January 25, 2016

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

Re: ENSC 305/440 Project Proposal for an Automated Pill Dispenser and Reminder System

Dear Dr. Rawicz

The following document is a proposal for our Automated Pill Dispenser and Reminder System. Our goal is to develop a system that aids elderly in keeping track of the medication they are required to take. This will be accomplished by the creation of a device which automatically manages a patient's pills and dispenses them when needed. In addition, a mobile application will accompany the device in providing feedback and serve as a secondary reminder tool for the users.

This document provides an overview to our proposed product. It includes our design with considerations to the benefits and risks involved, finance and funding information, project planning with milestones, and the company profile. It also provides a discussion to the background leading up to this product and a comparison of existing products.

Health-Assist is comprised of five talented Simon Fraser University engineering students: Connor Dueck, Adam Gabriel, Peter Hsu, Jerry Yao and Devon Louie. We aspire to become professional engineers in various specializations and strive to innovate economical products with simplicity.

If you have any concerns or inquires regarding our proposal, please feel free to contact Connor Dueck at (phone number please) or by email at cdueck@sfu.ca.

Sincerely,

Connor Dueck,
Chief Executive Officer
Health-Assist

Enclosed: *Proposal for an Automated Pill Dispenser and Reminder System*

Pill-Matic Product Proposal

Rev. 1

Health-Assist: Connor Dueck, Devon Louie, Adam Gabriel, Jerry Yao, Peter Hsu

ENSC305W, ENSC440W

1/25/16

Health-Assist

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Executive Summary

Prescription drugs use and polypharmacy has been on the rise for the past decade [1]. With an increased number of prescriptions, it becomes difficult to keep track of individual pill schedules and doses. Certain medication is required to be taken at specific times of day, multiple doses a day, and before or after meals. Missing scheduled doses or taking them at irregular times may limit the medications effectiveness or significantly impact the patient's' health.

At Health-Assist, we plan to develop Pill-Matic, a physical automated pill dispenser designed for the elderly, people with memory loss or forgetfulness, caretakers that are responsible for many patients, or any user that takes multiple pills or vitamins with a complex schedule. Pill-Matic will be linked with a mobile device through an Android application that will communicate information such as pill schedules, dosages, and missed alerts.

While current devices do exist in the market today, they fail to provide an affordable system that supports multiple medication types with individual dosage schedules. Our proposed device will support up to 8 different medications, each with a customizable schedule and reminder system which integrates with our Android application.

We plan on implementing an iterative development cycle that yields a fully functioning prototype for demonstration by April 1st, 2016. The tentative budget of the project is $705, which we hope to attain from various sources.

Health-Assist consists of five fourth-year engineering students from Simon Fraser University with experience with Android software development, Raspberry Pi programming, database management, and mechanical systems.

1. Introduction and Background

Medication has become an integral part of modern life, 40.5% of people from age 6 to 79 take prescription medication [2]. When you factor in vitamin pills, supplements and other types of medication taken on a daily basis, the number of pills being consumed climbs to a staggering amount. Due to the sheer number of medications taken, human error often occurs in the form of missed doses. This can be extremely dangerous, as patients who miss a dose often try to make up for this by taking double the dosage at the next scheduled time. At an age of 65 to 79, 82.7% of people take prescription medication. This risk factor is further increased by memory loss and forgetfulness, both symptoms which are associated with old age. We at Health-Assist wish to solve this problem by introducing an automatic pill dispensing machine.

As previously stated, we wish to introduce a home use pharmaceutical assistant. Our device will allow a user to easily program what medication they are taking and what times the doses should be given at. The reminders will be sent to patients through an Android application. The project is targeted toward the elderly who now forget to take their pills regularly as well as people who are taking many medications congruently, who would be prone to error.

