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February 06, 2012

Dr. Andrew Rawicz
Simon Fraser University
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Burnaby, B.C. V5A 1S6

Re: ENSC 440 Functional Specification for a Fall Detection System for Seniors

Dear Dr. Rawicz:

Enclosed is a document which describes the functional specification of the fall detection system for seniors being developed by Fall Alert Mechanism (F.A.M.) We intend to design and implement a system that recognizes when its elderly user has fallen and sends an alert to notify a medical professional. In this way, the user will quickly receive any necessary assistance or medical attention. The system will consist of a portable accelerometer-based device and central base unit.

The enclosed document will provide a set of high-level requirements and specifications for the intended functionality and design of our proposed product. It will serve as a guideline and reference for our project manager and design engineers throughout the product development phase.

Our group, F.A.M., consists of five skilled and enthusiastic engineering students: Behdad Jamshidi, Eric Swanlund, Nastaran Naghshineh, Ted Lee, and Zack Frehlick. If you have any questions or concerns about our proposal, please contact our designated spokesman, Zack Frehlick, by phone at (778)385-3590 or by e-mail at zfa2@sfu.ca.

Sincerely,

Nastaran Naghshineh

Nastaran Naghshineh

Enclosure: Functional Specifications for a Fall Detection System for Seniors

F.A.M.

Functional Specification for a Fall Detection System for Seniors

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Contact Person:	Zack Frehlick	**Date issued:**	February 6, 2012

Executive Summary

Every day, elderly people who require special attention in home care centres are left alone for extended periods of time. Many of these individuals have a desire to maintain their independence and live under limited supervision. However, independence presents its own challenges. While these seniors carry out independent activities their safety must be ensured. Falling down is one of the greatest threats to guard against [1]. Home care centres make a strong effort to ensure the health and wellbeing of their clients, but care is limited by man power and incidents like falls can go undetected for long periods of time. The F.A.M. (Fall Alert Mechanism) device addresses this issue and improves quality of care. With an automated and portable system to detect if the wearer has fallen by measuring changes in acceleration and orientation, falls will no longer go undetected and care will always arrive promptly.

The F.A.M. device development will be broken down into 3 distinct phases. After completion of Phase 1, the accelerometer-based portable belt unit should be operational and will support:

- Easy replacement of battery pack
- Measuring acceleration capabilities
- Cancellation/panic button
- Easy on/off switch

Phase 2 includes the development of the central control unit, which will have an LCD display. The LCD display will be able to output pertinent information to help staff when a fall is detected. In Phase 3 development, the portable belt and central box components will be integrated. This phase includes enabling communication between the two components; data transmission will be done through RF (Radio frequency) transceiver technology. The central box will use an electrical outlet as a power source and the belt mechanism will be powered by AAA batteries. The belt mechanism will ideally last on the battery power source for a few weeks per charge. The F.A.M. device will adhere to all relevant standards and guidelines, particularly those from CSA.

List of Figures

Figure 1: System Block Diagram……..... 2
Figure 2: Illustration of System Components.....3

Glossary

CSA	Canadian Standards Association
F.A.M.	Fall Alert Mechanism.
IEC	International Electrotechnical Commission.
ISO	International Organization for Standardization.
LED	Light-emitting diode; a semiconductor diode that glows when a voltage is applied.
LCD	Liquid crystal display.
MTBF	Mean time between failures; a measure of the reliability of a device or system.
RF	Radio frequency; a frequency or band of frequencies suitable for use in telecommunications

Table of Contents

1. Introduction 1
1.1 Scope 1
1.2 Intended Audience 1
1.3 Classification 1
2. System Requirements 2
2.1 System Overview 2
2.2 General Requirements 3
2.3 Electrical Requirements 3
2.4 Packaging 4
2.6 Standards 4
2.7 Reliability and Durability 4
2.8 Environmental Requirements 5
2.9 Training of Users 5
2.10 Usability Requirements 5
2.11 Performance Requirements 6
3. Central Control Unit 6
3.1 General Requirements 6
3.2 Electrical Requirements 6
3.3 Physical Requirements 7
4. Portable Accelerometer Unit 7
4.1 General Requirements 7
4.2 Electrical Requirements 7
4.3 Physical Requirements 8
5.User Documentation 8
6. System Test Plan 8
7. Conclusion 9
8. References 10

