F.A.M.

Post Mortem for a Fall Detection System

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Glossary

F.A.M.	Fall Alert Mechanism
GSM	Global System for Mobile Communications
LCD	Liquid crystal display.
MCU	Microcontroller Unit
RF	Radio frequency; a frequency or band of frequencies suitable for use in telecommunications

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1. Introduction

Our Fall Alert Mechanism (F.A.M) device has the potential to help elderly people all over the world. Initially, our intention was to design our device specifically for home care centers and then expand into all home environments. We have since realized that making the device adaptable to all home environments should be a priority and updated our design to meet that goal. The fall detector device located on an elderly person's belt will sense when the user has fallen down. Once a fall is detected a signal is sent to a central device where two things happen: an LCD display shows that the person has fallen (for home care centers), and a text message is sent to a family member (for typical home use). The purpose of the device is to allow elderly people to be able to live more independently and with less supervision while remaining safe and secure. Eventually F.A.M. will also become integrated with cell phones to monitor the customer no matter where they go during the day. The future of health care for the elderly is arriving, with F.A.M. as part of a safer and more independent daily routine for our seniors.

2. General Overview

The general system design of the F.A.M. system is presented in this section. This includes a high level view of all major system components and their interconnections. Sketches of the approximate appearance of the central and portable components of the system are also provided. Finally, a state diagram is included, which illustrates the flow of information through the system and the relationship between various states of operation such as fall detection and alert message sending.

