype of our device. The few modifications from the functional and design specifications are detailed in this document, as well as an analysis of how well we were able to follow our proposed budget and timeline, and a personal reflection from each group member of the Capstone Project experience.

2 Current Status

Following the functional and design specifications previously outlined, the VeloStream Technologies team has developed the VivaceFlow, a state of the art flow sensing system with a sleek and compact design to be used for in vivo measurements. The following chapter outlines the current state of the device, after 13 weeks of development. The general system capabilities are defined, as well as the final design for each subsystem.

2.1 System Overview

The VivaceFlow system consists of three subsystems: the UniscaSuite, the GenioBox and the PiccoloProbe.

- The UniscaSuite is a software system that controls the GenioBox by starting and stopping the flow speed measurements.
- The GenioBox contains a mixture of analog and digital circuits needed to process data from and regulate the PiccoloProbe.
- The PiccoloProbe is a long thin probe, having the flow and temperature sensor on the end, which is used to insert the flow sensor into the cavity of interest.

Figure 1 below is a block diagram demonstrating the current high level functionality of the prototype. Using the UniscaSuite it is possible to control the GenioBox to start and stop flow measurements. Upon command, the GenioBox will power the elements required for flow measurement, and begin sending raw data to the UniscaSuite. The UniscaSuite collects this data and prints the flow measurements, based on calculations determined from calibration, to the screen. The raw voltage measurements for speed and temperature data are saved in a log file, as well as the calculated speed and temperature values.

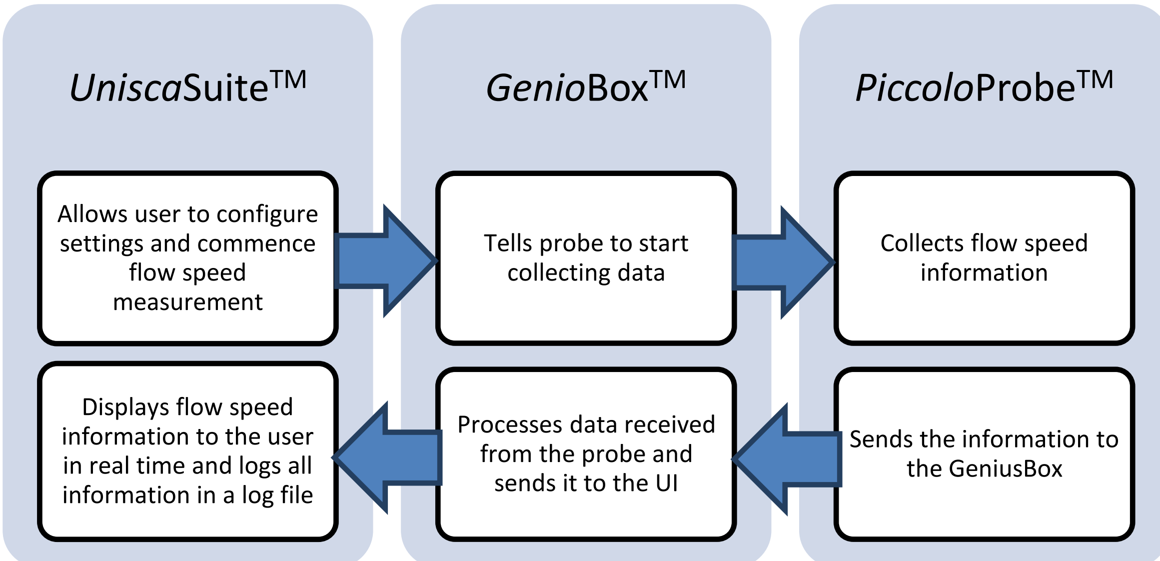

Figure 1 – Current High Level Functionality of the System

2.2 *Piccolo*Probe

The *Piccolo*Probe takes flow speed and temperature measurements. The head of the probe contains two thermistors: one performs temperature measurements and the other performs flow speed measurements. The flow sensing thermistor was chosen to have the lowest thermal dissipation constant reasonable. This reduces the response time, allowing our device to respond to flow changes within one second. The temperature sensing thermistor was chosen to have a higher thermal dissipation constant, which reduces sensitivity to its self-heating. The thermistor can measure temperatures to an accuracy of 0.1 degrees.