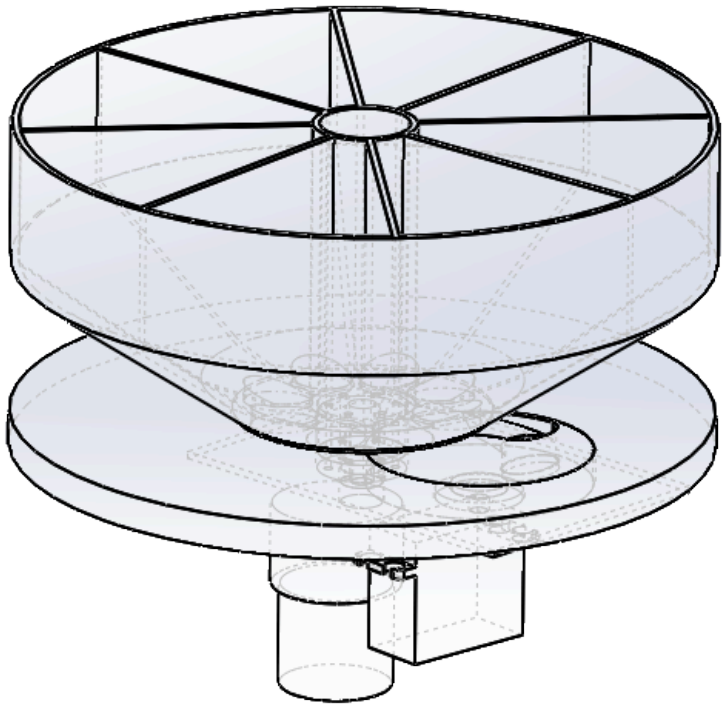

Figure 1: The SolidWorks design of the Pill-Matic hopper system

2. Project Scope

The main goal of the Pill-Matic is to deliver a reliable and convenient pill scheduling and dispensing machine that will help the elderly in taking their prescribed medications on time. However, what separates the Pill-Matic from other similar devices is our company's approach at tackling the scheduler in a modern method; specifically in integrating a smartphone companion application alongside the Pill-Matic so that reminders and warnings are clearer, precise and also less intimidating. This product rational is formed from the growing trend of the "Internet-of-Things" idea that has recently exploded in terms of popularity and success, and our company sees this as an opportunity to modernize some of the concepts within the automatic pill dispensing industry.

