

October 12, 2014

Dr. Andrew Rawicz School of Engineering Science Simon Fraser University 8888 University Drive Burnaby, BC Canada V5A 1S6

Re: ENSC 440 Functional Specifications for the Smart Stroller Braking System

Dear Dr. Rawicz,

Attached is the Functional Specifications for our Smart Stroller Braking System prepared on behalf of Baby Guerrero Technologies. Our goal is to design and construct a fail-safe braking system on an existing stroller, which will put a stop to the dangers associated with unmanned stroller roll-aways.

This document is designed to provide an overview of the functionality and features that we intend to implement on the prototype design of our automated stroller braking system. Enclosed is a list of requirements my team will be referencing closely throughout the design process. Following these requirements will ensure the construction of a functional and Standard compliant prototype.

Baby Guerrero Technologies was created to provide effective solutions to real societal problems. If for any reason you have any concerns or questions that might prevent us from reaching our goal, please contact myself directly at 778-317-8995 or by email at esiddiq@sfu.ca.

Sincerely,

Elyas Siddiq Chief Executive Officer Baby Guerrero Technologies



Baby Guerrero Technologies

Functional Specifications for the Smart Stroller Braking System

ENSC 440/305 Capstone Project

Elyas Siddiq Santiago Roche Nicholas Holden Houssam El-Hariri Majed Kawam

Contact Person: Majed Kawam - majedk@sfu.ca Proposed to: Dr. Andrew Rawicz, Steve Whitmore Issue Date: October 14, 2014 Revision Number : 1.6

EXECUTIVE SUMMARY

Baby Guerrero Technologies

Due to the unsafe design of modern baby stroller brakes, strollers are prone to rolling away from the driver if they mistakenly forget to latch the brakes. This honest mistake can lead to a disastrous incident if it happens in the wrong setting. In fact, there have been several reported incidents of strollers rolling onto train tracks and endangering the babies' lives [1]. To solve this problem, the dedicated team at Baby Guerrero Technologies is designing a Smart Braking System (SBS) for baby strollers as an alternative to conventional stroller brakes.

The operation of the SBS is straightforward. When the driver of the stroller has a safe grip on the handles of the stroller, the brakes are disengaged and the wheels are free to move. When driver releases the handles or loses grip, the brakes automatically engage to lock the brakes. The touch sensors on the handles will be electronic and will operate with minimal pressure, making the SBS less strenuous for the driver than a fully mechanical braking system. The SBS will be designed to brake quickly but smoothly to prevent the stroller from rolling away and avoid possible harm to the baby from sudden deceleration.

The SBS is composed of several subsystems: mechanical system, battery, sensors, and electronics. The mechanical system will include the braking pads, calipers, cables, springs, gears, and motor. The sensors will include an encoder (for monitoring speed), gyroscope (for monitoring incline), and handle touch sensors. The electronics will include necessary the amplifiers, buffers, LEDs, and microcontroller. The battery will power the sensors, electronics, and motor.

This document lists all the functional requirements for the overall system as well as the aforementioned subsystems. Each requirement will be numbered and given a priority designation based on the stage of development in which this requirement must be met. There are three priority designations: proof of concept (p1), ongoing development (p2), and final production (p3). In addition, the requirements are listed under different categories, including: general, physical, electrical, mechanical, environmental, standards, reliability, safety, performance and usability. Finally, the document briefly outlines test plans to meet these functional requirements.



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GLOSSARY

Encoder	An electro-mechanical sensor used to calculate the speed of the wheel
Gyroscope	An electronic sensor used to measure the orientation of the stroller
Harsh Environments	Cold, rainy, humid, or hot temperature
Microcontroller	A small programmable computer that takes inputs, performs
	computations, and produces outputs
РСВ	Printed circuit board
Peripheral component	A device that is not part of the computer but connects to and works
	with the computer
Peripheral initialization	To make the device familiar to the computer
Pinch Points	Areas in the system where one or more of the user's body parts might
	be caught, causing injury
Portable	Can be lifted by and possible user
R&D	Research and Development
Standard Usage Policy	The braking system will function explicitly under the following
	Weather conditions: rainy, arid and humid
	Usage Condition: No less than 1 year with regular brake and battery
	replacement.
	Temperature Condition: Between 0°C and 50°C
	Speed of the stroller shall not exceed 10km/h
	Weight of the load placed on the stroller shall not exceed 60lbs
	System shall operate at a maximum altitude of 2000m above sea level
	WARNING: Stroller must not be used in icy, snowy, oily, lubricated,
	submerged or airborne conditions.