The body of the probe is made from a metal pipe. Its long, thin design ensures minimal disturbance of the surrounding fluid. The functional end of the probe hosts the both the temperature and flow sensing thermistors. The thermistors are attached to the pipe via a spring which allows steering of the probe. The spring is connected via a string to a nob located at the opposite end of the pipe. The nob allows the user to bend the spring up to 135 degrees, allowing the user to steer the probe head. The probe body is sealed completely in heat-shrink and super-glue allowing it to be safely submerged in water.

2.3 *Genio*Box

The *Genio*Box performs pre-processing of signal data, analog to digital conversion, and sends the data to the computer's COM port. The GenioBox contains an analog circuit which interfaces with the PiccoloProbe. The electronics consist of the three circuits shown in Figure 2. The top circuit performs flow measurement via a Wheatstone bridge. The signal's offset and amplitude are adjusted to increase the accuracy of measurement via the microcontroller's analog to digital converter. The bottom right circuit measures fluid temperature via a voltage divider. The signal is again amplified to minimize the error of analog to digital converting. The bottom left circuits are the power converts used to convert the 24V supply we get from the wall into the 20V and 5V supplies we need for the circuit.

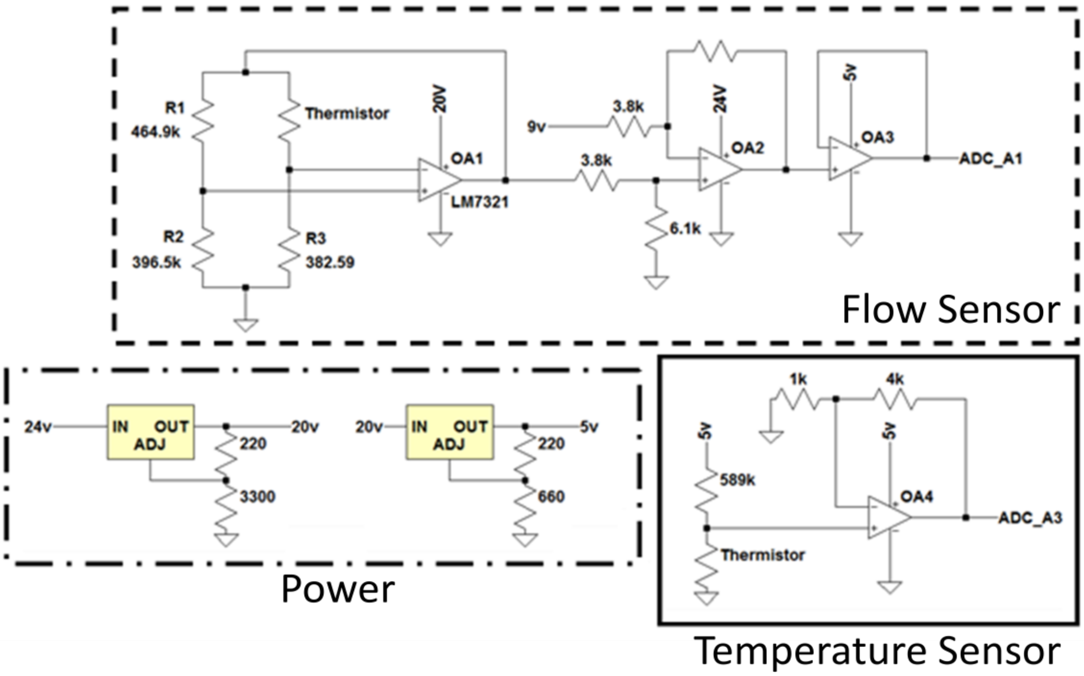

Figure 2 – Schematics of the analog circuits within the *Genio*Box

As mentioned the *Genio*Box contains a microcontroller which performs analog to digital conversion of the two signals. The microcontroller sends the raw voltage readings to the attached computer's COM port so it can be analyzed by the *Unisca*Suite.