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1. Introduction

The Fall Alert Mechanism (F.A.M.) device will change the lives of elderly people everywhere. Beginning in home care centres and evolving into even bigger markets, this product will provide safety and peace of mind to users and their families. The purpose of the device is to monitor user acceleration (through a small device attached to the belt), so that if a fall occurs it can be recognized and help can be notified. Upon detection of a fall, the belt unit will inform the central control unit. The central device will notify nursing staff that a patient has fallen and requires assistance. 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 is arriving, with F.A.M. as part of a safer and more independent daily routine for our seniors.

1.1 *Scope*

This document outlines the function specification of our F.A.M. device. It provides a complete description of required functionality for a proof-of-concept model and partially provides the required functionality of production model. These specifications will be relied on during the design and implementation of the proof-of-concept device. There is a possibility that minor modifications may occur during development or after testing.

1.2 *Intended Audience*

The functional specification is intended to be used by all individuals involved in development of the F.A.M device throughout the design, implementation and testing stages. This document will also ensure that development remains on the right track and act as a reference for creating different test scenarios.

1.3 *Classification*

The following convention will be used to indicate functional requirements:

[R-s-n p] A functional requirement,

Where **s** specifies the section number, **n** specifies the functional requirement number, and **p** specifies the priority of the functional requirement. The priorities are defined as:

- **I** High priority: must be addressed in the completed prototype
- **II** Medium priority: will be addressed in the prototype is time permits
- **III** Low priority: not planned for prototype, but necessary for product quality

2. System Requirements

General overall system requirements for the F.A.M. are presented in this section. These include requirements with respect to performance, operating environment, safety and reliability. All factors which affect system development and functionality must be taken into account.