1 INTRODUCTION

Baby Guerrero Technologies

Baby Guerrero Technologies intends to reinvent baby stroller braking systems. By combining state of the art sensors, electronics, and mechanical systems, Baby Guerrero Technologies aims to reduce the amount of stroller related accidents. Current generation strollers will benefit greatly from the new way of braking compared to the archaic manually engaging brakes.

The new and improved braking system will be integrated with touch sensors that detect when the user has firmly grasped onto the handle of a stroller. Once the touch sensors are active, a signal is sent to the microcontroller that disengages the brake. The feedback sensors will constantly monitor the speed, incline and decline of the stroller as to optimize the braking time for maximum safety while maintaining as much comfort as possible for the infant. Baby Guerrero Technologies firmly believes that stroller-related accidents due to unsupervised rollaway will be a thing of the past. Welcome to the future of safety.

1.1 Scope

The scope of this document is to outline the functional specifications of the braking system as stipulated by the Baby Guerrero Technologies team. The document breaks down the revolutionary new braking design into modular parts that include the Mechanical System, Battery, Sensors, and Electronics. The subsystems are further broken down into respective requirement factors such as electrical, physical, environmental, safety, and reliability requirements. The requirements are prioritized within each subsystem and are differentiated between priority level 1, 2, or 3. The details of each subsystem is discussed thoroughly as to ensure maximum productivity at the development and testing stages.

1.2 Intended Audience

The document titled Functional Specification is designed for the review of all members of Baby Guerrero Technologies. The Baby Guerrero Technologies team will use this document as reference to ensure that the functionalities of the finalized product will be on par with what has been discussed and listed below. In addition, this document will also be used to provide further specifics to potential investors that may be interested in the company and our product. The marketing team will also benefit from reviewing this document as they will have a deeper understanding of what the product is about and what functions it can accomplish as to further market the product to the right demographic.

1.3 Classification

The following convention will be used throughout the document: [**Rn-pm**] A functional requirement.



Where **n** stands for the requirement number and **m** stands for priority number. Priority levels range from level 1 to 3 and are defined below:

Development Stage 1: Proof of Concept (p1)

The first stage of development for our fantastic product is the proof of concept prototype. The priority in this stage of development is to provide the basic functionality of smooth and reliable electronic braking triggered through by the touch sense pads of the stroller. In order to do this, the team at Baby Guerrero technologies will focus on testing, developing, and integrating the various units of the stroller to ensure we are able to develop a working prototype which guarantees smooth braking capabilities.

Development Stage 2: Ongoing Development (p2)

The second stage of development concerns itself with the ongoing development of the braking system. Once functionalities of the braking system have passed the proof of concept stage and have been decided that it needed to be implemented, we have entered the stage of ongoing development. At this stage, design specifications will be considered that complies with the current industry standard of the stroller.

Development Stage 3: Final Production (p3)

In the final production stage, the functionalities have been polished, ironed out and ready to be implemented for mass production.

2 OVERALL SYSTEM REQUIREMENTS

Functional requirements for the complete system are outlined in this section.

2.1 System Overview

The Smart Stroller Braking System will function as the main braking mechanism of our baby stroller.

The basic operation of the braking system is as follows:

- The braking system will disengage to release the wheels when the driver has a firm grip on the handles of the stroller.
- When the driver releases or loses grip of the handles, the braking system will engage to lock the wheels quickly but smoothly.

The complete system flowchart is illustrated in Figure 1.



Figure 1: Complete system flowchart.

The complete braking system will include several subsystems as illustrated in Figure 2.





2.1 General Requirements

[R001-p3] The braking system shall be built in a modular fashion to facilitate maintenance.

[R002-p3] The braking system shall not increase the retail price of our baby stroller by more than \$100 CAD.

2.2 Physical Requirements

[R003-p3] Stroller shall remain as light as possible.

[R004-p3] Stroller and braking system shall be aesthetically pleasing.



[R005-p2] Stroller and braking system shall be robust.

