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February 16, 2003

Lucky One
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
V5A 1S6

RE: ENSC 440 Project Functional Specifications

Dear Lucky One:

Attached is the Links Performance Incorporated (LPI) group's *Functional Specification for the SmartShifter™ System*, which outlines the functional plan of our project for ENSC 440. Currently, LPI is in the process of designing and implementing the SmartShifter™ system so that a bicycle may shift automatically. The SmartShifter™ system will allow riders to freely enjoy cycling without the burden of shifting gears.

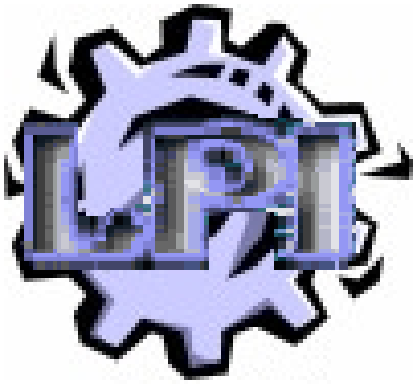
The attached functional specifications will outline the required functionality and limitations of the SmartShifter™ prototype and final product. This document is broken down into key sections so that each important feature or requirement could be discussed thoroughly.

LPI consists of four fourth year engineering science students, who are all very dedicated to the SmartShifter™ project. The SmartShifter™ members are Nin Sandhu, Trevor Hawkins, Zafeer Alibhai, and Jack Choi. If there are any questions or concerns regarding the functional specifications, please don't hesitate to contact me at (604) 721-8529 or email the SmartShifter™ team at links-440@sfu.ca.

Sincerely,

Nin Sandhu
President and CEO
Link Performance Inc.

Enclosure: *Functional Specification for the SmartShifter™ System*



Links Performance Inc.

Functional Specifications
for the SmartShifter™ System

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February 17, 2003

Executive Summary

LPI proposes developing an automatic gear shifting system, the SmartShifter™, which will interface with existing bicycles. The SmartShifter™ will automatically shift gears over all types of terrain, in order to maintain a user-defined pedaling rate or cadence. Most riders prefer to maintain a constant cadence as this allows for peak efficiency, comfort and enjoyment.

The development of the SmartShifter™ will be split into two main stages. These stages will be the development of a prototype and then final products. LPI is currently in the prototype development stage, which is scheduled to complete April 2003. Upon completion of a working prototype, design enhancements will be made for the final product.

This document describes the required functional specifications of both the prototype and the final product.

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1. Introduction

The SmartShifter™ is a device that adds an automatic shifting to a standard mountain bicycle. The system shifts gears and communicates with the rider. The product development cycle will be split in stages, starting with a prototype deliverable for April 2003. Further design and development will be conducted to bring the final product to market.

1.1 Scope

This document summarizes the functional requirements of the SmartShifter™ system. Also included are the test plans developed to analyze the functionality and quality of the working product. This document will be the basis for the design of the working prototype. The prototype will not incorporate all the necessary requirements of the final product.

1.2 Intended Audience

This document details the requirements of our SmartShifter™ system which implements an automatic gear shifting solution for bicycles. The functional specifications are intended for the SmarterShifter™ design team to ensure adequate performance and functionality of the system. The functional specifications will also be used as a test plan for the project design and implementation.

2. System Requirements

2.1. System Overview

The SmartShifter™ system removes the necessity for riders to shift gears, thus allowing greater enjoyment of the ride. The principle of operation is analogous to an automatic transmission in a car, where the gas pedal is used to determine the vehicle's speed and an automatic gearbox performs the necessary shifts. For the SmartShifter™, the rider's pedaling will perform the same function as a car's gas pedal. An increase in pedaling rate (cadence) and effort will result in an increase in velocity and correspondingly a number of upshifts may need to be performed. The operation is the opposite when the rider slows their pedal rate and puts less effort in. In fact, most riders attempt to maintain a relatively constant cadence in order to improve efficiency and workout benefits. Thus, the SmartShifter™ system will control the user's pedaling rate over all types of terrain by automatically shifting the bicycle's transmission appropriately. Figure 1 illustrates the block-diagram overview of SmartShifter™ automatic bike transmission system.