2.1 *System Overview*

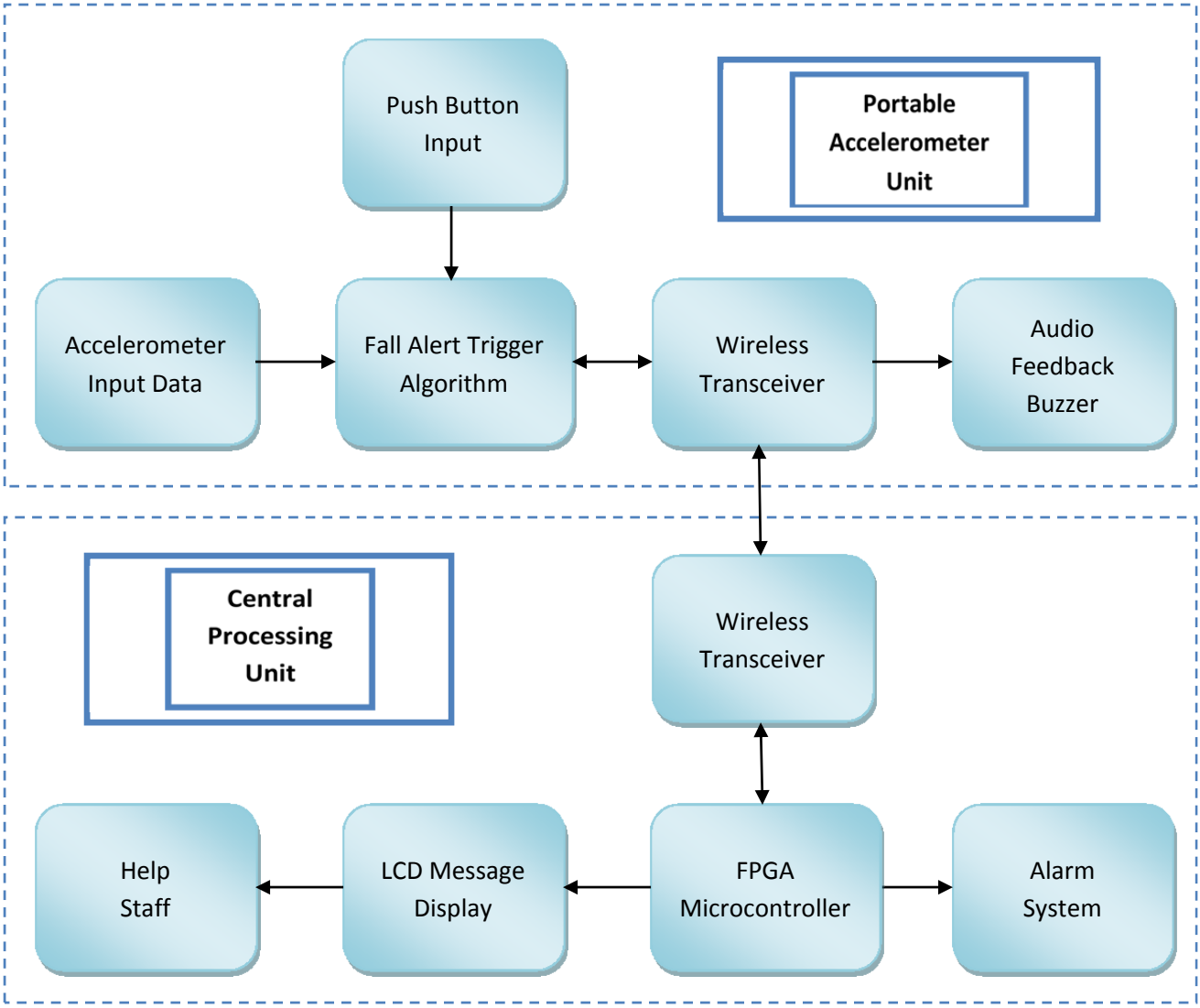

Figure 1 – System Block Diagram

Figure 1 on the previous page illustrates the general flow of information and linking of components in the F.A.M. system. The portable accelerometer unit has an accelerometer and a push button as data inputs to a fall detection algorithm. Upon detection of a fall, a signal is sent to the central unit using RF (Radio frequency) transceivers. The central unit sounds an alarm and displays an appropriate message to inform help staff of the problem. Figure 2 provides an example of what the two system components may look like after development is complete.