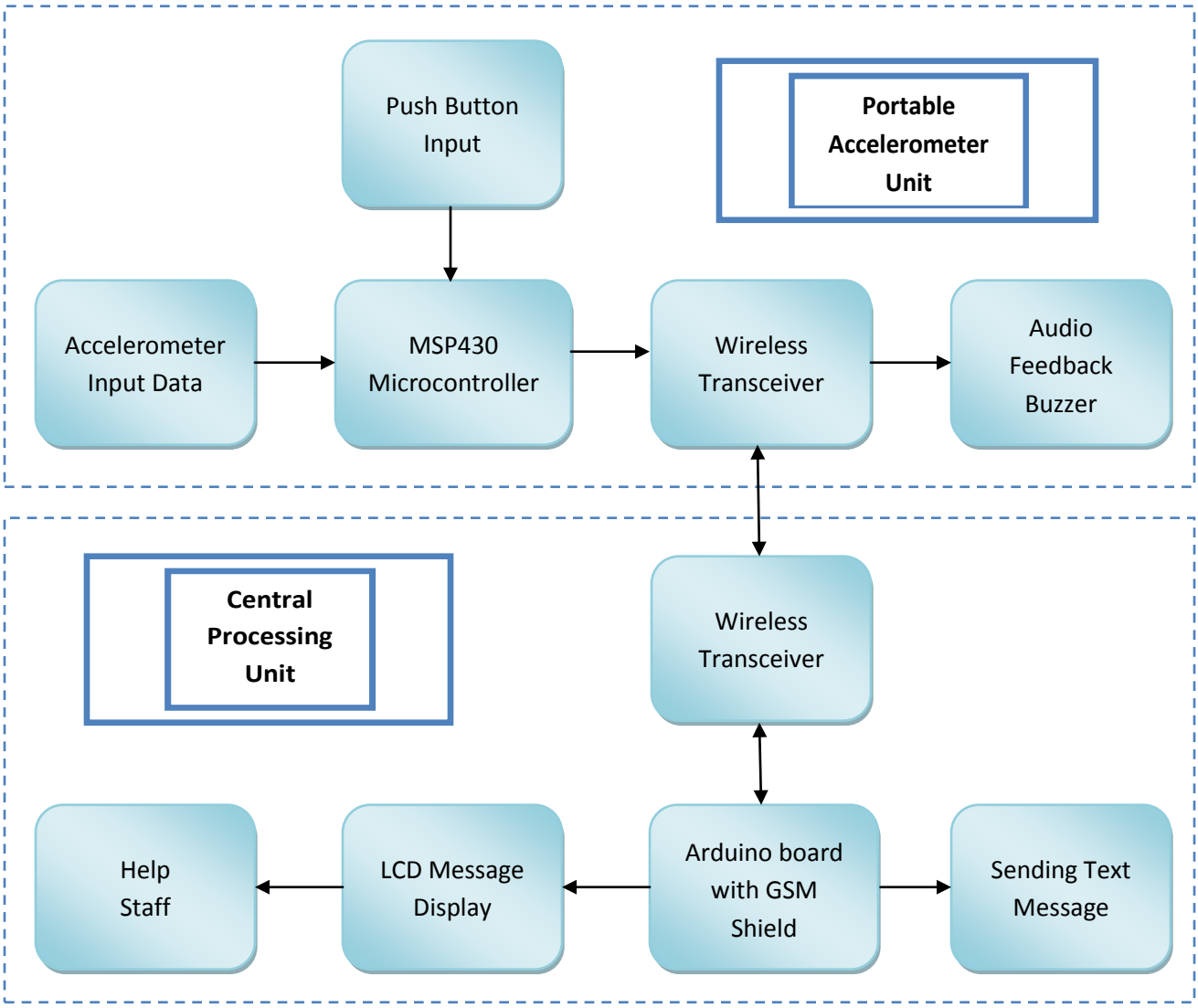

Figure 1 – General System Hardware Block Diagram

Figure 1 illustrates the general flow of information and linking of hardware components in the F.A.M. system. The portable accelerometer unit has an accelerometer and a push button as data inputs to a microcontroller running a fall detection algorithm. Upon detection of a fall, a signal is sent from Portable Accelerometer Unit to the Central Processing Unit using RF transceivers. The central unit sounds an alarm and displays an appropriate message on LCD to inform help staff. Since the central Arduino board with GSM shield has text messaging capabilities, the central unit also sends a text message to a family member or appropriate authorities. Figure 2 and 3 show how the central unit and portable device looks like, respectively after development is complete.

