

October 18, 2005

Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
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Re: ENSC 340 Functional Specifications for a Bicycle Energy Measurement System

Dear Dr. Rawicz:

The enclosed document, *Functional Specifications for a Bicycle Energy Measurement System (BEMS)*, summarizes the functionality of our device for the ENSC 340 project. The purpose of our product is to allow the user to measure the energy expended while cycling in an easy and affordable manner. The energy measurement system shall acquire data in real time and perform the necessary calculations and display the results.

In this document, we have provided in detail a list of functionalities that our completed prototype will feature as well additional specifications that shall be implemented in future versions of the system.

Exigo Technology consists of two fifth year engineering students: Denis Dmitriev and Mimi Wu. If you have any concerns or questions in regards to our proposal, please do not hesitate to contact me by phone at (778)892-0552, or by e-mail at mwua@sfu.ca.

Sincerely,

Mimi Wu

Mimi Wu
Exigo Technology

Enclosed: Functional Specifications for a Bicycle Energy Measurement System



Exigo Technology

Functional specifications for a
Bicycle Energy
Measurement System

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Executive Summary

Exigo Technologies recognizes the emerging need for devices that make exercising enjoyable. Our product combines the advantages of both worlds, retaining the recreational aspects of cycling as well as providing detailed output information. Our product is meant to provide detail information about the current cycling conditions at an affordable price, so as to reach the mass public. The prototype of our product will be completed by December 2005.

To be competitive in the current market, the BEMS must meet a series of functional requirements. In our functional specifications we specify these requirements including

1. The ability to run on 3 AA batteries.
2. The ability to allow the user to enter personal information through the display unit.
3. The ability to collect samples in real time, perform the necessary calculations and display the results on the display unit.

In addition, we have outlined the requirements for the accuracies of the measurements, the reliability of our device, the portability and ease of use. We also specify the regulatory requirements which must be fulfilled by our design. In addition to specifying the requirements for the prototype, the functional specifications also specify requirements for the next generation of the device.

The functional specifications will serve as a guide for the design and further development of the system.

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1 Introduction

The BEMS is a product that measures the energy expended by the cyclist during an exercise session. This is done by an indirect measurement of the power based on the speed, acceleration, and inclination of the bicycle at any given moment. The BEMS is a device intended to provide detail energy expenditure information while allowing the cyclist to do so on a budget. The prototype of the BEMS is under development with the intent of being tested on the road by December 2005.

1.1 Scope

This document includes detailed functional specifications for the prototype of the BEMS as well as additional requirements of future generations of the product.

The functionality of the entire energy measurement system is stated as well as functional requirements for its individual components. Sections addressing regulatory requirements and documentation and user training are also included.

1.2 Intended Audience

This document will allow the project manager to measure project success as well as verify the design.

1.3 Objectives

The specifications listed in this document aim at outlining the functional specifications of the BEMS to its potential users and guide in the design process of the system.

This document will use the following convention to denote requirements:

R[#] A functional requirement

When describing functional requirements, this document uses the term *must* to indicate a requirement deemed critical to the success of the product. The term *should* is used exactly once to indicate that an effort will be made to address an inherently qualitative aspect of the device functionality; however, the degree to which this requirement is satisfied will depend entirely on the particular user.

Most requirements listed in the section 2 will apply to the final product as well as the prototype. Section 4 describes how the prototype is expected to differ from the final product.

2 System Requirements

Figure 1 shows the overview of our energy measurement system. The system consists of a sensor unit attached to the front fork of the bike and a display unit attached to the handlebar and a cable connecting them. As the cyclist pedals, the sensors transfer the gathered information into the BEMS, which calculates the amount of energy expended by the cyclist. This information is tallied and displayed on the unit at regular intervals.

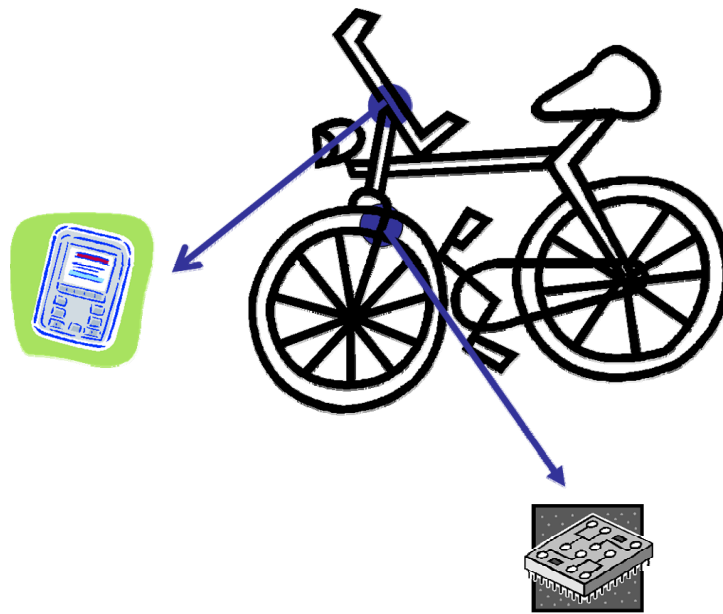


Figure 1: Conceptual system overview

2.1 Physical Requirements

- [R1] The combined weight of the system must not exceed one pound so as not to significantly affect the performance of a bike [1].
- [R2] The sensor unit must be attached to the fork at the front wheel of the bicycle.
- [R3] The display unit must be conveniently mountable on the handlebars.
- [R4] The connecting cable must be of sufficient length to connect the sensor and display units to accommodate shock absorber-equipped bikes.
- [R5] The sensor unit's impact on bicycle handling characteristics should be undetectable by most amateur riders. It is expected, however, that a professional cyclist will notice even the slightest changes in bicycle behaviour.