2.3 Electrical Requirements

[R006-p1] Braking system shall not pose shock hazard to the driver or the baby.

[R007-p1] Braking system shall be rechargeable.

[R008-p2] User shall be able to charge the battery while installed in or removed from the stroller.

[R009-p2] Electronics shall be protected from water damage.

2.4 Mechanical Requirements

[R010-p1] The brakes shall be based on conventional bicycle brakes.

[R011-p1] The wheels shall have metallic rim sidewalls (braking surface) to be compatible with the rubber brake pads of the bicycle brakes.

[R012-p2] The mechanical system shall operate efficiently in order to prolong battery charge.

2.5 Environmental Requirements

[R013-p2] Braking system shall function as stipulated in the Standard Usage Policy operations.

[R014-p2] Stroller and braking system shall operate under regular vibration caused by bumpy road.

[R015-p2] System shall be protected from external factors such as water, mud, sand, and dust.

[R016-p2] System shall be resistant to shock and vibrations from travelling on cement, grass and gravel terrain.

2.6 Standards

[R017-p3] The system complies with the act of "Carriages and Strollers Regulations" [2].

[R018-p3] All electrical elements shall comply with "IEEE Standard for User Interface Elements in Power Control of Electronic Devices Employed in Office/Consumer Environments" [3].

[R019-p3] All charging elements shall comply with "Canadian Electrical Code, Part 1" [4].

2.7 Reliability and Durability

[R020-p2] The brakes shall function for no less than a year as stipulated in the Standard Usage Policy operations [5].

[R021-p3] The battery shall not need to be replaced for no less than 3 years following Standard Usage Policy [6].

2.8 Safety Requirements

[R022-p2] Braking system shall function under Standard Usage Policy operations.

[R023-p1] Braking system shall not pose shock hazard to the driver or the baby.

[R024-p2] Braking system shall include a self-monitoring system and provide warnings to the driver in case of detected failure.

[R025-p2] Braking system shall offer mechanical override in case of electrical system failure.

2.9 Performance Requirements

[R026-p1] The braking system shall place minimal strain on the driver.

[R027-p1] The braking system shall be able to stop the stroller as stipulated in the Standard Usage Policy operation.

[R028-p2] The brakes shall engage smoothly to protect baby from possible whiplash.

[R029-p1] Braking system shall not interfere with regular operation of the stroller.

2.10 Usability Requirements

[R030-p1] The braking system shall engage when the driver releases the handle.

[R031-p1] The braking system shall disengage when the driver grips the handle.

[R032-p2] Stroller shall remain portable (foldable).

3 MECHANICAL BRAKING SYSTEM

The mechanical braking system includes the braking pads, calipers, cables, gears, and motor. The functional requirements of this system are outlined below.

3.1 General Requirements

[R033-p1] Brakes shall be able to engage quickly.

[R034-p1] Braking system shall not interfere with normal operation of the stroller.

[R035-p1] Braking system will provide rear wheel braking.

[R036-p3] Braking system will provide front wheel braking.

3.2 Physical Requirements

[R037-p2] The system shall be robust and durable.

[R038-p2] The system shall be as light-weight as possible.

3.3 Electrical Requirements

[R038-p2] Motor shall operate with a 12V DC power supply.

3.4 Mechanical Requirements

[R039-p1] Motor shall be non-back-driveable to preserve battery charge and prevent motor from burning out (i.e. motor will only be active for a few seconds while changing the state of the brakes, and inactive in between).

[R040-p1] Motors shall provide enough torque and power to bring the stroller to a quick and safe stop.

[R041-p1] The force of braking shall be controllable to allow for smooth braking.

3.5 Reliability and Durability

[R042-p2] The brake pads shall function under harsh environments without significant deterioration.

3.6 Safety Requirements

[R043-p2] Mechanical components must be securely fastened to the stroller.



[R044-p2] All mechanical pinch points must not be accessible to the user.

[R045-p2] Motor shall operate freely without harming the user.

[R046-p2] A manual over-ride of the mechanical system shall be provided in case of system failure or loss of power.

3.7 Performance Requirements

[R047-p2] Brakes on different wheels shall operate synchronously so as not to alter the direction of the stroller.

4 BATTERY

4.1 Physical Requirements

[R048-p3] Battery shall be kept in a weather/childproof enclosure.