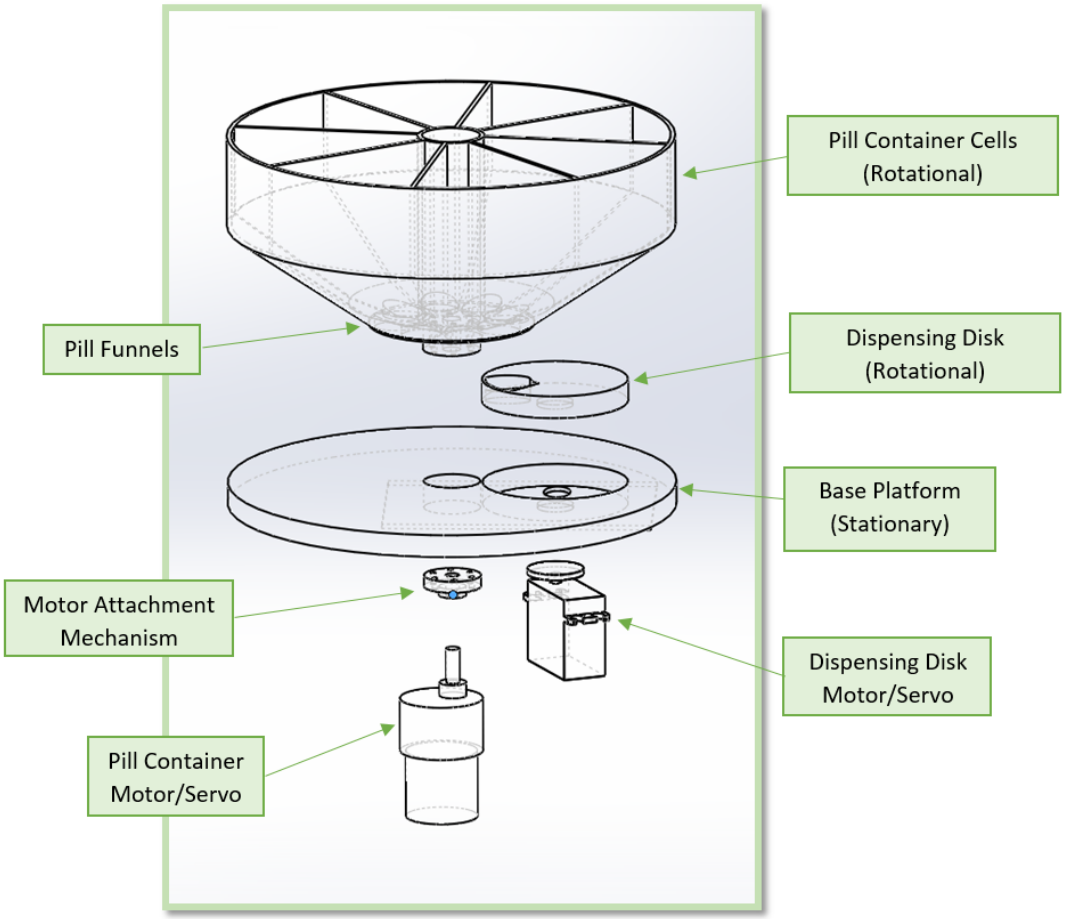

Figure 2: The SolidWorks design of the Pill-Matic dispensing mechanism

On the whole, the scope of this project is intended to act as an "improvement" solution, rather than a completely new answer. We first researched the market for similar ideas and concepts, and tried to find areas of improvement, we then expanded on these negatives so that they could be resolved in our system without the cost of losing any of their positives.

For example, existing devices in the market require the user to manually sort their pills beforehand and do not synchronize to the user's device. Having to manually sort pills ahead of time can be a tedious task and is prone to human error, thus, we have designed our device to avoid the need of manual sorting. Instead of having compartments to store each individual time to take the pills, we have eight compartments that store the pills themselves. When it is time for the user to take their medication, a mechanism will be responsible for dispensing the correct pill and amount.

Next, many existing solutions today rely on warnings that are located on the pill dispensing unit themselves in the form of flashing LED lights and some beeping noises – both of which are completely unreliable for people who are at the time away from the unit, or have a difficult time seeing and hearing the alarms. The way we approached fixing this issue was to build a reminder system atop a device that most people already have on them – their handheld smartphones. This provides a clear visual and audio feedback directly to the patients in real-time, thus allowing them to instantly gain a cue to take their medicine at the appropriate timeslots.