- [R6] The display must be clearly readable in all conditions, day or night.

2.2 Power Requirements

- [R7] The entire product must be able to operate using three regular AA batteries for at least 25 hours.
- [R8] The product must have an auto-off functionality to avoid draining the batteries when not in use.
- [R9] Data entered by the user and certain cumulative statistics, including but not limited to odometer information and the total amount of energy spent during the last trip, must be stored in non-volatile memory so as not to be lost during battery replacement or accidental removal of the connecting cable.

2.3 Environmental Specifications

- [R10] The entire product must operate without any loss of accuracy over the temperature range from -40°C to $+70^{\circ}\text{C}$, to allow the cyclist to use the product in any condition.
- [R11] Both the display and the sensor units must be waterproof.

2.4 Reliability and Serviceability Specifications

- [R12] The entire product must be easy to install by a person with little or no experience in bike maintenance.
- [R13] The entire product must be able to survive bicycle fall-overs and most moderate crashes—crashes that do not result in significant damage to the bike itself.
- [R14] The product must be able to withstand vibration and repeated shocks arising from normal operation of a bicycle.
- [R15] Barring excessive abuse, the product must provide a service life of at least two years.

2.5 Accuracy Specifications

- [R16] The instantaneous cyclist power output as reported by the product must be within 5% of the actual power output value when riding on an asphalt road in the absence of wind.

- [R17] Cumulative energy spent by the cyclist over the duration of several hours as reported by the product must be within 10% of the actual value regardless of riding conditions, excluding conditions giving rise to protracted systematic measurement errors, such as strong head winds for the duration of the trip or riding exclusively on gravel.

2.6 Interface Specifications

- [R18] The user interface must have a minimum of buttons and allow most commonly used functions to be accessed with no more than two button presses.
- [R19] The user interface must be able to display instantaneous power output of the cyclist, total amount of energy expended since the last reset, odometer, current, maximum, and average speeds, and the state of the batteries (though not all at the same time).
- [R20] The product must provide the means of entering essential calibration information, such as cyclist's and bike's weights.
- [R21] The product must allow the user to switch between metric and imperial units with ease.
- [R22] The user interface must refresh often to make the updates appear continuous.

2.7 Regulatory Requirements

- [R23] The final product must comply with all relevant Canadian Standards Association (CSA) and Underwriters Laboratories Inc. requirements pertaining to users handling electronics equipment.
- [R24] The final product must also comply with all relevant CSA and Federal Communications Commission rules pertaining to electromagnetic radiation from consumer electronics.

3 Documentation and User Training

The intended user for the BEMS is a cyclist who is used to operating regular bicycle computer, but it is expected amateur cyclists shall not encounter difficulties operating our product.

- [R25] The documentation for the production version of the device will consist of one user manual in English.
- [R26] The user manual will include information on the functional features of the device, operation conditions, instructions for navigating the display.
- [R27] The user manual will also include a troubleshooting and safety section.
- [R28] Minimal user training should be necessary to operate the device.
- [R29] Training for the production version of the device will be provided by the system's user manual.
- [R30] Users of the prototype will be instructed by the project members.

4 Concessions Made for the Prototype

Due to limited time and resources available to us at this point, the prototype will deviate somewhat from the final product requirements set forth in the previous section. The following list covers the anticipated discrepancies:

- [D1] The prototype may exceed the weight requirement of [R1] since all of its mechanical parts will have to be made out of metal rather than suitable plastics.
- [D2] Contrary to [R11], the enclosures used for the prototype will not be waterproof.
- [D3] Every effort to attain the accuracy goals set in [R16] and [R17] will be made, but due to the limited amount of time we will be able to allot to calibration and the lack of reference equipment, the prototype's the primary goal will be achieving appropriate behaviour in situations where theoretical estimates of energy are possible and reproducibility of the results in other circumstances.
- [D4] Since certain techniques, such as epoxying the circuit boards, are not practical in a prototype, service life expectancy stated in [R15] will neither be guaranteed nor anticipated.
- [D5] User manual will only be produced if there is sufficient time for such an endeavour.
- [D6] The prototype will not be tested or certified by any regulatory boards.

5 Conclusion

The functional specifications listed in this document are rigorously detailed. They specify a final production system that will integrate the functionalities specified in this document with ease of use. Requirements specified for the prototype will be completed for December 2005. Requirements specified for the production device will be part of the future development of the device.

References

- [1] Torelli Imports, *Bicycle Weight, the Benefits Quantified*,
<<http://www.torelli.com/tech/weight.shtml>>