2.4 *Unisca*Suite

The *Unisca*Suite, shown in Figure 3, allows a user to control the system via a computer GUI. The software is able to control the *Genio*Box, commanding it to stop and start flow measurements. Additionally, the software is able to retrieve data sent via the host computer's COM port. The *Unisca*Suite processes this data, converting the raw voltage signals it reads into a flow speed and a temperature. The software has to be able to consider different fluids and temperatures, and is able to do so by reading a configuration file containing calibration constants. Currently the software has only been calibrated for saline at 37°C.

The software displays both the current speed and temperature to the user in real time via the GUI. The GUI receives data updates at a rate of 10Hz, and displays values which are an average of the data collected during that period. The software also logs the data into a log file at a rate of 100Hz. The log file contains both the calculated values, as well as the raw voltages read from the COM port.

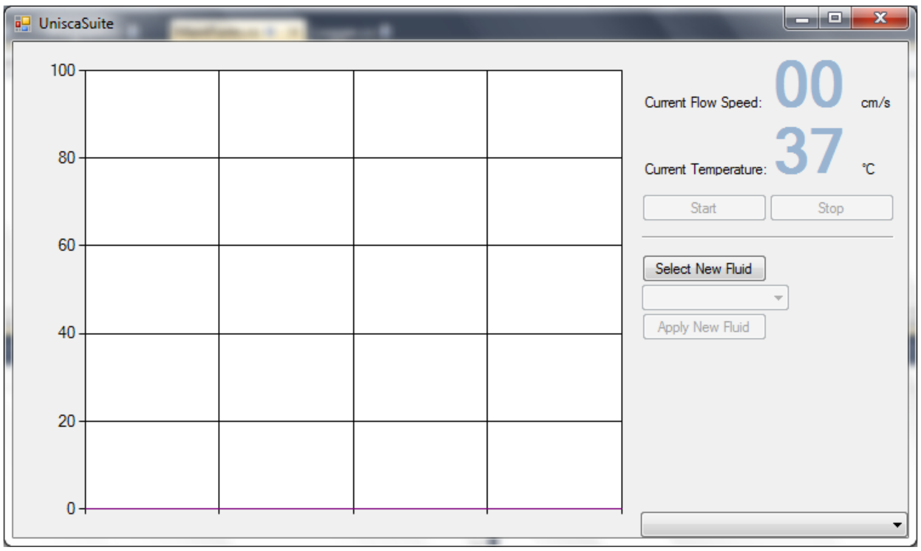

Figure 3 – The *Unisca*Suite Graphic User Interface

3 Deviation from the Proposed Design

As is evident from the current state of the VivaceFlow prototype, there is limited deviation of the project from the proposed design. Presented in the following chapter are a few of the problems which arose during the process of building the prototype and any implementation deviations that resulted from this. Also presented are the functional specifications we have failed to be met by the current prototype state. Proposed future work which will satisfy these requirements is presented in the following chapter.

3.1 *Piccolo*Probe

The current PiccoloProbe body design contains limited deviations from the originally proposed solution. The changes that were made to the design succeeded in improving the overall system and removing some previously concerning issues. In the original proposal the bending of the probe would be controlled by a string which would, produce a torque on the head of the probe from the outside. This was a real issue as it resulted in problems related to sealing the exit and entrance hole for the string, and insulating the string from the fluid in which the device was placed. The new design contains a spring which compresses significantly, allowing the controlling string to be placed inside the device and remove any insulating issues.