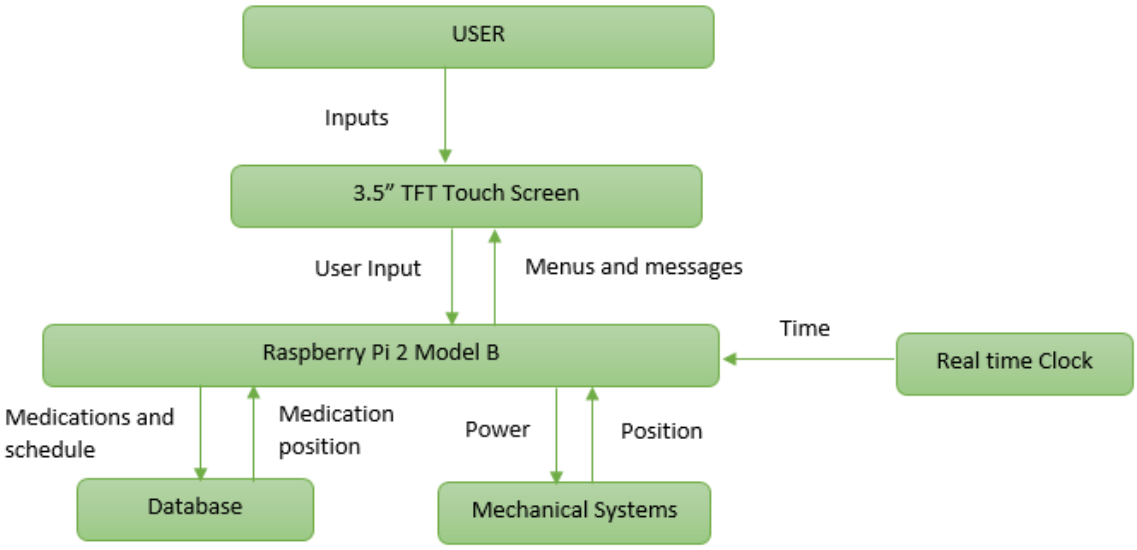

Figure 3: System block diagram for Pill-Matic

- The Raspberry Pi 2 Model B will be the processing system of the Pill-Matic prototype. The Pi allows us to execute on a well-documented development platform and gives us a SOC micro-processor, allowing programming functionalities to be built on top of the Pill-Matic's features. It also has a small form factor, a relatively cheap price, and an ARMv7 processor that will allow us to run Linux distributions.
- A DS1307 Real Time Clock will also be needed for the Pill-Matic to maintain good timings when out of range from the smartphone's Bluetooth capabilities or when device power is lost.
- Bluetooth module allows connectivity between the physical Pill-Matic system and the Android companion app.
- Servos and motors are needed for our dispensing mechanism to work. They will be powered by a 12V 5A power supply and regulator.
- The 3.5" LCD touchscreen allows the Pill-Matic to be programmed and operated on manually when there is no companion app nearby.
- Miscellaneous electronics such as wiring and passive components will be needed to patch up the final version of the prototype.
- The platform, casing, and the rotational disks will all be made from 3-D printed materials when costs allow and are based on our own SolidWorks designs.

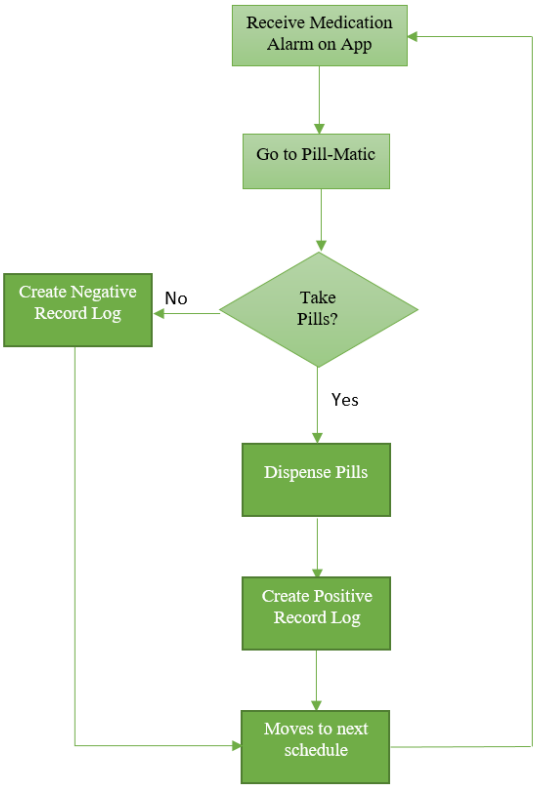

Figure 4: Basic flow chart of Pill-Matic dispensing routine. Light green are user actions, and dark green are internal system actions

3. Risks and Benefits

3.1 Risks

Table 1: Risks, their severity, mitigating factors, and consequences

Risk	Severity	Mitigating Factors	Consequences
Ordered parts do not arrive in time	Critical	Parts have already been ordered, estimated arrival is February 6.	Will not be able to complete project
Unable to develop a system to reliably dispense one pill	Critical	Develop system that can dispense one type of pills one at a time, then increases the compatibility	The system will function; however, it will not meet the requirements of the project.
Unable to produce software to interface Raspberry Pi with hardware	Critical	Development timeline does not extend until the end of the project	Will not be able to complete project
Unable to overcome market competition	High	Our product offers many more features than the competition	Problems bringing device to market
User does not understand how to use device	Critical	Explicitly clear documentation will be included with device	User will cause harm to themselves
Unable to make device interface with Android smartphone over Bluetooth	High	Firmware and software developers have experience working with Bluetooth protocol. Raspbian supports OPP.	Pill-Matic will act as a standalone device
Team does not cooperate	Medium	Team personally knows each other, have agreed to share work evenly.	Possible divides in the team, team member's responsibilities may become lopsided

