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February 6, 2010

Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
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Re: ENSC 440 Functional Specifications for Rolada , Rollator with Controlled Braking System

Dear Dr. Rawicz:

The attached document describes the functional specifications of *Rolada, Rollator with Controlled Braking System*. Our goal is to design and implement a rollator which produces automatically controlled variable braking resistance while going down a steep slope to provide the user with a stable support, and reduce stress on the knees. Issues such as difficulty opening doors and accidentally kicking the seat while walking will be mitigated by a new ergonomic frame construction which incorporates a seat that is clearly out of the path of the user's legs when folded. Safety features such as obstacle notification and nighttime LED lighting are also added.

This functional specification presents the product's top-level functional requirements from conceptual analysis to the demonstration stages of the project. This document will serve as an important reference for reviewing the specified functions during design and implementation of the device.

Xotro is composed of three Systems and two Electronics Engineering students from SFU: Henry Kam, Jeff Ip, Chuck Lee, Nathaniel Seung and Benjamin Chen. Please feel free to contact me at (778) 865-8859 or by email at xotro-440@sfu.ca, if you have any questions or concerns.

Sincerely,

Henry Kam
President and CEO
Xotro

Enclosure: *Functional Specifications for Rolada, Rollator with Controlled Braking System*

FUNCTIONAL SPECIFICATIONS FOR ROLADA, ROLLATOR WITH CONTROLLED BRAKING SYSTEM

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Executive Summary

Many elderly people rely on a wheeled walker (ie. rollator) to help them maintain balance while walking to a desired destination. Travelling down slopes or through uneven surfaces may be necessary during the trip; this is strenuous to the femoral-patellar joint since the generated forces are comparable to running [1]. Brakes can help increase safety and comfort in these situations. Many conventional rollators have a very basic manually controlled braking mechanism which presses a piece of metal into the wheel that in turn stops the rollator. Dirt or mud on the wheel can adversely affect the performance of this brake and some individuals may not have the necessary grasping strength to pull the brake wire effectively to control speed. Rolada offers an automatically controlled braking resistance to the wheels according to the slope and velocity of the rollator, providing a safer and more enjoyable trip for the user.

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Glossary

Rollator	A common name for a wheeled walker
Rolada	The product name of our rollator
ANSI	American National Standards Institute
CSA	Canadian Standards Association
Ergonomic	Designed for ease of use and to prevent repetitive strain on the user
Femoral-patellar joint	Medical term for the knee joint
Rolada user	An adult user who meets the following criteria: • height between 145 cm and 190 cm • weight between 35 kg to 100 kg • has no physical disability which impedes proper use of a rollator • has body dimensions that fall between 5th percentile female and the 95th percentile male [3].
MTBF	Mean Time Between Failures

1. Introduction

Rolada, Rollator with Controlled Braking System is an innovative wheeled walker which provides automatically controlled resistance to the wheels according to the slope or velocity of the walker. Using acceleration and velocity sensors, Rolada detects the slope angle or speed and will adjust the braking force on the wheels accordingly to provide safe and comfortable walking support for the user. Rolada also features an obstacle detection system which uses sensors to spot curbs or other barriers before the front wheels. Once an obstacle is detected, the user is warned by audible feedback through a beeper. The frame of Rolada is ergonomic because it offers more legroom than most conventional models while maintaining easier access to doorknobs by allowing the user to move closer to the front. To provide easier passage through doorways, the walker will have a door-wheel mechanism which allows the user to push through a door without damaging it. Finally Rolada provide LED lighting when ambient light is low thus increasing its night time visibility to other road users.

1.1. Scope

This document describes the functional requirements that will be met by Rolada. The requirements expressed here associate mainly to the preproduction model (proof-of-concept) and also partly to the final production device. The design of Rolada as well as future documents will directly reference the requirements stated here.

1.2. Intended Audience

The intended audience of this document is all the members of Xotro. The Chief Operating Officer will use the functional specifications to analyze the progress of design and development. Designing and testing engineers will use the document to check for conformity with the stated criteria of the model.

1.3. Classification

Throughout this document, the following convention shall be used to denote functional requirements:

[Rn-p] A functional requirement.

where **n** is the functional requirement number, and **p** is the priority of the functional requirement as denoted by one of three values:

- **I** The requirement applies to the proof-of-concept system only.
- **II** The requirement applies to both the proof-of-concept system and the final production system.
- **III** The requirement applies to the final production system only.

2. System Requirements

This section describes the general requirements of Rolada as a system.

2.1. System Overview

The rollator system is illustrated in Figure 1 and 2, showing the basic functions and feature of the product. The back wheels of the rollator will have a braking system to control the speed of the rollator and the front wheels will have a sensor to measure the speed. Hence it allows the speed controlling brakes to activate when the acceleration or speed value exceeds the limit or when slope gradient is high. Sensors on the front of the frame are used to detect any obstacles in front of the rollator. The user is notified through an audio device. To increase night visibility of the rollator, flashing LED will be added to increase awareness of surrounding pedestrians and drivers. Please note that figure 1 is meant to depict a general outline of the functions of the device. The final design may differ from the diagram shown.