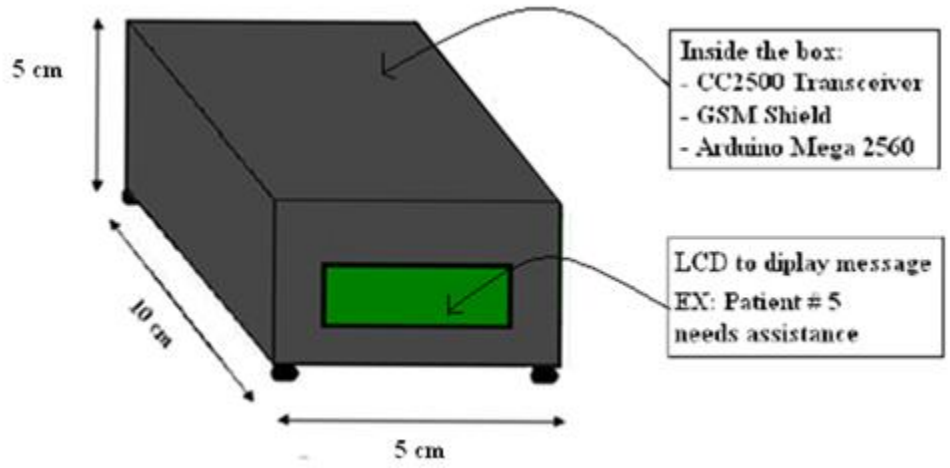

Figure 2 – Illustration of Central Unit

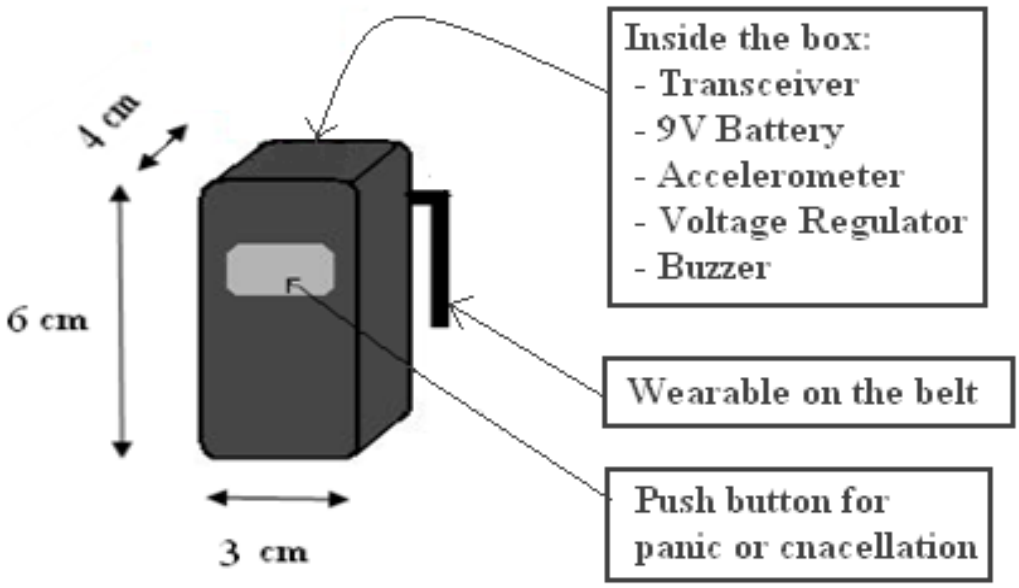

Figure 3 – Illustration of Portable Unit

Figure 4 below shows a flowchart of alert information through the entire system, starting in the portable unit and moving to the central unit.

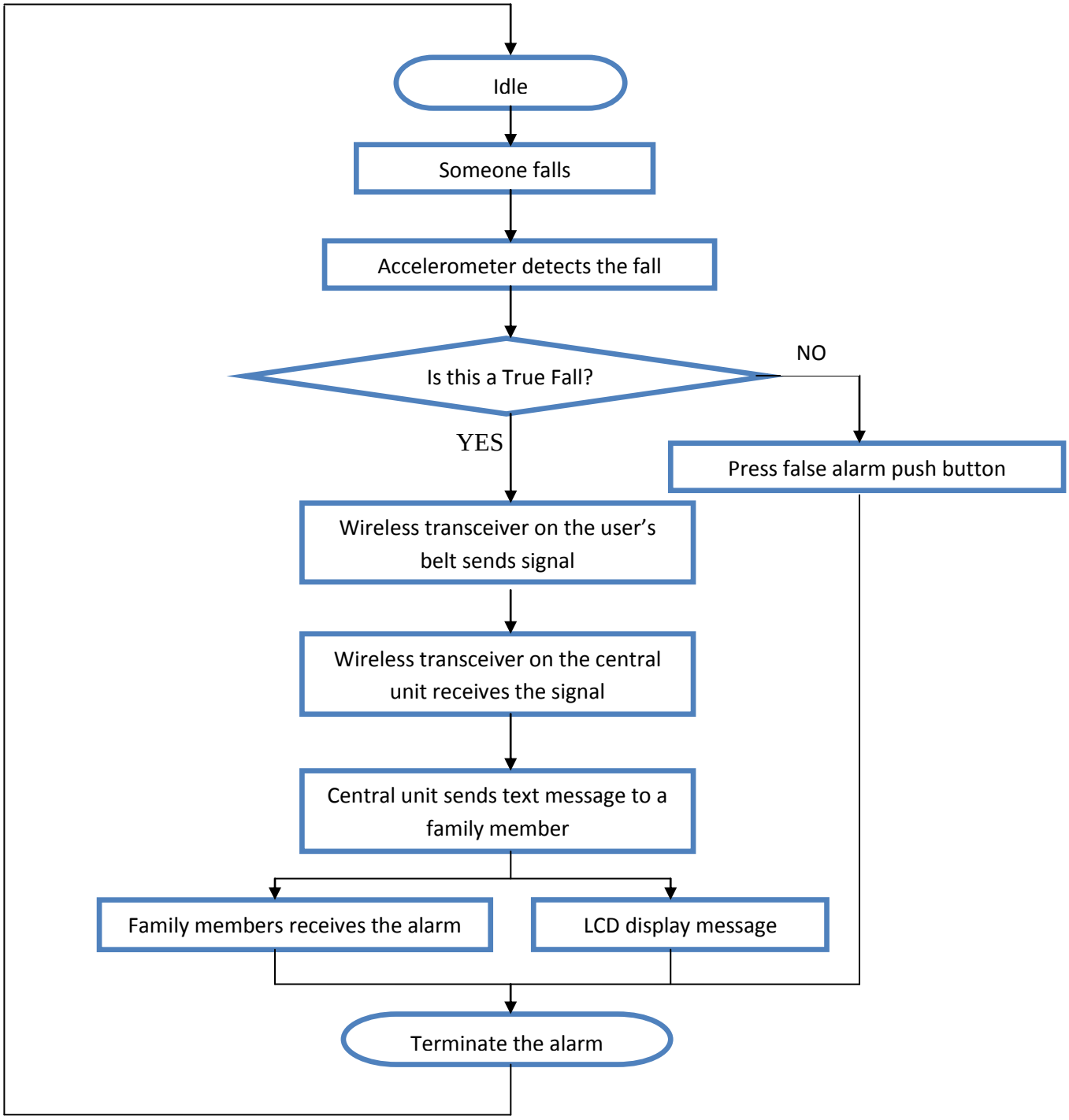

Figure 4 – General System Flowchart

3. Portable Device Current State

The hardware for our portable device, including microcontroller, accelerometer, and wireless transceiver, has been successfully implemented and tested. The device loops through the software flow seen in Figure 5 below.