3.2 Benefits

At Health-Assist, elderly health and safety are our primary motivation for developing the Pill-Matic. That being said, the main benefit of all pill dispensing devices is to ensure a healthy and convenient pill schedule for the user. However, Pill-Matic has a number of additional benefits when compared to the alternative devices on the market.

The primary benefit of the Pill-Matic is the affordability and increased pill capacity. To compare with our current competition, the Ivation has a pill capacity of 336 at a retail price of $150.00, E-pill has a capacity of 700 at $995.00 while Phillips' device has a capacity of 1000 at $49.00/month. Our proposed device has a pill capacity of 1600 while being priced at only $400.00.

With the elderly as Health-Assist's targeted audience, the Pill-Matic aims for a simplistic and user-friendly solution to pill scheduling. Programming a user's prescription schedule into the existing devices can be tedious and time-consuming. The Pill-Matic interfaces with an Android mobile application, allowing users to effortlessly input their prescription information and schedule.

4. Market and Competition

4.1 Primary and Secondary Target Market

Our primary target market for the Pill-Matic is currently aimed towards the 60 and over demographic in North America who rely on constant intakes of multiple medications daily to maintain their healthy lifestyle. Beneficiaries of this demographic may also choose to purchase our system as an alternative to our target audience to act as a mediator in the commercialization process.

This target market will grow significantly in the next few years through two key influences which act as Health-Assist's main motivation to seek the monetization of this industry:

1. The 60 and over demographic population in North America will be expected to grow due to the aging of the baby boomers. Table 1 below shows that our target market will significantly increase in the next 25 years, and will allow us to have a stronger foundation when it comes to building up a user base for the Pill-Matic.

Table 2: Population Projection of the "65 years and older" demographic in the U.S. from 2012-2040 [3]

Ratio of 65+ demographic to total population in the U.S.	**Year**
13.70%	2012
16.80%	2020
20.30%	2030
21.00%	2040

2. As the Internet-of-Things concept becomes increasingly widespread and accepted over time, products that deliver a "smart" integration of technology and daily life will benefit from a population that is technologically adept as they have ever been.

While the product will be predominately marketed as a system used in a home setting, a potential secondary target market will be caretakers in senior care centers. The product will be offered as a convenient way to keep track and distribute the pill schedules of multiple patients that will be dependent on a single caretaker – leaving more time for the caretakers to do other things to aid the seniors. Expected tertiary target market will be any potential users who want to use the Pill-Matic as a dispensing unit for other products such as vitamins, protein pills, and even candy.

4.2 Brand and Marketing Strategies

Health-Assist's brand and logo are to reflect a simple and healthy lifestyle that is synchronous with what the image of Pill-Matic should be.

The Pill-Matic itself is also designed to be convenient and friendly to use. The design is specifically made to be modest and elegant to attract older people that may be confused by complex features. Mobile interactions on the app and the touchscreen will also show a bold and clear interface that will be easy to navigate with unambiguous instructions.