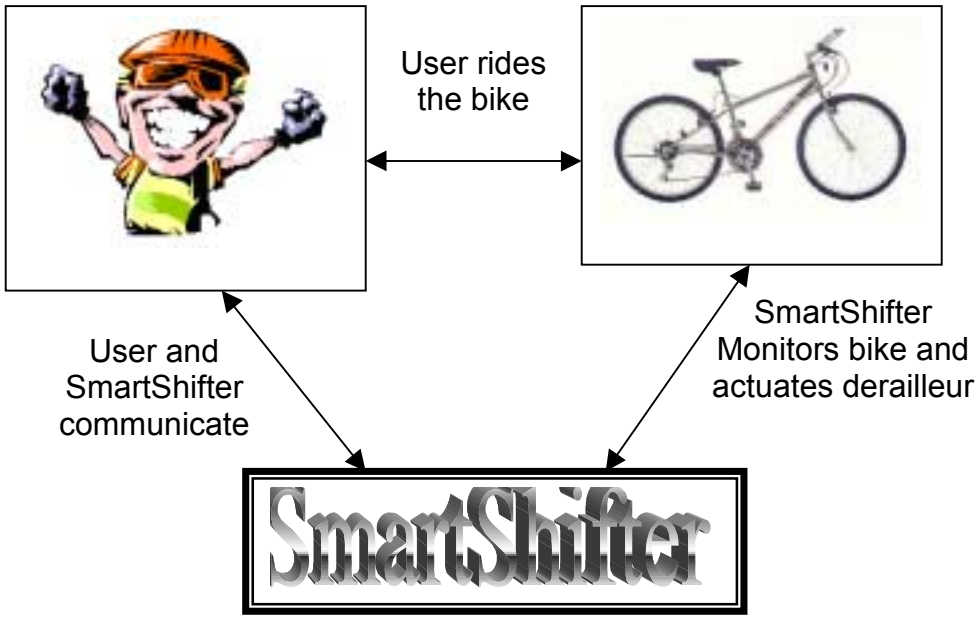

Figure 1: SmartShifter™ Functional Overview

As shown above, we can abstract the entire system into three main components: the rider, the bike and the SmartShifter™ system. We also note that the SmartShifter™ system requires a user interface (UI) and means to both monitor the bike speed and rider's cadence as well as control the selected gear.

Finally, we can derive the following block diagram below lists the inputs, functions and outputs of the system, as shown below in Figure 2.

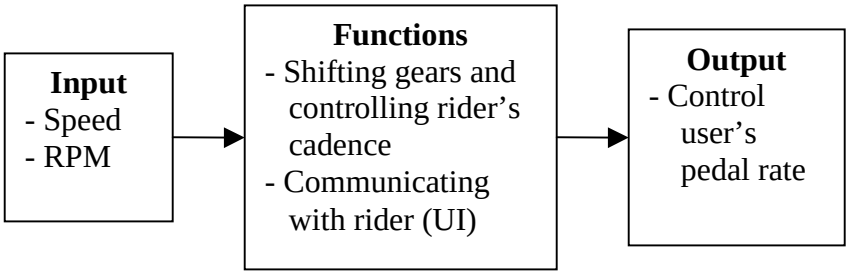

Figure 2: SmartShifter™ System block diagram

2.2. Physical Requirements

Throughout the following sections, the following convention is used to denote the functional requirements:

[#] Indicates a Functional Requirement

This number indicates the [#]th requirement of the SmartShifter™ for that section. The description following the functional requirement number details the specifics of the requirement. A description in the form of a table indicates different requirements for the final product and the prototype. In the case of a table the relaxed requirements for the prototype will be placed on the left side.

The SmartShifter™ prototype system is intended to interface with standard mountain bikes. The final products will be design to work with all types of bicycles. The system requirements are specified for easy integration onto existing mountain bikes.

Requirement	Prototype	Final Design
[1] All components will be mounted directly onto the frame of a mountain bicycle in key locations.	●	●
[2] All components must be mounted in rugged solid enclosures		●
[3] The system will be lightweight and space efficient.		●
[4] All components will not interfere with the rider or bicycle operations.		●

2.3. System Requirements

The SmartShifter™ has some basic requirements as derived from the system overview in section 2.1.

