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February 26, 2004

Lakshman One
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RE: Ensc 440 Project Functional Specifications for the BEAM Pedometer

Dear Mr. One,

Attached is the BEAM Pedometer Functional Specifications for Ensc 440: Capstone Engineering Project. The included document summarizes the functional requirements of the BEAM Pedometer. The BEAM team currently is designing and implementing the BEAM Pedometer, an accurate and low cost distance-measuring device for fitness and health enthusiasts.

The purpose of the attached document is to outline the functional requirements of the BEAM Pedometer prototype, and final product. Major system component functional requirements describe the overall system functionality in this document.

The BEAM team includes four dedicated senior engineering students: Eliot Aharon, Manpreet Johal, Aaron Payment, and Biljana Pecelj. If you have any questions or comments please feel free to contact me via email at eaharon@sfu.ca or the team at ensc440-beam@sfu.ca.

Sincerely,

Eliot Aharon
CEO
BEAM Inc.

Enclosure: *Functional Specifications Version 1.1 for the BEAM Pedometer*

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Pedometer
Functional Specifications

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Executive Summary

Over the years, various studies have shown the connection between obesity, diabetes, heart disease, and stroke. The devastating diseases associated with obesity can be avoided through regular exercise and a healthy diet. New studies indicate that walking 6,000 steps a day is sufficient for good health and 10,000 steps a day can result in weight-loss [1]. Such studies have encouraged walking and step counting, making pedometers a very popular fitness item. The team is in the process of designing and implementing the BEAM Pedometer, an accurate and low cost device.

The project development will occur as a two-step process. The first phase of the project is the development of the prototype. The prototype will have the following features:

1. Accurate step counting algorithm
2. Distance traveled measured in km
3. Easy to use user interface
4. An ankle unit and a display unit connected with a wire

The second phase of the development will include:

1. RF module to replace wire between ankle and display units
2. Display unit redesigned into a wrist attachable module
3. Protective casing for the ankle and wrist module
4. Watch feature

The first development phase will end by the first week of April 2004.

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Glossary

Acronyms

BCI	Battery Council International

Definitions

Accelerometer	An instrument used to measure acceleration.
Pedometer	An instrument that gauges the approximate distance traveled on foot by registering the number of steps taken.

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1. Introduction

The BEAM *Pedometer* is a fitness gadget that people can use to measure accurately the distance traveled and the number of steps walked in a day. The unique combination of an *accelerometer* combined with a highly accurate algorithm improves the accuracy of the BEAM Pedometer. The team is currently in the first phase of development. By April 2004, the proof of concept phase will be completed.

1.1. Scope

This document explains in detail the functional requirements that the fully completed prototype BEAM Pedometer must meet by April 2004. On top of the full set of functional requirements for the proof of concept device, we have provided a partial set of functional requirements for the commercial version of the BEAM Pedometer.

1.2. Intended Audience

The intended audience of this document includes design engineers, managers and the marketing department.

Design engineers will use these functional specifications while developing the modules for the BEAM Pedometer.

The project manager will use the functional specifications to gage project progress and the development goals of the first phase.

The marketing team will use the functional specifications during the initial development of promotional materials.

 

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2. System Requirements

2.1. System Overview

The system consists of two modules: an ankle unit and a display unit. The ankle unit consists of an accelerometer attached to a Velcro strap, which wraps around a user's ankle. The display unit indicates the number of steps taken and the distance traveled by the user. An Atmel microprocessor processes the data collected, and calculates the steps and distance traveled. Figure 1 illustrates the system overview of the BEAM Pedometer.