4.3 Current Competition

Table 3: Competitors products by feature set compared to Pill-Matic [4] [5]

	Ivation	**E-Pill**	**Phillips**	**Pill-Matic**
Retail Price (CDN)	$150.00	$995.00	$49.00 Monthly	$400.00
Pill Capacity	336	700	1000	200 per hopper * 8 hoppers = 1600
Reminder System	✔	✔	✔	✔
Max # of Alarms	4			100+
Custom Scheduling		✔	✔	✔
Tamper Proof	✔	✔	✔	✔
Smartphone Notifications				✔
LCD Touch Screen				✔
Alarm Duration	Until it is turned off	Until it is turned off		User Controllable
Missed Pill Notification			✔	✔
Usage Record				✔

4.4 Proposed Time Frame Length

Current projected timeline for commercial sales are expected to take place in the next year, after design and manufacturing agreements have been heavily optimized. We expect the first model of the Pill-Matic to last in the market for approximately 5-8 years, and our company plans to expand on the product brand annually in future models through additional features. Ultimately, we can expect this industry to remain fairly stable as there are minimal threat factors that could reduce the presence of the product in the next few decades at the very least.

4.5 Pricing Scheme and Potential Revenue Streams

The initial pricing scheme of the Pill-Matic is fairly simple; to earn a profit off every Pill-Matic model sold. This revenue can be increased with greater sales, cutting further overhead costs, and also expanding our target markets. In the future, the Pill-Matic will serve as a base model for growth as the company trends towards the fast growing internet of things market space, and shift emphasis from traditional unit sales to a subscription based model of monetization.

Since our product is primarily intended for elderly use, another possible approach is to expand our target audience. By introducing a line of products that appeal to particular audiences, we can maximize our user base to generate more profit. Once Pill-Matic has been well established in the market, we can introduce a multi-users supportive version. Although Pill-Matic does have a basic support for multi-users, it is extremely limited and would not be feasible to a whole family that take multiple prescription drugs and supplements or a nursery home with many residences. This would widen our audience and expose many people to our product possibly leading to an over decrease in cases of non-compliance for prescription drugs.

5. Project Planning

5.1 Design Tasks

Table 4: Design tasks, their start dates, end dates, and deadlines

Name of Task	Start Date	End Date	Deadline
Research	1/10/16	2/15/16	
Proposal	1/20/16	1/25/16	1/25/16
Functional Specification	1/15/16	2/15/16	2/15/16
Design Specification	1/25/16	3/7/16	3/7/16
Implementation	2/1/16	3/15/16	3/15/16
Documentation	1/15/16	4/1/16	4/1/16

5.2 Development Tasks

Hardware

Table 5: Hardware development tasks, their start dates, end dates, and deadlines

Name of Task	Start Date	End Date	Deadline
Model Design	1/10/16	2/15/16	1/25/16
Parts Arrival	1/20/16	1/25/16	1/25/16
Model Finalization	1/15/16	2/15/16	2/15/16
3D Printing	1/25/16	3/7/16	3/7/16
Servos and Motors	2/1/16	3/15/16	3/15/16

Firmware

Table 6: Firmware development tasks, their start dates, end dates, and deadlines

Name of Task	Start Date	End Date	Deadline
Driver Development	2/13/16	2/20/16	2/29/16
Feature Development	2/20/16	2/27/16	2/29/16
GUI Design & Integration	2/27/16	2/29/16	2/29/16
Bluetooth Integration	2/29/16	3/12/16	3/31/16
Software Integration	2/29/16	3/12/16	3/31/16
Testing & Debugging	3/12/16	3/31/16	3/31/16

Software

Table 7: Software development tasks, their start dates, end dates, and deadlines

Name of Task	Start Date	End Date	Deadline
Mockup Design	1/26/16	2/5/16	3/15/16
GUI Design	2/1/16	2/12/16	3/15/16
Feature Development	2/12/16	3/9/16	3/15/16
Firmware Integration	3/5/16	3/12/16	3/15/16
Testing & Debugging	2/1/16	3/15/16	3/15/16