The original flow sensing thermistor was chosen to have a thermal dissipation constant of 0.8mW/°C. Testing with this device showed that the time response of this element was almost ten seconds to a change in flow speed. This response was deemed unacceptable and further research and testing ensued in order to improve these results. In the end a flow sensing thermistor with a 0.1mW/°C dissipation constant was found and implemented in the design. As previously stated, the current thermistor, in water, will respond to changes in flow after less than one second, which is an improvement over the previously measured ten. Research was also performed on thermistors which provided an even smaller dissipation constant and the hot-film method with a tungsten wire. Although these two methods produced faster results, they were not practical for implementation in a robust, in vivo flow sensing probe and were abandoned. As a result, the response time was much higher than the 10ms time which was outlined in the functional specifications.

Also added to the design was a second thermistor, spaced a few millimetres away from the flow sensing thermistor, to be used for temperature measurements. This was not in the original design proposal, but upon further investigation it was determined that the relationship between the output voltage and the flow speed not only depended on the type of fluid being used, but also depended on the temperature of the flow. As a result, the temperature measuring thermistor was added to the design.

3.2 *Genio*Box

The flow sensing mechanism used a Wheatstone bridge and feedback amplifier in order to maintain a constant temperature of the thermistor. The original proposal had assumed that the dynamic range of the voltage output from the op-amp would be sufficiently large such that direct measurement by the microcontroller would be possible. Once building and testing began it became evident that the dynamic range was much smaller than expected, for some temperatures being less than 1V. As a result, a differential amplifier system was introduced into the GenioBox, thereby increasing the dynamic range to exploit the limits of the microcontroller.

The Arduino MEGA2560 microcontroller was replaced by Arduino UNO. UNO has the same basic features as MEGA2560, but cheaper. The switch between microcontrollers was due to problems with ADC. During testing, for some reason, analog to digital converters (ADC) of MEGA2560 were broken and readings from it were unreliable. After replacing it with UNO, the problems were solved. ADC of both microcontrollers have a resolution of 10 bits, which we thought sufficient at first, but to get more accurate readings from other components an external ADC with higher resolutions should instead be employed.

The implementation of power supplies inside *Genio*Box was also changed. First an LM2678, a switcher, would be used to convert 24 volts from AC adapter to 20 volts. Due to the difficulties in soldering very small surface mount components, LM317, a regulator, was used instead. After we had all the tools needed to solder surface mount parts such as solder paste, a hot plate, we then could be able to make a converter to convert 24 volts to 9 volts. We did not pursue in making another 20 volts using LM2678 because LM317 output very stable 20 volts supply. A 5 volts power supply was also added to the circuit using LM317 to make buffers between circuits and microcontroller. The buffers were there to avoid voltage spikes that could damage microcontroller pins.

Operational amplifiers were also deviated from the initial design specifications. At the beginning, UA741 was used, but it was more complicated to implement dual polarities power supplies LM324, a single supply op-amp, was used to replace UA741.

3.3 *Unisca*Suite

The GUI now displays the current temperature recorded by the *Piccolo*Probe. Given the method of flow measurement, it was determined by our sponsor, Kardium, to display the currently temperature. The GUI has been adjusted to display the temperature alongside the current speed. Additionally, they requested that the raw voltages are logged.

Due to this, the communication protocol between the *Unisca*Suite and the *Genio*Box has changed. Instead of calculating the speed and temperature, the *Genio*Box simply passes the raw voltage values to the *Unisca*Suite. Data sent by GenioBox is now in the following format.

F Voltage_Speed Voltage_Temperature Timestamp(in ms)

UniscaSuite now handles conversion from voltages to speed and temperature. Additionally, *Unisca*Suite has been modified to be able to read configuration data from a text file named fluids.conf. This would allow Kardium to calibrate the probe for other liquids should they feel the need.