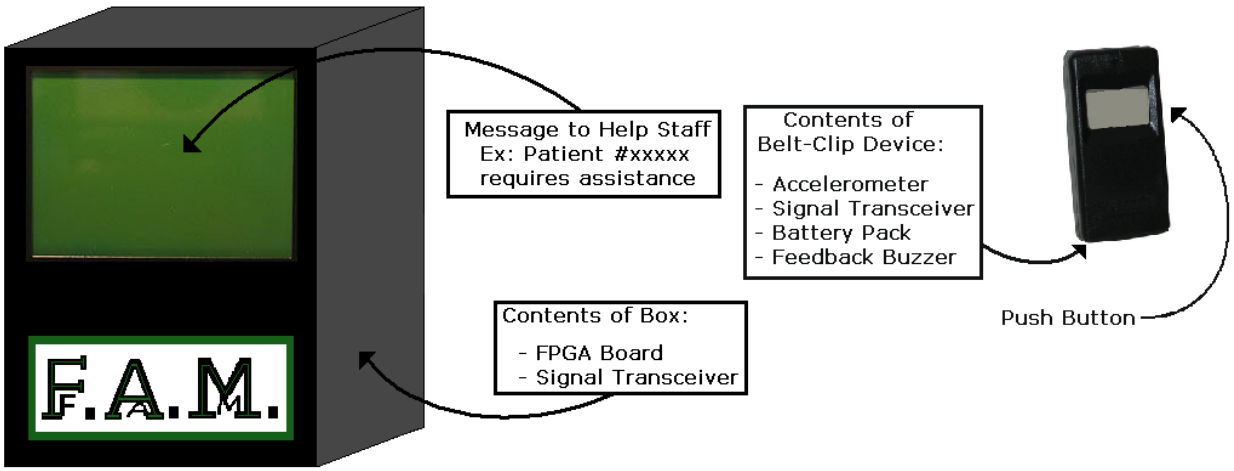

Figure 2 – Illustration of System Components

2.2 *General Requirements*

[R-2.2-1 I] Development costs of the device must be under $1000.
[R-2.2-2 I] Retail price of the device should be under $200.
[R-2.2-3 I] System must function without any interference with other devices.
[R-2.2-4 I] Proof-of-concept system must be fully functional.
[R-2.2-5 II] System design should allow for additional functionality to be easily implemented at a later date (i.e. cell phone communications).

2.3 *Electrical Requirements*

[R-2.3-6 I] All components should operate with low current consumption and low voltage operation; low power consumption is very desirable.
[R-2.3-7 II] Device cases should allow for heat dissipation into the environment.
[R-2.3-8 I] System signal transmission range should be about 200 m, the typical range of an RF transceiver pair [3].

2.4 *Packaging*

[R-2.4-9 II] Portable unit casing will be minimally noticeable on the body.
[R-2.4-10 I] Device should be wearable either on the belt or around the neck.
[R-2.4-11 I] Physical aesthetics should make the device attractive and non-intrusive to the user.
[R-2.4-12 I] Portable unit casing will have rounded edges so as to not injure the user.
[R-2.4-13 I] Packaging design will ensure that the push button is never obstructed.
[R-2.4-14 I] Portable unit packaging will protect inner circuitry from water damage or impact damage.
[R-2.5-15 I] Casing must allow for easy access to batteries, but also isolate batteries from user when the device is in use.

2.5 *Safety Requirements*

[R-2.5-16 I] Device must be able to withstand a fall from at least 1 m without interruption of function.
[R-2.5-17 II] Device failure or power loss must have no adverse consequences and be easily recognizable to user (i.e. LED turns off).
[R-2.5-18 II] System must provide feedback to user about the state of operations (i.e. audible beep to indicate help is coming, etc.).
[R-2.5-19 I] Device should not cause injury if the user falls directly on the casing.
[R-2.5-20 I] Device will not generate excess heat or present any danger of a burn.
[R-2.5-21 II] Button must be robust and not breakable under significant pressure.
[R-2.5-22 II] Device must be electrically isolated from the outside environment and the user.
[R-2.5-23 I] Other electromagnetic devices must not interfere with alert signal transmission.
[R-2.5-24 II] Alert transmission must not cause interference with surrounding devices.

2.6 *Standards*

[R-2.6-25 I] Device must conform to CSA standard Z32-04 governing Electrical Safety and Essential Electrical System in Health Care Facilities [4].
[R-2.6-26 I] Device must conform to all other applicable IEC, ISO, and CSA standards [5][6].

2.7 *Reliability and Durability*

[R-2.7-27 I] System must withstand all normal activities of the user's daily routine.
[R-2.7-28 I] Impact upon falling must not interrupt device function.
[R-2.7-29 I] System must work in all areas of the home care centre or household.

[R-2.7-30 II] Technical support and maintenance interval should be at least 1 year.
[R-2.7-31 II] System must function in the presence of other RF devices.
[R-2.7-32 II] System MTBF should be at least 1 month.
[R-2.7-33 II] System must not crash on a regular basis.

2.8 *Environmental Requirements*

[R-2.8-34 II] Portable unit case must be able to protect the device from drops of water in case customer is in a potentially damp environment like a restroom or kitchen.
[R-2.8-35 II] Will work at all elevations above sea level up to 5 km where gravity still measures extremely close to 9.8 m/s^2.
[R-2.8-36 II] System will use rechargeable batteries to be environmentally friendly.
[R-2.8-37 II] Device casings should be constructed from recyclable or otherwise environmentally friendly materials.
[R-2.8-38 I] Device needs to be able to work in average minimum and maximum house hold temperatures.
[R-2.8-39 I] Device needs to be able to work in minimum and maximum humidity level of house hold.