6. Cost Breakdown

Table 8: Cost breakdown of the Pill-Matic

Item	Description	# of Items	$ Per Item	Total Price
Pololu Dual DC Motor Driver	Motor to drive pill dispensing assembly	1	$6.78	$6.78
Pololu 6mm Mounting Hub	Mounting assembly for motor	1	$10.89	$10.89
12V, Gear Motor with Encoder	Motor to drive hopper system	1	$29.21	$29.21
DFRobot Micro Servo		2	$4.79	$9.58
3.5" TFT Resistive Touch Screen	User interface device which allows for user to configure device	1	$39.56	$39.56
12vDC 5A power supply	Enough to power both motors and Raspberry Pi 2	1	$33.80	$33.80
Socket Head Screws -3/4" x 4-40		1	$8.70	$8.70
Raspberry Pi 2	Electronics platform, provides CPU, RAM, I^2c, GPIOs	1	$59.99	$59.99
Bluetooth Module	Interface via OPP with smartphone application	1	$15.99	$15.99
DS1307 Real Time Clock	Keep time when device loses AC power	1	$10.30	$10.30
Building Materials	Construction of all mechanical systems			$300.00
Total Cost (Including Tax)				$587.78
Expected Expense (Cost +20%)				$705.33

7. Conclusion

To summarize, Health-Assist is the byproduct of a group of individuals who wants to change the pill dispensing industry through an impactful way, but with a modern twist. The Pill-Matic is our company's first attempt at revolutionizing the traditional pill alarm dispenser into something much less intimidating. The benefits of building a smartphone companion app alongside a dedicated physical machine allows our company to specifically tailor and elevate a patient's normal pill taking experience to a greater level of convenience and comfort. Seniors will feel at ease knowing that they can be reliably reminded at anytime and anywhere to take their medications, and that their progress is being kept and maintained so that caretakers and guardians can check efficiently.

With this proposal, our company has given an appropriate and general overview of how we plan to go from proof of concept all the way to first commercial sales. It has demonstrated the necessity in our world for the Pill-Matic; a good working partnership backing a sound design; and finally, the potential for a viable commercial success with right marketing strategies.

Ultimately in the future, Health-Assist plans to build upon the ideas of the Pill-Matic to create a stronger collection of hardware models and software that will further push the idea of building not just a simple physical product; but an ecosystem that is tightly interwoven and interdependent with each other.

8. Who we are

8.1 Devon Louie

Devon is a 4th year Computer Engineering student. Up to this point, he has focused his learning in the computer science portion of his degree. He has experience working with embedded systems as a firmware engineer at Sierra Wireless Inc, where he has done 12 months of co-op and continues to work as a part-time firmware engineer. At Sierra Devon's main responsibilities were maintaining the factory procedure to ensure high factory yields, triaging level 3 customer issues and adding new features.

8.2 Peter Hsu

Peter is a 4th year Computer Engineering student. He recently finished 12 months of co-op at Plexia EMS Inc as a software developer. His main roles included developing web features using ASP.NET and C#, managing databases using SQL, overseeing client-specific feature developments and assisting with tests of new features. He is interested in both software and hardware development and likes to find elegant and simplistic solutions to the problems he encounters. His skills will play an important role in the development of the mobile application of the project and testing of the overall system.

8.3 Jerry Yao

A 4th year Electronics Engineering student, Jerry is interested in engineering because of his fascination with using creative technology to improve human lives. He has completed a 12-month co-op experience working as a compliance specialist for smartphone batteries at BlackBerry Ltd. - specifically dealing with the CTIA 1625 standard. He is proficient in technical writing and documenting reports, as well as working as a hardware tester in a laboratory environment. He hopes to leverage these skills into making both the project itself and the subsequent documents a well-received success.

8.4 Adam Gabriel

Adam is a 4th year Computer Engineer student. During his time at Simon Fraser University, Adam has gained experience developing software in C++, C, VHDL, and Swift 2. Through numerous group projects including the development of an iOS fall detection application, he has developed strong teamwork and communication skills that are necessary for a successful project. Adam is proficient in technical document writing and software development and he hopes to apply these skills to the project.

8.5 Connor Dueck

Connor is a 4th year Systems Engineering student interested in both the hardware and software sides of development. During a recent 4 month co-op with the MENRVA research group, he was able to develop a wide range of hands-on and programming skills while working on various projects. Designing circuits, developing prototype PCBs and writing firmware for microcontrollers were some of the tasks he accomplished during his stay. These skills along with his knowledge of 3D modeling will play an important role in the hardware development of this product.