The data *Unisca*Suite sends has been completely reworked. *Unisca*Suite will send "start", "S", and "ping" to start, stop, and ping the *Genio*Box, respectively. Initially, 'stop' was used for stop. However, testing showed that when the *Genio*Box is transmitting data, it may not properly read 'stop' in its entirety. Using 'S' has proven to be significantly more reliable. Additionally, *Genio*Box will notify *Unisca*Suite when it receives a stop command. This allows *Unisca*Suite to ensure the stop command gets through: it will periodically send 'S' until confirmation is received.

4 Future Plans

VeloStream group will commercialize the *Vivace*Flow meter. The first step is to calculate the budget needed in order to meet all of the requirements mentioned in the functional specification [1]. Considering that we only covered the minimal requirements for demo/validation purposes, namely the "B" category of our ranking in the functional specification document, we will need to go back and meet all the "A" and "C" category of our ranking as well, which is the requirement for both proof of concept and production models. Some of these requirements are extremely involved and lengthy, such as the approvals of both Canadian and American standards.

Once the budgeting is calculated, there will be a business plan preparation, which will be a road map to the approximate budget and time needed on each step. Our business plan will cover important topics such as:

- Executive Summary
    - essential section for VeloStream investors, based on the statistics and attractive figures this section can bring in the next funding needed or reject the company
- Business overview
- Service or Products
- Industry Analysis
- Market Analysis
    - The SWOT (Strength, Weaknesses, Opportunities, Threads) approach will be effective for this section. VeloStream group will remain focused on North American market in the primary stage and upon success roll to international market
- Competitive Analysis
- Sales and Market Strategy
    - considering that we are a biomed company, our break even points will take longer to reach and strong justifications are essential
- Operations
- Management
    - team structure will remain the same more or less as it seemed very effective with the current product
- Risks
- Equipment and Technology
    - the nature of our work is in life sciences and spacious labs and expensive equipment is needed for this type of work which would drive the product research and development forward
- Financials
- Use of Funds
    - VeloStream can benefit from many research and development programs that fund our group such as NRC-IRAP and SRED

This document involves a more thorough research on the overall market, market segmentation, and defining the target market and even the niche market (as this is a biomedical device for research companies.) This can be a great challenge to the VeloStream group as we are all from an engineering background. Market research can be a complicated and tricky process. Even marketers from different backgrounds may not be able to simply change to the next area that may be out of their expertise. So, considering the capabilities of our group, getting help from experienced mentors with marketing background will be a need and even allocating a good chunk of budget for this purpose is a wise decision. Furthermore, the preparation of this analysis needs to be in line with the rest of our business plan and hiring forces in this field is one of our primary steps as well.

Furthermore, there will be a need of provisional patent application in order to protect our technology and the method of implementing it. Also, after the provisional patent, we are obligated to do the utility patent, which would get us the monopoly of 20 years on the use and license of this technology. This process, similar to the approval process is lengthy and can be complicated. Also, usually in biomedical companies such as VeloStream Technologies Inc. patents are one of the most important assets, which will add value to the company and in our case patenting is important not only for North America, but international patent in the countries that matter as well. As much as the protection of an international patent is a desirable choice, the cost of such deed can increase dramatically and may not come to a realistic figure for a start-up company. However, our goal is to maximize the regions that matter the most and protect our technology as already mentioned to increase the shareholders' value.

There will be further documentation involved in regards to the entire venture. Due diligence and proper legal documentation, such as partnership and shareholder agreement of the corporation is an essential task that will be carried out. Corporate structure and external circumstances can influence the group members, who may change their direction in life, especially for a bigger group like ours. Therefore being pro-active legally can save the team from running into idle effort and prevent the collapse of the entity due to partnership issues. This is a common problem in start-up where a failure of partnership leads to the death of a corporation. Having terms such as probation period, where members cannot keep shares if they decided to bail out are very beneficial to the safety of the corporate and the investors' money and will be taken into consideration.