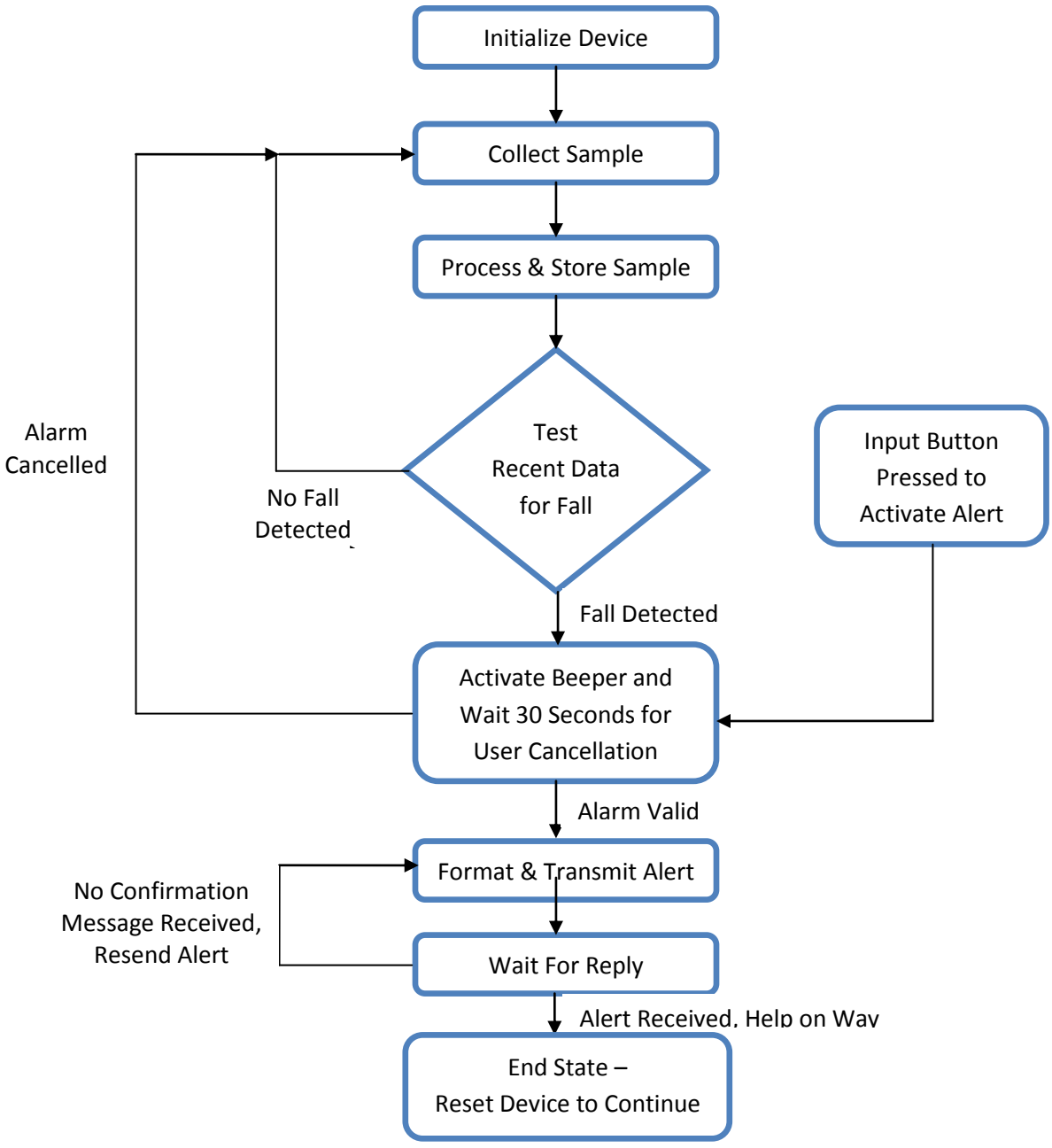

Figure 5 – Portable Device Software Flowchart

After initializing, the portable device enters a loop of reading, storing, and processing accelerometer data and then testing the data for a fall. The loop continues until a fall is detected or the user presses the push button. At that point, the beeper is activated with sonic pulses at ~1 Hz to inform to user that an alert has been triggered. The user is given 15 seconds to press the button to cancel the alert and return to normal operation. The fall detection algorithm has been implemented and tested extensively, and can reliably identify all types of falls. The algorithm also minimizes false alarms by ignoring near falls (loss and recovery of balance) and normal daily activities. The fall algorithm follows the following steps:

1) Calculate magnitude of acceleration sample:
$$Mag = \sqrt{Acc_X^2 + Acc_Y^2 + Acc_Z^2}$$
2) Compare magnitude against threshold:
$$Mag > 2.5g$$
3) If threshold is exceeded by magnitude peak, compare orientation of accelerometer 1 second before and 1 second after the peak.
4) If orientations are different, fall has been detected.

Unfortunately, the transceiver module of the device recent failed and so communication with central device is currently extremely unreliable (we have implemented a short-term solution).

4. Central Device Current State

As mentioned, due to transceiver malfunction, proper communication with the portable device is not working as it should be. However, all other aspects of the central device are working properly. An Arduino microcontroller interfaces with a GSM shield (for implementing phone text messaging) and an LCD display. The device is able to display an alert message on its LCD screen and send an alert text to a preprogrammed phone number. Prior to transceiver failure, these tasks were triggered by a