9. References

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[3] J. Ortman, V. Velkoff and H. Hogan, "An Aging Nation: The Older Population in," May 2014. [Online]. Available: https://www.census.gov/prod/2014pubs/p25-1140.pdf. [Accessed 23 January 2016].

[4] Canadian Shoppe, "Ivation Automatic Pill Dispenser and Electronic Medication Reminder with Metal Lock and Louder Alarm with Flashing Light - Solid Top," Amazon.ca, 23 January 2016. [Online]. Available: http://www.amazon.ca/Ivation-Automatic-Dispenser-Electronic-Medication/dp/B00FL623G2. [Accessed 23 January 2016].

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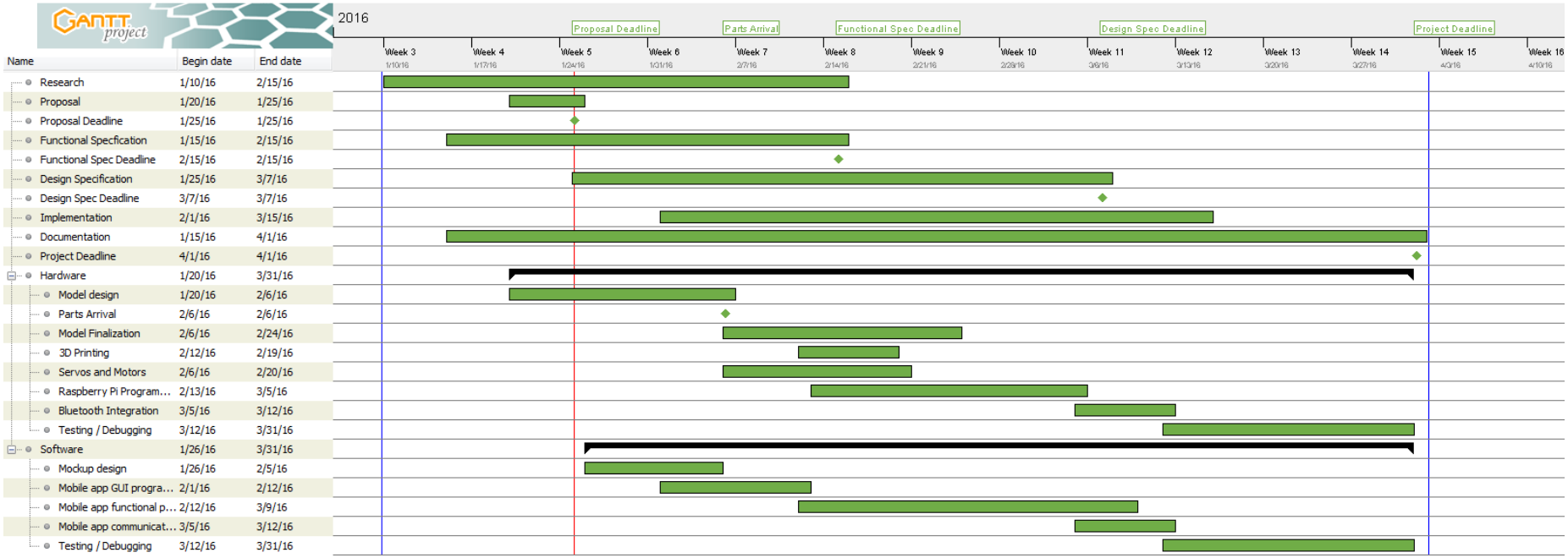

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Project Deadline	4/1/16	4/1/16
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Software	1/26/16	3/31/16
Mockup design	1/26/16	2/5/16
Mobile app GUI progra...	2/1/16	2/12/16
Mobile app functional p...	2/12/16	3/9/16
Mobile app communicat...	3/5/16	3/12/16
Testing / Debugging	3/12/16	3/31/16