Requirement	Prototype	Final Design
[1] The system is capable of measuring the pedal rate.	●	●
[2] The system is capable of measuring the bike speed.	●	●
[3] The system detects a change in pedal rate and/or bike speed, which is used as basis for required gear shifts.	●	●
[4] The system is capable of shifting the gears of a standard bicycle transmission.	●	●
[5] The system communicates with the user easily and efficiently.	●	●

2.3.1. General

The SmartShifter™ will operate in any environment that a mountain bike rider would be expected to enter.

Requirement	Prototype	Final Design
[1] Normal user temperature range.	0°C to 30°C	-20°C to 45°C
[2] Weather conditions – Dry	●	●
[3] Weather conditions - Rain, snow, mud, and ice		●
[4] Operation in 0% to 100% humidity.		●
[5] Terrain – Paved	●	●
[6] Terrain – Gravel and dirt trails		●
[7] Impact Protection		●
[8] Protective packaging	●	●
[9] Sealed and waterproof packaging		●

2.3.2. Performance

The SmartShifter™ performance must be comparable to that of existing cable driven systems.

Requirement	Prototype	Final Design
[1] The system will be able to shift gears within 250ms.	●	●
[2] The UI will have a response time of 250ms.	●	●
[3] The UI will be updated at least every 500ms.	●	●

2.3.3. Reliability and Serviceability

The SmartShifter™ will perform reliably and require little user maintenance.

Requirement	Prototype	Final Design
[1] The unit will be easy to install by a person with bicycle service experience.		●
[2] Once installed, they only user service requirement will be to reconfigure the system via the UI.		●
[3] The user will only be expected to recharge and change batteries.	Optional	●
[4] The unit will have an operating lifetime of at least 3 years.		●

2.3.4. User Interface

The SmartShifter™ will incorporate an aesthetically pleasing, easy-to-use user interface (UI) for complete setup and control of the system. The following table lists the UI requirements that must be met for the prototype and the final design.

Requirement	Prototype	Final Design
[1] UI displays (1) current speed, (2) current gear, and (3) shifting mode. Also, a shift indicator will flash when a shift is pending.	●	●
[2] UI also displays (1) maximum speed <R>, (2) odometer, (3) trip meter/time <R>, (4) average speed <R>, (5) time of day <R> and (6) battery power. Parameters followed by "<R>" can be reset by the user.		●
[3] UI allows the user to (1) set the derailleur position for each gear, (2) enter the tire circumference for speed calculations and (3) configure automatic shifting mode options.	●	●
[4] UI also provides terrain and rider/workout options, such as flat/hilly or road/trail.		●
[5] Auto/manual mode can be toggled by the user without moving their hands from the handlebar grips. Up/down selectors located nearby allow for manual gear control and setup of the desired cadence when in automatic mode.	●	●
[6] UI must incorporate a large, easy-to-read display with low reflectivity from the sun and wide viewing angle.	●	●

[7] UI must have a minimum of buttons, which should be large and easy to use even with gloved hands. The buttons will have dynamic functions as indicated on the display.	●	●
[8] All setup/option menus will be self-explanatory and will normally be hidden from the user.	●	●
[9] All components of the UI must mount solidly on a standard handlebar such that they are conveniently accessible/viewable by the user.	●	●

2.3.5. Safety Features

The SmartShifter™ will not introduce the user to any new dangers, beyond those of conventional bicycles. The main possible failure mode of the SmartShifter™ is the chain jamming and/or derailing. Other possible methods include the wrong gear being selected in an important situation or a failure of transmission hardware. Any of these failures could result in the rider being injured or falling off the bicycle.

Requirement	Prototype	Final Design
[1] The unit will have a reset mode incase the system fails	●	●
[2] There will be a battery indicator on the UI to indicate the status of the battery life. The user will be notified of low battery levels.		●
[3] When the battery fails, the user will still be able to ride the bicycle.	●	●
[4] If the system fails, the user will still by able to ride the bicycle, but will be unable to shift.	●	●
[5] The user will be protected from electronic shorts and shocks	(we are expendable)	●
[6] The user can shift manually in critical situations where manually control is desired for safety reasons	●	●
[7] Incorporation of additional safety features and components		●

2.3.6. Power Supply

The power supply will need to be mounted on the bicycle for operation of the SmartShifter™ system.