Once the company is incorporated provincially and federally and there is an appropriate business plan in place, the VeloStream Technologies will seek a second round of financing. Upon successful second round of financing from the existing investors and perhaps some new ones the business plan will get executed and will be modified accordingly. We are planning to make the company a public company and perhaps do an initial public offering (IPO) exist strategy in between five to seven years, which is reasonable time frame for a life science corporate. The members can choose to hold their shares or cash out their effort for retirement.

5 Budget

Table 1 compares our budgeted and realized costs for each major section of our project as of April 17, 2011. We were provided with funding from our contractors in the amount of $1000.00. We were able to complete our project under budget, which is due to a few key factors. First, we had budgeted $200.00 to be allocated to our testing device. Our contractors allowed us to borrow their flow machine for our calibration and testing, which reduced the amount we had to spend on this section since it was not necessary for us to purchase any testing apparatus. Second, our shipping and mechanical component costs were less than we had expected. Last, we used an inexpensive microcontroller to digitize the analog output voltage reading from our flow measuring circuit. We realized by the final weeks of our testing that we may have been able to gain accuracy by instead using a DAQ card, which would have been much more expensive.

Table 1 – Comparison of Budgeted and Realized Costs

Item		Budgeted Cost	Required Cost
Electronics Components	Microcontroller, Power Supplies, PCB Components	$200.00	$289.35
	Analog Circuitry and Sensors	$250.00	$359.01
Mechanical Components	Probe Materials	$150.00	$52.00
Testing Device	Flow Machine, Flowmeter	$200.00	$0.00
Shipping		$100.00	$38.49
Contingency		$100.00	$0.00
Sum:		**$1000.00**	**$737.86**

6 Timeline

We planned our milestones such that we felt we would be able to complete most of them on time. Although we were able to decide on our flow sensing method by the planned date, due to the method of choice, we spent longer than expected experimenting with the method. We had to purchase and test a wide variety of thermistors before deciding upon the one best suited to this application. Due to this, integration of the sensor, digital circuitry and software was delayed. As a result, our testing and calibration did not occur until early April. Although our timeline was slightly delayed, we spent many long hours calibrating and testing our device to ensure it works correctly and reliably.

Table 2 – Comparison of Proposed and Actual Completion of Milestones

Stage		Proposed Date	Actual Date
1	Order Parts	Feb. 7	Apr. 10
	Flow Method Design	Feb. 3	Feb. 10
2	Body Prototyping	Feb. 14	Feb. 10
	Flow Pump Design	Feb. 21	Not Necessary
	Flow Sensing Assembly	Feb. 21	Mar. 7
3	Feedback Loop Integration	Mar. 7	Mar. 15
	Body Assembly	Mar. 7	Mar. 10
	Logging Software Integration	Mar. 21	Apr. 1
4	Building of Test Pump	Mar. 28	Not Necessary
	Formal Testing	Mar. 31	Apr. 15
5	Presentation of Device to Contractors	Apr. 12	Ongoing

7 Individual Experiences

Elizabeth Steiner – Chief Executive Officer

One of the greatest experiences, I found, with doing our particular Capstone project was the opportunity to work with an established company and build a device which had been defined by them. Although this took away the freedom from our group to choose our own project, I find that this sort of experience is much more realistic and much more challenging given the functional restrains which were placed by the company. Although we didn't choose the final project, we still had the freedom to design and build it any way that we wanted, thereby not limiting our creativity and intelligence, but enhancing it because we had been given a project to tackle which we had not come up with on our own. Often, when one decides on a project for a design task such as this, they would choose a project which was in their realm of knowledge; something which they had a general idea about how to tackle. In our case we were charged with a project we had limited knowledge about, and were forced to get extremely creative in order to determine how to tackle it.

My main role during the progression of the course was to bridge the gap between the PiccoloProbe and the GenioBox, straddling the lines for both components and worked on designing the electronics required for these pieces along with my peers. The dynamics in the group worked extremely well. I can safely say that I enjoyed working with each and every one of them, and that there was limited conflict between us regarding the project. Considering the horror stories I have heard from some people about group dynamics in 440, I know I am extremely lucky to have worked with such an amazing group.