help message from the portable device. When communication with the portable device is improved, the full system will be functional. Figure 6 below represents the state flow diagram of the central device. The device waits for an alert from the portable device. Upon reception, it sends text and displays help message. Then it sends an echo to the portable device and resumes normal operation.

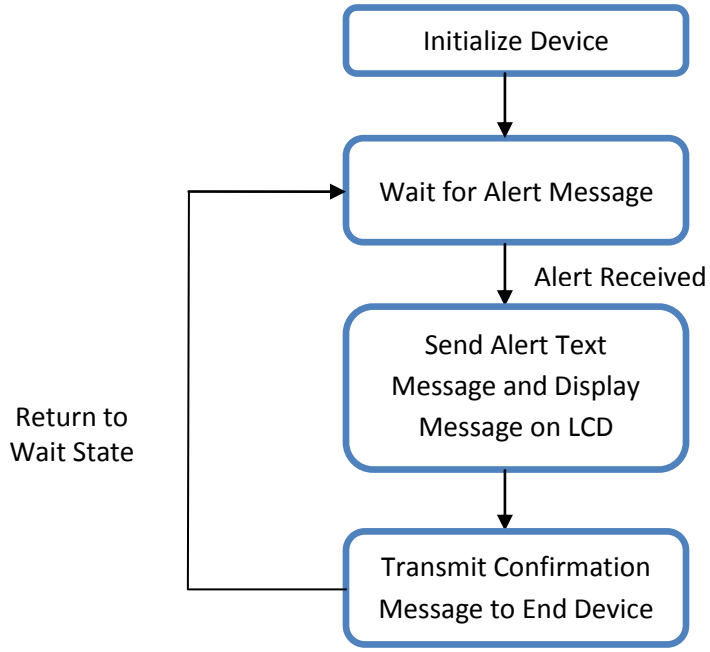

Figure 6 – Central MSP430 Software Flowchart

5. Future Work

The first task for future completion is fixing RF communication between the central and portable devices. Our current communication solution is too unreliable and easy to break. We will likely need to purchase a new transceiver module to use with the portable device microcontroller we already have. With more reliable technology, the problem will be easy to solve. After this, we will need to improve the device case to make it sleeker and more attractive. If we can make these two improvements, we will have fully implemented the device we initially planned in our functional specifications.

In the long term future, we will need to consider more changes to the device. Adding a keyboard for entering phone numbers and clearing the display would make the device much more usable. Additionally, the portable device should be implemented on a single chip. This would be necessary for commercial production. Finally, complete design such as integrating the central unit with a cell phone, integrating the portable device with clothing, or implementing the device as a smart phone app might occur in the extreme future.

6. Budget and Timeline

The two tables below show the original projected budget for this project and the actual development costs. The higher than expected development cost is due to having to replace broken components and to make some purchasing errors early on.