2.9 *Training of Users*

[R-2.9-40 I] A small pamphlet will be provided to the user to show them how to wear the device on their belt and explain the function of the push button.
[R-2.9-41 II] A training session will be run for the nurses of each care facility to demonstrate how the central unit functions
[R-2.9-42 II] Technical support will be provided to answer questions and troubleshoot problems.

2.10 *Usability Requirements*

[R-2.10-43 I] The portable device should be easy to turn on and off.
[R-2.10-44 I] The function of the button must be intuitive and simple.
[R-2.10-45 I] Alert messages must be informative and easily understood by the nursing staff.
[R-2.10-46 I] The portable device should be able to clip onto the belt easily and comfortably.
[R-2.10-47 II] Firmware updates shall be upgraded by a qualified service person.
[R-2.10-48 I] Clothing should not obstruct device operation or signal transmission.

2.11 *Performance Requirements*

[R-2.11-49 I] If it is worn properly, the system should detect at least 95% of falls which occur.
[R-2.11-50 II] The number of false positives must be much less than the number of correctly identified falls.
[R-2.11-51 I] The signal transmission from portable unit to central unit must occur within 1 second.
[R-2.11-52 I] The central device should raise an alarm to notify help staff within 5 seconds.

3. Central Control Unit

The following section outlines the functional requirements of the central control unit. The considerations to be accounted for include important functionalities such as alert message display and audio alarm. Additionally, the electrical power consumption and physical appearance of the device case are dealt with here. Generally speaking, the central device will be a stationary device, plugged in all times, which communicates with the portable unit through RF signals.

3.1 *General Requirements*

[R-3.1-53 II] Device must have a display on which it can show alert messages.
[R-3.1-54 II] Device must trigger an audible alarm that attracts attention when a fall alert is received and displayed.
[R-3.1-55 II] Unit will be permanently placed in a nurse's common area; it must have a professional and appropriate aesthetic.
[R-3.1-56 II] Unit will be designed to allow new functionality to be added without a total reconfiguration.
[R-3.1-57 I] Unit must reliably receive alert signals, even in the presence of other RF devices.
[R-3.2-58 I] Device must have button to notify the system that the alert was received and dealt with.

3.2 *Electrical Requirements*

[R-3.2-59 I] Central device will function using typical 120 V, 60 Hz wall supplied power.
[R-3.2-60 I] Device will be plugged in at all times, therefore it must not accumulate heat.
[R-3.2-61 II] Device may be able to function independently for a short period during a power outage so that service is not interrupted.

3.3 *Physical Requirement*

[R-3.3-62 II] Entire case should be about 20 cm length, 15 cm width and 15 cm height.
[R-3.3-63 II] The entire case is about 1 kg in weight.
[R-3.3-64 I] Box must contain ventilation holes to allow air flow and heat dissipation.

4. Portable Accelerometer Unit

This section provides functional requirements for the portable accelerometer unit. This device is the most important part of the system. The portable unit will be placed on the user as they are doing their daily activities. There are therefore a great number of situations to be accounted for in its design. In addition to the need for accurate fall detection and reliable signal transmission, factors to be considered include device physical size and weight, battery life, aesthetic appeal and durability.

4.1 *General Requirements*

[R-4.1-65 II] Device must monitor user acceleration without interruption.
[R-4.1-66 I] Embedded fall detection algorithm must reliably recognize the acceleration profile of a fall (includes sudden change in magnitude and prolonged change of orientation).
[R-4.1-67 II] Push button on device must allow for cancellation of alarm.
[R-4.1-68 I] Push button on device must allow user to call for help in situation other than a fall
[R-4.1-69 I] Device will comfortably sit on a user's belt without being bulky or intrusive. A necklace band will also be provided.
[R-4.1-70 II] Device must inform user if battery power is low.
[R-4.1-71 II] Device must notify user that an alert is being sent or has been sent.
[R-4.1-72 I] All users need to learn to work with the cancellation/send help button.
[R-4.1-73 I] Case must protect the device from environmental factors and impact damage.
[R-4.1-74 I] The device should be able to function without any interference with other devices.