The best part of the project was the freedom to design and build our own system. Nowhere, in our other classes is this sort of experimental freedom obvious and it takes a lot of work and experience in order to become good at it. Being given (forced into) the chance to have to devote myself to this sort of developmental experience is one of the most important parts of my degree, and something that I will never forget.

Kaveh Naziripour – Chief Visionary Officer

Being an enthusiastic entrepreneur I was involved with two start-up companies and gained a lot of knowledge in different areas of a start-up. Moreover, I always struggled when it came to technical aspect of a "concept to product". ENSC 440 was something that covered what I needed.

The process of concept to product is a very extensive topic in business and entrepreneurial world. However, when it came to technical and engineering aspect I never knew the structure. At the beginning I was always disappointed about the tedious documentation of proposal, functional specification, design specification, even though I was aware of its importance. Surely knowing the path is different from walking it. Because it was then that I realized how these documents become a bible to the team and synchronize every member of the group whom work on different parts, where before I always thought that they are purely for legal purposes.

Effective communication is a must for a team to succeed. There were two different occasions that we did excessive work due to poor communication. As Allen Mollaly, the former president and CEO of Boeing Company once said communication is not a matter of what's said, but it is the matter of what's understood. This clearly manifested in our team work and I realized that the fact that the words take place within a group is not communication, but rather what each individual concluded. Based on the different conclusion miss-communications can happen and lead to excessive work and tension amongst member.

This course walked me through the technical process of concept to product life cycle in terms of technical work and documentation and I learnt tremendous things from it that are valuable asset to my career as an entrepreneur.

Wyatt Gosling – Chief Technology Officer

Coming into this class, all I really knew was that this was "The Project Class" and that one year a group made a fart analysis system (or so the rumour says). When I was recruited into the group, I actually thought I wouldn't be taking this for a while as I would need to take 400 level courses to actually know enough to design anything myself. Thankfully, I learned that I had been selling myself way too short.

A big concern for me was coming up with a product idea. When given the ability to choose anything, I can't think of anything. As my teammates where bursting with ideas, this concern was rather quickly put to rest. However, I quite liked that the course was left entirely up to us. Some classes are overtemplated to the point that you only learn a small portion of the big picture. As an example, in a previous course we developed an application that did COM port communication but it wasn't until this course that I learned most of the details of what is involved. I really appreciated that we simply could not get by without learning the details of the tools we worked with.

I stuck mostly to working on the software side of this project. I used this as an opportunity to learn a new language, as well as some new tools, and some other tidbits of knowledge related to Windows software development. I learned to use the C# language as well as the .NET platform, which both are quite popular given their support and backing from Microsoft. Additionally, I gained experience working with Visual Studio, which is perhaps the most common IDE on the Windows platform. I also worked with NSIS, a tool used to create Windows application installers. I was honestly quite baffled at how complex creating an installer for Windows actually was. I learned more about Microsoft Word than I had learned anywhere else. I can actually make a professional looking document with it now. It was also nice to do real testing of a software product. Often, we are given a single test case which we had to pass. That is not applicable to this course. We have to produce a product that can work in a live demo where the user can do anything. We had to be confident that we could pass any case, not just the one provided to us.

Connie Drewbrook – Chief Financial Officer

Working on this project throughout the past semester has been an exciting, rewarding, and work intensive experience. I feel as though I have gained many new skills in both technical and non-technical areas over the semester, and I have surprised myself by how much can be learned about a new area in a short period of time. When I think back to the initial stages of planning it is a very rewarding feeling to now see our device in operation, and see how far we have come from the initial planning stages. The project has also allowed me to develop several soft skills such as group organization, planning, and efficient communication through weekly group meetings, and writing skills through the documentation part of our project.