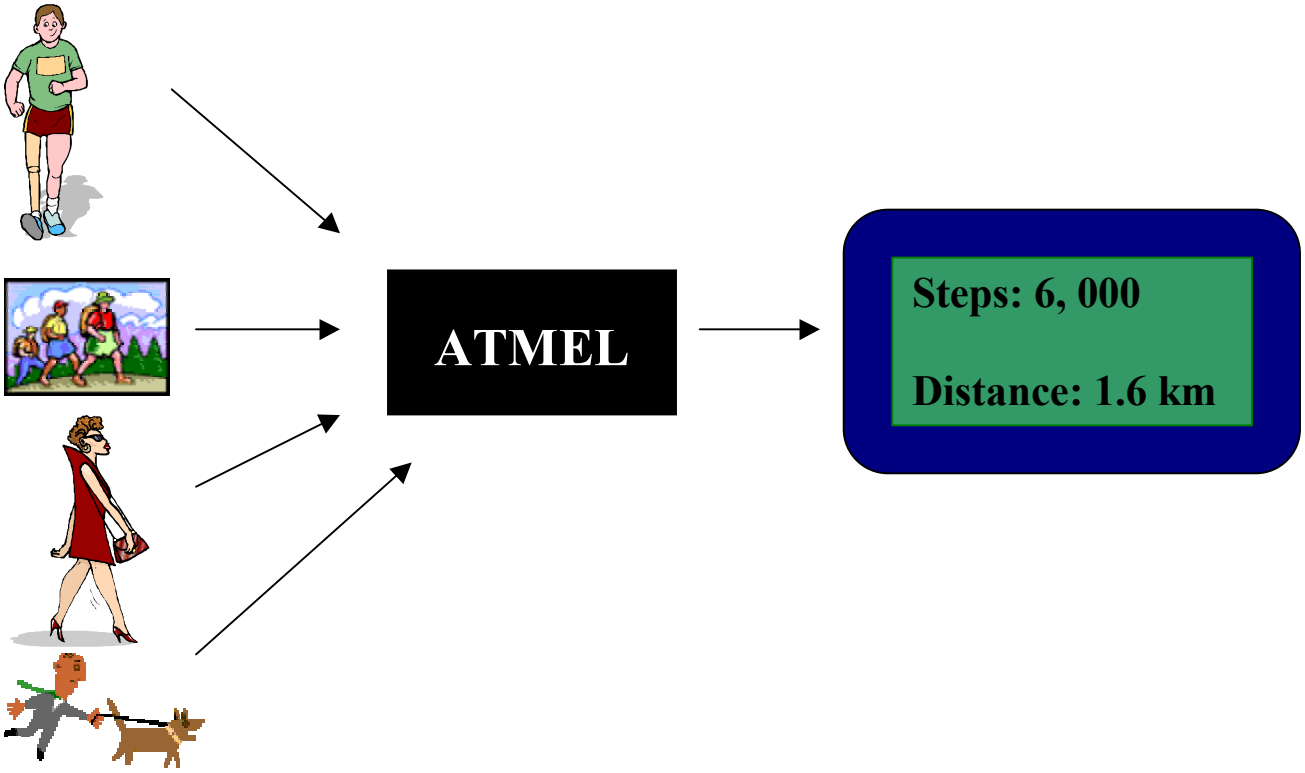

Figure 1: System overview

The BEAM Pedometer is a unit designed to determine the distance traveled by a pedestrian or runner. This being the case, several functional requirements must be met. These specifications can be broken into several categories. The following section contains a brief description of each category.

2.2. Physical Requirements

The BEAM Pedometer must be used in numerous environments on a daily basis. To accomplish this, the unit must meet certain physical requirements. The prototype device will meet the following requirements:

- an ankle unit consisting of an accelerometer and a Velcro strap for easy fastening
- ankle unit will be mounted on a board no larger than 5 cm by 5 cm
- the ankle unit should not exceed 100 g so as not to discomfort the user
- display unit will be mounted on a board no larger than 10 cm by 10 cm
- display unit should not exceed 200 g so as not to discomfort the user
- a wireless connection will join the ankle and display unit by passing the raw accelerometer data

Some general physical requirements of the commercial version of BEAM Pedometer are:

- ankle unit will be encased in a plastic case reinforced with stainless steel
- protective casing for the ankle unit should not exceed the prototype mass requirements stated above
- instead of a large display unit, a compact watch like unit will be used which the user will wear around the wrist

2.3. Environmental Requirements

The BEAM Pedometer should ideally work in all weather environments. The proof of concept device will have the following features:

- operating temperature is going to be the room temperature (around +25 ºC)

For the commercial version of the BEAM pedometer, the following is expected:

- splash resistant for use in wet weather, both the ankle and display unit should be submersible to 2 m for use in extreme environments
- shock resistant up to 10 G's to withstand continuous jarring motion as well as accidental falls onto hard surfaces (accelerometer proposed withstands several thousand Gs of impact force)
- electrically isolated from external environment (to reduce erosion and wear)
- operating temperature from -50ºC to +50ºC (for use in most temperature ranges worldwide)

2.4. System Interfacing

The BEAM Pedometer will have a simple RF interface between the sensor and the base unit. The proof of concept device will have a simple wireless interface. The final product will included an improved version of the interface. The following specifications are expected:

- non-interference RF transmission (to not interfere with other electronic equipment)
- individually tuned with low power (to not interfere with a neighbor's identical device)
- low power LCD (for output to user)

2.5. Power Supply

The BEAM Pedometer receives its power from a DC voltage source of approximately 6V and both the base unit and sensor will have individual power supplies. The proof of concept prototype will have the following specifications:

- powered by a two 9V batteries on both the base unit and the sensor

The following specifications are intended for the commercial version of the product:

- low current consumption in the order of 50uA (for prolonged use without battery replacement or charging)
- AC adapter supplying a 4.5V to both units simultaneously for convenient overnight or between use charging
- high quality rechargeable batteries (for cost, longevity and environmental friendliness)
- a single set of batteries should serve for at least 50 hours of continuous use

2.6. Performance

The BEAM Pedometer will meet the following performance characteristic for both the proof of concept and the commercial device:

- at power up or reset, there will be a 10 s initialization to allow for calibration of the accelerometer and display initialization sequence
- there will be no data retained between power off and the beginning of a new session
- the ankle unit will output raw data every 10 ms which will be sampled by the display unit approximately every 50 ms
- the instantaneous velocity will be updated every 100 ms on the display
- the total distance traveled will be updated every 1s on the display

2.7. Standards

It is important to note that there are no specific industry standards for pedometers or other electronic distance accumulators, and therefore this prototype does not have to comply with any industry standards. For the commercial version of the BEAM pedometer, these standards are relevant:

- C-95-1-1991, RF exposure standard as stated by the IEEE [2]
- Battery Council International (*BCI)* environmental standard for batteries [3]

2.8. Reliability

The reliability of the device is dependent on all aspects of the system due to the increased scope of reliability itself. For customer satisfaction and warranty purposes, we have outlined the key reliability requirements for our device.

2.8.1. Durability

The commercial version of the device should be able to maintain the following:

- reliability in all aspects of the physical and environmental requirements described above
- ability to withstand a reasonable amount of abuse leading to failure

2.8.2. Accuracy

Accuracy is a key reliability issue since the BEAM Pedometer's accuracy distinguishes the product from other less accurate devices. A device that fails to measure traveled distances accurately should be considered unreliable.

The proof of concept device will meet these accuracy requirements:

- reliably calibrate and extrapolate distance traveled within a range of 5%
- behave reliably on flat terrain (degree of elevation 0%)

The commercial version will meet the following requirements:

- reliably calibrate and extrapolate distance traveled within a range of 1%
- behave reliably in various environments on different terrain

2.9. Safety

The commercial version of the BEAM Pedometer will include the following safety features:

- electrically isolated from the user to avoid chances of electric shock
- in the event of an electrical shock the damage would be minimized due to the limited voltage in the unit
- sign stating “Danger! Electrical components, do not open if unqualified!” and warning “Keep out of reach of children under the age of 4 due to risk of choking on small parts.”

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3. User Interface

The user interface is a key feature of any product including the BEAM Pedometer. For the prototype the display module will be a very simple LCD with four lines each containing 20 characters. The example of such an LCD is shown below in Figure 2.

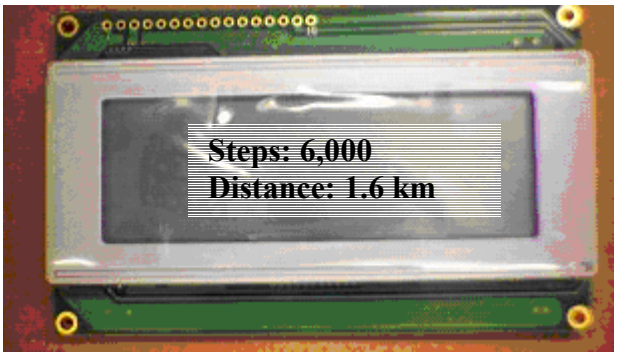

Figure 2: LCD with four lines of 20 characters each

The display module will be outfitted with five user input terminals (buttons). Each terminal will offer different information to the user. Figure 3 shows these buttons in a linear organization with the modes of operation they represent.