[R049-p1] Battery shall not interfere with normal stroller operation.

[R050-p3] Battery and enclosure must not impede the folding of the stroller.

[R051-p3] The battery must be no heavier than 15lbs.

4.2 Electrical Requirements

[R052-p3] A single charge should last for 4 hours under Standard Usage Policy operation.

[R053-p2] Battery must provide enough current to the entire system (motor, microcontroller) without over-discharging (i.e. battery must be rated for safely discharging at worst-case current consumption)

[R054-p2] Battery shall provide enough power to ensure correct response time and functionality of the motor as its charge level drops.

[R055-p2] Battery shall be fully rechargeable over-night.

4.3 Safety Requirements

[R056-p1] Battery must not pose a shock hazard to the user.

[R057-p2] Battery shall be enclosed to protect driver and baby from over-heating and explosion.

5 SENSORS

Touch sensors will be implemented to disengage the brakes, and feedback sensors will be implemented to inform the controller about the speed and the incline of the stroller. The sensors will relay signals to the Arduino board which in turn communicates with the motor to engage or disengage the brakes accordingly. The functional requirements of the sensors are listed below.

5.1 General Requirements

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[R058-p2] Touch sensors shall function if user is or is not wearing gloves.

[R059-p2] Touch sensors shall operate with both one-handed and two-handed touch.

[R060-p2] Encoders installed on wheels shall provide stroller velocity as feedback to the microcontroller.

[R061-p2] A gyroscope shall provide shall provide stroller incline angle as feedback to the microcontroller.

5.2 Physical Requirements

[R062-p3] Touch sensors shall be ergonomic.

[R063-p1] Sensors will not interfere with normal operation of the stroller.

[R064-p3] Feedback sensors shall not be visible or easily accessible to the user.

[R065-p3] Sensors shall not be bulky or add too much additional weight to the stroller

5.3 Electrical Requirements

[R066-p2] Sensors shall drain minimal current to conserve power.

5.4 Reliability and Durability

[R067-p3] Sensor is guaranteed to work for 1 years

5.5 Safety Requirements

[R068-p1] Touch sensors shall not pose a shock hazard to the user

[R069-p2] Touch sensors shall differentiate between real and false touch (i.e. a human hand safely grabbing the handles vs. a random object touching the handles).

6 MICROCONTROLLER AND ELECTRONICS

An Arduino microcontroller will be used to control the braking system. It will monitor the stroller speed using via the encoder on the wheels and the stroller incline with the gyroscope, and will accordingly adjust the amount of pressure the braking system applies to the wheels. A "Fuel Gauge" IC will monitor the charge of the battery and will provide the necessary warnings to the user. Amplifier circuits and buffers will be used where necessary. In addition, a motor control circuit will be required.

6.1 General Requirements

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[R070-p2] Circuit shall have a power switch.

[R071-p2] Circuit shall have a reset switch.

[R072-p2] Electronics shall be placed in an enclosure.

[R073-p3] The enclosure shall be located in a discrete/aesthetically pleasing way.

6.2 Physical Requirements

[R074-p2] The electronics shall be securely fastened to the stroller.

[R075-p3] Enclosure must not impede the folding of the stroller

[R076-p2] Enclosure must have ports for signal wires

6.3 Electrical Requirements

[R077-p2] Must be powered by 12V battery

[R078-p2] Must be secured on a PCB

[R079-p2] Circuit shall include 5V voltage regulator for the Arduino microcontroller.

[R080-p2] All connections and electrical signal wires are firmly secured and soldered to the PCB

6.4 Reliability and Durability

[R081-p2] All connections and electrical signal wires are firmly secured and soldered to the PCB.

[R082-p3] Circuit shall be protected from over-heating.

6.5 Safety Requirements

[R083-p3] Electronic circuit shall have static protection.

[R084-p3] Enclosure shall be grounded for short-circuit protection.

7 SYSTEM TEST PLAN

In order to maintain the integrity of our braking system, all units comprising the overall scope of the project will be thoroughly tested both individually prior to integration into the stroller, as well as after integrating into the system. The test plan for each of the units is described in the sections below.