My main role in this project was centered upon designing and building the probe sensors and the analog circuitry required to control the sensors. There were several methods available, which were researched and tested before deciding upon using thermistors as the sensors. Designing the probe and choosing the optimal sensors proved to be a challenge which required testing several before deciding upon the one best suited to our application. Our device requires both flow and temperature sensors, so the necessary characteristics of the two sensors was very different. Another major challenge I encountered is due to the environment in which our device is used: liquid. The properties of the sensor changed when immersed into liquid, so again testing and calibration of the sensors was a necessity. This also complicated the probe calibration and testing, since in addition to producing a working prototype, it was a challenge to come up with suitable test conditions.

I found it was helpful to start integrating components early on in order to determine what changes may optimize the performance of our probe. For example, simply changing an op-amp provided a much better response time due to higher current output to the flow themistor. Also, I realized that it is vital to decide which components need to be really high quality, and which can have a bit more flexibility. In retrospect it may have been better to have purchased a DAQ card instead of using the microcontroller's ADC for reading the voltage output, as this may have produced more accurate results.

Furthermore, in my role as the Chief Financial Officer I was responsible for keeping track of our expenses to ensure we stayed within our budget. I oversaw a significant amount of the ordering of parts and enjoyed tacking a range of roles throughout the past few months.

Lastly, I feel that this experience has been a very valuable learning experience due to my team members. For the most part, we worked great together, and due to our range of interests and expertise, I feel that I have gained knowledge in areas that I did not excel in when starting off this semester.

Jedsada Sahachaiwatana – Chief Operating Officer

For this project I have been assigned to design electronics circuits inside The GenioBox to process data from a thermistor inside the PiccoloProbe, amplify the signal, then forward it to the UniscaSuite software to further refined data and plot them. I have learnt a lot from the past 13 weeks in order to make the circuits working with the rest of the components.

The team has decided to use 20 volts as a power supply for the whole circuits. In order to meet this specification, I have decided to purchase 24 volts AC adaptor and implement a circuit to regulate 24 volts to 20 volts. The circuit using LM317 voltage regulator turned out to be very simple and easy to implement. After adding a couple of capacitors, the signal was very stable and had very low noise.

Because we have decided to use microcontroller, I also have to design a circuit to power it. The microcontroller Arduino takes 9 volts supply. I have encountered so many design challenged until I came across an online software from National Semiconductor. This software eliminated all the calculations I need to design a power supply. I only needed to specify voltage input and output and it picked and chose the right chip for me. I have decided to use LM2678, a switcher, due to its power efficiency and the circuit looked easy to implement. It turned out to be a bad idea after I received the parts and realized that the surface mount components were too small to solder them using solder iron. I then had to use solder paste and hot plate technique to solder all the components to the circuit board.

This is my first time fabricated circuit boards. I learnt various ways to transfer designs to the board and decided to go for a toner transfer method. By printing the designs on photo papers using a laser printer, the designs could be transferred to copper clad boards by using cloth iron. The method looks and sounds easy on paper but it in fact was messy. If I could change, I would go for a traditional method, using photoresist.

We changed microcontroller several times throughout the semester. First, we started off with an evaluation board EVK1101 from Atmel to later realize that there were components attached to pins we needed to use. We then switched to a cheaper solution, an Arduino board. I have no experience with Arduino, so I picked the one that has most features, Arduino MEGA. It took a few weeks to test this board and I could not solve problems with ADC readings. I thought it would be from my circuits or bad coding, but later I discovered that ADC channels of Arduino MEGA were broken so I bought a new board that's cheaper and well suited for our need, Arduino UNO. Although UNO worked well in this project, in the end ADC did not have enough precisions to meet specifications.

References

[1] Elizabeth Steiner, Connie Drewbrook, Wyatt Gosling, Kaveh Naziripour, and Jedsada Sahachaiwatana, "Functional Specifications for the VivaceFlow Speed Measurement Probe," Simon Fraser University, Burnaby, 2011.