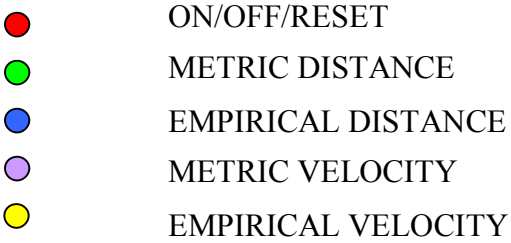

Figure 3: User interface on display Module

It is important to note that an on/off button will be placed on the ankle unit to save battery life while not in use.

The final product will contain a more user friendly and aesthetically appealing interface. The display unit will be modified into a wrist module. The unit will contain several buttons for easy navigation between various modes. A sample design for the final wrist modules is shown in Figure 4.

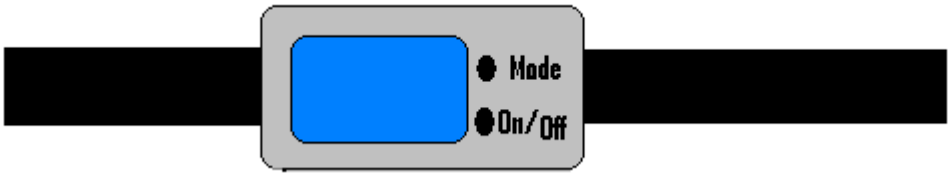

Figure 4: Final product wrist module

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4. Documentation

The target group for our product includes all fitness and health conscious individuals who wish to better their lifestyle through regular exercise. Since the product target group is so broad it might include people who are technologically savvy or technologically inexperienced. To maximize user benefits and satisfaction, we plan to develop documentation that will make the BEAM Pedometer easy to use for people of any knowledge level. For our final product, our documentation and user training will include the following:

- A detailed user manual will provide instructions in English, French, Japanese, and Spanish.
- The user manual will be easy to read so that people with very basic technological knowledge can have maximum comprehension.
- A website will be accessible for all users and will contain basic information, a copy of the user manual and a help section.
- For more advanced customers the website will contain additional software that they may use to track their daily progress and exercise regimen.

For the proof of concept device, the users will receive verbal instructions from us as to how to operate the device.

5. Test Plan

The following section outlines the method by which we intend to test and characterize the BEAM Pedometer. Testing will focus on power battery life and deterministic accuracy. It is important to note that the tests are designed to prove the functionality of the BEAM Pedometer based on the factors previously described in this document.

5.1. Test Overview

The main functionality of the BEAM Pedometer can be placed into two key categories. The categories are deterministic accuracy of distance traveled in different environments, and battery life over prolonged use. The BEAM Pedometer should behave accurately in all terrain types within an acceptable error of 5 %, while it should have a respective battery life of at least 50 hours of use.

5.2. Testing Strategy

Testing of the BEAM Pedometer will be separated into two distinct sections: Battery Life and Distance Accuracy.

5.2.1. Battery Life

The battery life will be tested by observing several operating factors of the system consisting of LCD intensity, voltage consumption at power supply, and measurement consistency of the distance sensor at varying power levels.

5.2.2. Distance Accuracy

Testing of accuracy will be accomplished by observing the output for several users and comparing it to known distance traveled.

Based on the results of successive tests it will be possible to determine and apply appropriate changes to circuitry and analysis algorithm resulting in an iterative design process to improve the functionality of the BEAM Pedometer.

6. Conclusion

The functional specifications outlined above give detailed descriptions of all the requirements the BEAM Pedometer will meet. The requirements for the final product will be completed in phase two of the development cycle. The functional specifications for the proof of concept device will be completed and fully met by April 2004.

7. References

[1] walking.about.com/cs/measure/a/countsteps.htm

[2] www.argentinc.com/html/rf_standards.html

[3] www.batterycouncil.org