Requirement	Prototype	Final Design
[1] Power will be supplied via a wall socket	●	
[2] The power will be provided via a portable battery.		●
[3] The battery will be small and light-weight for mounting on the bicycle.		●
[4] The battery will be rechargeable		●

2.3.7. Regulatory Requirements

Since the SmartShifter™ is intended for consumer use, the final design will have to meet government regulations.

Requirement	Prototype	Final Design
[1] CSA, CE and UL government approvals		●
[2] Warning and danger labels with descriptions		●

3. Test Plan

3.1. Hardware Test Plan

The main functionality of the hardware is to interpret specified parameters (speed, rpm, and derailleur position) and then move the derailleur accordingly. The following steps are the procedure for the Hardware Test Plan.

Test procedure is as follows:

1. Input bike parameters and calibrate derailleur via the UI.
2. Begin by selecting the automatic shifting mode from UI.
3. Apply a no load test and slowly rotate the pedals at a constant speed.
4. Check UI for appropriate speed and gear position.
5. Visually insure the derailleur is in the correct gear
6. Let the bike return to rest then begin rapidly rotating the pedals.
7. Check UI for appropriate speed and gear position.
8. Visually insure the derailleur is in the correct gear
9. Let the bike return to rest and now gradually rotate the pedals
10. Check UI for appropriate speed and gear position.
11. Visually insure the derailleur is in the correct gear
12. Let the bike return to rest then begin rotating the pedals at a constant speed then come to an abrupt stop.
13. Check UI for appropriate speed and gear position.
14. Visually insure the derailleur is in the correct gear
15. Calculate motor lag and response times

These specific steps will be repeated under varying load resistance and different modes of operation (auto/manual). These tests will help simulate outdoor riding on flat or hilly terrain and show how the system will respond. During each set of tests the system will be visually inspected to ensure the SmartShifter™ system is giving the correct user information and derailleur positioning. Additional ad-hoc testing will also be performed to ensure quality testing.

3.2. Software Test Plan

Software also plays a very critical role in the operation of the SmartShifter™ system, so just like the hardware it also needs to undergo thorough testing and debugging. The software insures that the correct information is being gathered and displayed to the user/rider. LPI intends to provide a product that is virtually bug free inorder to insure the success of the product. LPI will provide a overview of how the software will be tested, but further details will require a larger separate test plan document. The software will not be tested by the individuals who wrote the code, but by the remaining group members to insure quality testing.

3.2.1. Testing the UI

The UI will require extensive testing to test the ease of usability and that the correct information is being displayed. Each button, screen, and function will be tested in all possible ways and feedback from user groups will be used to revise and improve usability and functionality of the UI. The tester will be required to test that the buttons work and are being mapped to their desired menus and also check everything is being displayed properly.

A test program will be created to generate dummy numbers and display them via the UI. This will simulate real life input and provide feedback with how the SmartShifter™ will actually respond. Response and update times will also be measured to guarantee data is being provided at close to real time.

3.2.2. Testing the Derailleur Software

The SmartShifter™ software will also cause the dearilleur mechanism to move based on external parameters. A separate test program will be created to simulate the movement of the derialleur system. Dummy wheel and pedal speeds will be provided to test if the derailleur is on the correct gear based on wheel and pedal speeds. Various wheel circumferences will be tested to insure proper derailleur alignment and usability. Software response time will also be tested, so that the SmartShifter™ system will respond within an appropriate time.

4. Conclusion

In this document, LPI has outlined all the functional requirements its prototype and final design should meet. LPI plans to complete all the functionality for the prototype as listed throughout the document and even hopes to exceed them. Current progress on the SmartShifter™ project has been excellent, which suggests that at this pace it is highly possible to implement some of the final design specifications onto the working prototype. The final prototype will have a working SmartShifter™ system that automatically shifts based on pedal and wheel speed. This document has also provided LPI with the necessary information to better manage time and resources inorder to complete the project.