4.2 *Electrical Requirements*

[R-4.2-75 I] Device will be power by a rechargeable battery pack.
[R-4.2-76 II] Single charge of battery pack should last for up to 2 weeks.
[R-4.2-77 I] Batteries pack must be easy to remove, replace and recharge.
[R-4.2-78 I] A simple on/off switch should be provided.

4.3 *Physical Requirements*

[R-4.3-79 II] Entire case should be about 2.5 cm in length, 1.5 cm in width and 1.0 cm in height
[R-4.3-80 II] Entire device should weigh about 200 g.
[R-4.3-81 I] Button must be large and easy to press.
[R-4.3-82 I] Case design should prevent obstruction of the button (by clothing, etc.).

5.User Documentation

[R-5.0-83 III] User documentation will be available online and include a user manual for elderly users, a user manual for nursing staff and FAQ's.
[R-5.0-84 III] User manuals must use non-technical language and be easy to understand.
[R-5.0-85 III] Technical support will be provided through the internet and by phone.
[R-5.0-86 III] Support will be provided in English, French, Spanish, Mandarin and other languages as needed.

6. System Test Plan

There are many things to consider in constructing a test plan to ensure proper functioning of the F.A.M. system. Since the system encompasses multiple devices, the portable and central units must first be tested individually and then together as a system. Each part has to be tested thoroughly to make sure that everything works well together.

For the portable device that sits on the user's belt, the first test is to make sure that the device can connect to the central device in many situations. We will be testing to see how far the device can speak to the central device through direct sight. Once we establish that, we will start using it in different areas where walls and different object obscure the path. We will see which situations need to be addressed and take note to let users know when installing the device. Next, the device needs to be able to withstand a human fall. The main device also needs to be tested in situations where it may come in contact with water. Another series of tests will be required when pressing the cancellation button in case the user unintentionally activates the device.

Secondly, we need to run some tests on the central device. This device will receive signals sent from the portable device. As it's connected wirelessly to the portable unit, awaiting a fall detect,

a test case will involve picking up a signal from the portable unit. This signal doesn't necessarily have to be produced from a fall, but can be a "fake" signal that F.A.M. developers will force. The test scenario described above will signify connection between the central box and portable unit. Once we have confirmed connection, we can move on to testing the detection of voltage signals from the portable unit's accelerometer. In this scenario, we will need "free fall" motion tests.

Our final phase will involve testing the sufficiency of the power supply. A test case program will be hard coded to test all components working simultaneously. We can monitor the voltage provided by the accelerometer (through software) and will therefore be able to effectively inspect our system during power tests. Lastly, we will monitor the heat distribution of our device, making sure the temperature stays within safe thresholds.

Typical usage scenario:

The following steps describe the typical usage scenario of the F.A.M. device:

1. User attaches portable unit to belt
2. User adjusts portable unit to a comfortable position along waist line, then powers on the device by on/off switch
3. Nurse or care giver powers on the central box, which is automatically connected via wireless technology to the portable unit
4. Central box now awaits a fall detected signal

7. Conclusion

The functional specification explained in this document displays the capabilities, system and safety requirements and performance of the F.A.M. device. Test plan, user documentation and product standards are also outlined in this document. The final production device should be a complete deliverable after three development phases. F.A.M. aims to complete a functional device prototype, abiding by the primary specifications, by April 6th 2012.

8. References

[1] http://www.cdc.gov/homeandrecreationalsafety/falls/adultfalls.html

[2] http://money.cnn.com/2011/05/25/retirement/keeping-parents-safe.moneymag/#TOP?iid=EL

[3] http://www.embeddedrelated.com/groups/msp430/show/35917.php

[4] http://belley.org/Management/06-Risk%20Management/Z32-04.pdf

[5] http://www.iec.ch/

[6] http://www.iso.org/iso/home.html