EXPECTED BUDGET

Component	Price
LED light	$ 10
Accelerometer	$ 150
Wireless Transmitter Receiver	$ 300
Microcontroller	$ 50
Other Costs	$ 100

TOTAL: $ 610

ACTUAL BUDGET

Component	Price
Development Boards & kits	$ 151.65
Triple Axis Accelerometer	$ 39.04
GSM Shield	$ 126.70
Cellular Shield (Arduino Board)	$ 117.91
Material for outside box	$ 35.12
Other costs	$ 115.09
Unused components	$149.87
Broken Components	$ 151.65

TOTAL: $ 886.98

Similar to the budget tables shown above, the two figures below illustrate our expected development timeline versus the actual development timeline. The actual timeline differs by having less research time and integration time, but more assembly time. The assembly took longer because of unexpected problems with components and because we performed some testing tasks during the assembly phase.

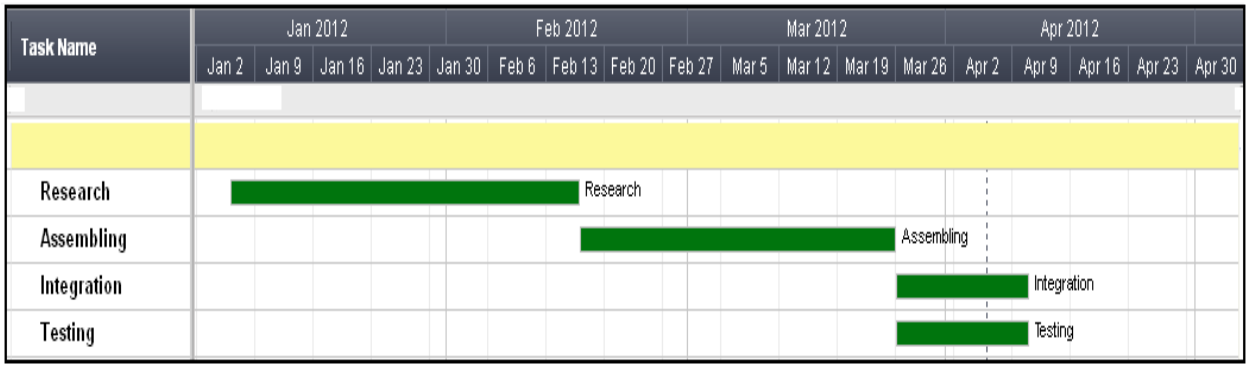

Figure 7 – Expected Project Timeline

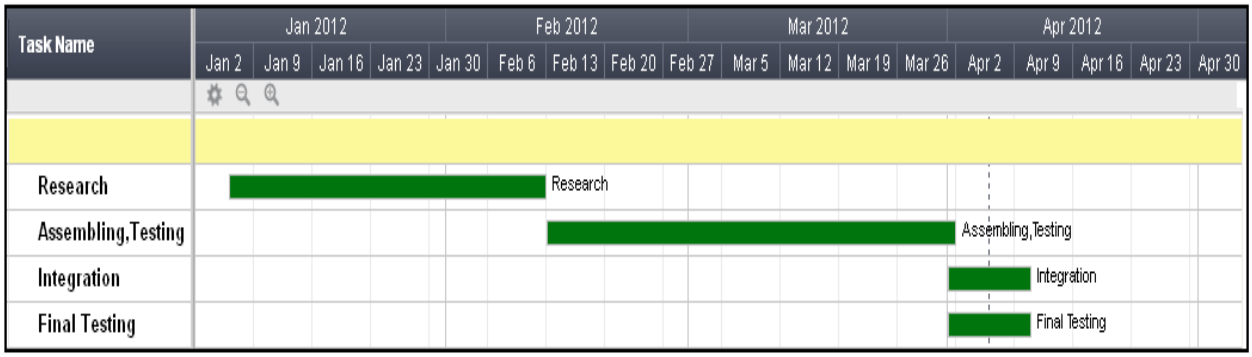

Figure 8 – Actual Project Timeline

7. Interpersonal & Technical Experiences

Behdad Jamshidi

Throughout this project I have learned various different communication and technical skills. I really enjoyed working with my group as everyone did their part and worked exceedingly hard to make sure our project came out right. I learned that even though something looks like it'll work

on paper and in pictures when you begin to use it there are many technicalities. It made me realize that extensive research should be done before ordering parts. I have also gained the ability to start a project from beginning to end and produce documents needed.