7.1 Mechanical System Unit Test Plan

Under the act of "Carriages and Strollers" compliance [2], the stroller's wheel should not be able to rotate more than 90 degrees once the brakes are fully engaged. This would be the primary test that will be conducted so that it complies with the requirement of the Canadian board of regulations [2].

Once this requirement is fulfilled, the braking system will be tested to work under several weather conditions to also see if it complies with the "Carriages and strollers" act. Under the condition of rain and various temperature gradients as to comply with our Standard Usage Policy.

When the weather component is satisfied, the braking system will then be tested in several incline and decline gradients which should also comply with the "carriages and Strollers" act.

Motors will be tested to ensure they work under the operating conditions specified in section 3. Thorough testing will be conducted once integrating the motors with the braking system and feedback system unit to make sure motors provide the desired power and smooth braking response.

7.2 Battery Unit Test Plan

To ensure the battery can meet both the load and the lifetime requirements of the system, durability, integrity and safety tests will be conducted on the battery unit. The stroller and all components of the system will be operated in the various operating conditions to guarantee the durability and safety of the system.

7.3 Sensor Unit Test Plan

The functionality of the sensors used for switching will be tested throughout the entire temperature spectrum mentioned in the previous requirements section. Depending on the final implementation choice, the switching system must also be tested using a variety of different activation mediums. For example, it

must work consistently whether the user is bare handed or wearing gloves. Another of our requirements is that the switching system can differentiate between a real and false sense of touch, so we will need to create a number of different test scenarios based on different forms of contact such as shakes, nudges, and vibrations.

All sensors making up the entirety of the feedback system unit will be thoroughly calibrated and tested to ensure operation meets the standards of our braking system. The feedback system unit response will be experimentally obtained to calibrate the control system implemented on the microcontroller. The extraction of system parameters and gain constants will be performed, and test runs completed to guarantee the integrity of the system.

7.4 Electronics Unit Test Plan

To ensure the microcontroller functions as expected, test routines will be developed and performed during microcontroller and peripheral initialization sequences. During the development and integration phase of each peripheral component into the microcontroller unit, standalone unit tests will be written for each component to guarantee proper functionality.

8 CONCLUSION

The team at Baby Guererro Technologies is dedicated to providing the safest solutions to real world societal issues. Using the latest state of the art technology, we intend to put an end to infant injuries due to unintentional stroller rollaway with our automated braking system.

This document presented the Functional Specifications that the Baby Guererro team has devised and will be following throughout the R&D stage of our product development process. These requirements are categorized and prioritized in to its respective subsystem. The functionalities will be implemented in accordance with its priority level. We will continue to adhere to these specifications to guide us up until the unveiling of our prototype product scheduled for mid-December.

We believe that the new level of safety achieved by our automated braking stroller will catapult Baby Guererro Technologies into the new era of baby transportation. Treading on new territory is dangerous but achievable. Functional Specifications for the Smart Stroller Braking System

9 **REFERENCES**

Baby Guerrer Technologies

- [1] D. Chang, "Caught on Cam: Baby in Stroller Falls on SEPTA Train Tracks," NBC Philadelphia, 16 May 2013.
 [Online]. Available: http://www.nbcphiladelphia.com/news/local/Toddler-in-Stroller-Falls-on-SEPTA-Train-Tracks-207611751.html. [Accessed October 2014].
- [2] the Minister of Justice, "Carriages and Strollers Regulations," 10 October 2014. [Online]. Available: http://laws-lois.justice.gc.ca/eng/regulations/SOR-85-379/FullText.html.
- [3] IEEE Computer Society, "IEEE Standards Association," 2009. [Online]. Available: http://standards.ieee.org/findstds/standard/1621-2004.html. [Accessed 7 October 2014].
- [4] CSA, Canadian Electrical Code, Part 1 22nd edition, Mississauga: CSA Standard, 2012.
- [5] Canadian Tire, "Supercycle Short Side-Pull Bike Brake Calipers," Canadian Tire, 2014. [Online]. Available: http://www.canadiantire.ca/en/pdp/supercycle-short-side-pull-bike-brake-calipers-0737427p.html#.VD3HSPldWMA. [Accessed 1 October 2014].
- [6] GS Battery, "GS Battery," GS Battery, 2013. [Online]. Available: http://www.gsbattery.com/Express-Limited-Warranty-GT12080-HG-FTTH-Battery. [Accessed 1 October 2014].