For this project I was the leader of the group and took the position of CEO. As a leader I learned that keeping the team on track and voicing my opinions were just as important as stopping and listening to other suggestions. I worked to keep the group on track and make sure that meetings were attending and project deadlines were met. I first set up everyone in the group with g mail and drop box so that we could keep in contact as well as, save all of our documents and progress in one place. This made it much easier to share everything with the group and make sure everyone was on the same page. In the documents I wrote the introduction as well as worked on the test and over all layouts of the documents. I also worked on making the logo. I also took the role in the beginning of dealing with paying for all the supplies and getting the funding from ESSEF.

As for the technical aspect of the project, I choose to work on the central box and texting. Throughout this I learned that there are many ways to do something. You just need to evaluate the cost and time needed to implement each. In the end I believe the approach Ted and I took ended up being the best. I also really enjoyed working with the Arduino board, GSM shield and LCD. I gained the ability to read data sheets and research on how to combine each and every part. In the end we came up with a pretty good design. I think some time in the future I'm going to get a board for myself to play around with since it was really fun. Ted and I also worked on coding the Arduino board which wasn't too difficult with the pre-defined libraries that were given to us. In addition, I soldered the GSM board, variable resistor, and power adapter so that our board will run off wall power.

Ted Lee

When this project begun in January, I had many doubts about how things will work out in terms of team work, productiveness and progression. We actually had our group set up before the semester of ENSC 440 started and had many ideas. When we decided to work with F.A.M idea, we were all convinced it would be a good project. When the term started it looked like this project was going to be close to impossible to complete in 4 months, but we stuck our heads in together as a group and got through one problem at a time. As time passed and great leading skills by Behdad, our project became to completeness faster than we thought. As time passed the

biggest problem I thought was that we had many miscommunications that lead to agreements. The hardest thing was to agree with the decisions that the group made even though the idea was completely different than what I had thought but as this happened more I have learned something. Just because I had an idea and thought my idea was the best, it does not mean it was the best idea and everyone liked it and if the majority people voted on an idea, you have to agree and stick as a team. As the rest of the members on the team have learned the same thing and that is why our group became very successful as a team and stuck to the team plan that we have made in the beginning to the end.

Looking back to the beginning of the semester, I feel that I have learned a ton on how to work with Arduino board and how our knowledge can be implemented to produce great projects. Having to know how to use Arduino board which is one of the most common micro-controller that is out there, I feel that I could build many products that can form into a company. Also throughout this course, while writing from proposal to design specifications and these skills have taught me how to write a proper papers if I were to go out in the real world and present it to people who will be funding my products. As I feel that this course is the sum up course for engineering, it has developed me into a wiser person and a person who believe that an idea can come true. The only thing I am unhappy is that engineering has only 1 capstone project course in our degree and they should make more.

Nastaran Naghshineh

First of all, I would like to thank Behdad for being such a responsible leader and my other team members for being such a wonderful people to work with. We all did our best to bring the project to success, came together with our skills and efforts, and made commitment to work continuously. Indeed, Capstone project was one of the most enjoyable courses I ever had in my undergrad program because not only I have dramatically developed my engineering skills, but I also learned a lot in terms of communication and team contribution.

One of my roles was to document the minutes and agendas for every meeting and to put them on Drop Box to provide the group with a summary of the discussions. In the documents I wrote all Letters of Transmittal as well as worked on the system overview and general requirements. I was also responsible to apply for Wighton Funding which required me to create a cost table, gathering all the receipts, filling forms, and submitting them to School of Engineering Science. I have created the entire presentation slides. In order to do that, I had to go over some of the data

sheets, choosing the relevant information and appropriate figures and placing them on the corresponding slides. I have also created Grantt chart in order to compare the expected and actual time as well as expected and actual costs.

I was responsible for deciding on the material for the outside box of central device and portable device based on the requirements that was set initially. After doing lots of researches, I decided to purchase Acrylic sheets of width 0.080inches for the central device and 0.090inches for the portable device. I have watched many videos on YouTube in order to learn how to cut, bend, drill, and weld the acrylic sheets. I also took role in constructing the outside box.

Since we all worked hard to meet the weekly milestones that were set at the very beginning of the project; fortunately, we were able to create the final F.A.M. prototype earlier than the expected date. However, the development kit broke 5 days before the demo that put huge pressure on us in terms of both time line and budget.

This project has employed all of my undergraduate engineering knowledge and skills. Getting a feel of the project lifetime from design to implementation gives a nice sight to real-world applications. In my opinion, the most important aspect to a successful project is to have an attractive idea and an enthusiastic group.

Zack Frehlick

ENSC 305/440 has been an excellent learning experience. In general, there is a relatively low amount of hands-on learning in many engineering courses. This course forced me and my group members to greatly improve and diversify our technical engineering skills in both hardware and software. We also learned valuable skills which are not taught in typical classes, such as how to research and order the correct components. The process of developing a large project from start to finish, with little external input, is very helpful for our professional development. It is also an excellent test of our current abilities, helping us learn to what we need to improve on.

Working on the portable device, much of what I learned relates to programming and interfacing with microcontrollers. Microcontrollers are a huge part of modern technology. While we do get some microcontroller training in other courses, my understanding was not as thorough as it should have been. The process of researching different types of controllers, using device user guides and specification sheets to learn about our device, and independently developing software code helped improve my knowledge level greatly. Since one of my main responsibilities was

developing the fall detection algorithm, I also improved my knowledge of accelerometers and fall detection research. I had worked in depth with accelerometers previously for a co-op, but this application required a different approach. Reading a larger number of scholarly papers about fall detection with accelerometers was very instructive and recommended. Additionally, I learned a lot about RF communication, transceivers, and antennas.

It is interesting to note that I learned just as much by making mistakes as I did by doing things correctly. Mistakes are often what force you to look more closely at the details of the task. Debugging software code and solving hardware problems forced me to learn much more than if things had initially gone smoothly. Making mistakes and encountering difficulties also helps develop non-technical skills. We suffered several technical issues and had to deal with broken and unreliable components, but learned important lessons about creative problem solving, persistence, and maintaining a calm outlook. Working through problems as a team was also helpful for developing teamwork skills. Things may not have turned out as we hoped, but we can be proud of our efforts.

One final aspect of the course that I think is very important is the project documentation. I have been learning through the ENSC 372 (Biomedical Instrumentation) class at SFU how important documentation is in the professional world. ENSC 305/440 is the only class that provides an opportunity to write the functional and design spec documents which are common in industry. It may not be the most enjoyable aspect of the course, but I am thankful for the experience.

Eric Swanlund

Our project planning began months before the Spring 2012 term, as we had many meetings where we brainstormed various product ideas. I believe that the pre-term planning was necessary as it reflected on how we were able to develop and implement our device in a timely manner; we were able to complete a functional prototype before April 10th. Dividing the product into two main components (ez430-rf2500 and Arduino/GSM) was essential, as it allowed us to focus on sub components exclusively without worrying about the other components (for the time being). I learned that team communication goes along way. As we progressed throughout the term we began communicating more proficiently. We evolved from a group of students not knowing exactly what the future holds into a group of professionals working towards a common goal. I learned that sometimes enough research is actually not “enough”. Extra time spent in becoming familiar with a certain device or component can help in the long run.

At the beginning of the term, I had zero experience with accelerometers (or even the ez430-rf2500 development kit). But after 4 months of working with the devices, including research, I've become comfortable with accelerometers and the ez430-rf2500. I was able to use my experience with Putty (telnet/ssh terminal) when connecting the ez430-rf2500 through serial port to my laptop for displaying data and testing. We were able to connect the central device board to the Arduino through the serial port, where I gained some experience of how the Arduino software correlates to its serial ports. Soldering the accelerometer, voltage regulator, and battery switch to the portable device required precision and patience. The pins on the portable device are very small and there isn't any room for error. We integrated the ez430-rf2500 with the Arduino/GSM device efficiently, and are very pleased how the devices came together easily.

Throughout the term, I became more and more confident with our project. I enjoyed working with my team and seeing our positive progression first hand. I believe ENSC 440 is a great course; you're given the due dates it's up to you and your team to complete a task that you have created. It's not like any other engineering course; you find your own questions that you have to answer. I feel that designing your own project, with your own rules, influences a level of responsibility and maturity that cannot be compared to any other course.

8. Conclusion

Overall, development of this project was a success. Due to component failures, we were unable to demonstrate the product properly. However, videos taken of our system functioning as desired prove that we were successful in achieving our goals. We presented our project on April 5th, concluding an arduous 3 months on development. This document has summarized the progress we made in developing this project, highlighted areas for future work, and discussed the personal experiences of each group member.