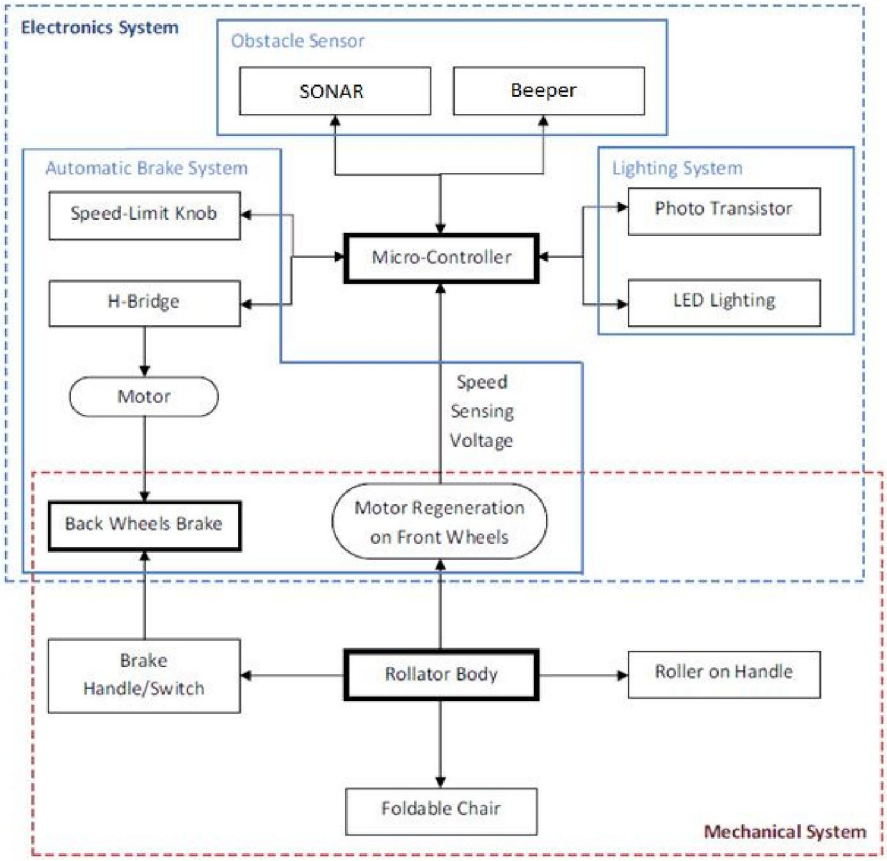

Figure 1 - Electrical and mechanical system outline

2.2. General Requirements

[R1-II] The rollator shall be able to function as a common conventional rollator.

[R2-II] The automatic braking system shall use a braking mechanism completely independent of the manual brakes.

[R3-III] The retail price of the rollator shall be under CAD $700.

[R4-II] Sensors and actuators shall be minimally intrusive to the user.

[R5-II] Lights on the rollator shall not be visually distracting or intrusive to the user.

2.3. Physical Requirements

[R6-I] The height of the rollator shall not exceed 120 cm.

[R7-I] The weight of the rollator shall not exceed 7 kg.

2.4. Electrical Requirements

[R8-III] The system shall have an accessible power jack for recharging the battery pack using an external power adapter.

[R9-II] The power adapter shall be usable with a wall supply of 110V/120V at 60 Hz AC.

[R10-II] The rollator shall enter a state of energy conservation after 15 minutes of inactivity or if the rollator is folded.

[R11-II] Electronics shall be accessible for maintenance or replacement.

[R12-III] The battery pack shall last for 24 hours between charges, based on traveling down a constant grade of 15% with the lighting system on for 15 hours.

[R13-III] The battery pack shall be easily accessible for maintenance or replacement.

2.5. Mechanical Requirements

[R14-II] The brakes shall always be capable of being manually applied using the brake handles.

[R15-II] The height of the handles shall be manually and mechanically adjustable.

[R16-III] The mechanical components of the system shall not be visually or physically obtrusive.

2.6. Environmental Requirements

[R17-II] The rollator shall operate normally in an elevation range from sea level to 2000 meters above sea level.

[R18-III] The rollator shall operate normally in a temperature range from -10 to 40°C.

[R19-II] The rollator shall operate normally in a relative humidity range from 20% to 80% (non-condensing).

[R20-II] The rollator must not be completely submersed in water.

[R21-II] The rollator shall be silent when it is inactive.

[R22-II] Motor noise generated during periods of activity shall be below 30 dB from 1 meter away.

2.7. Standards

[R23-II] The rollator shall conform to ANSI standards.

[R24-III] The rollator shall meet CAN/CSA requirement CAN/CSA-Z412-M00 [2].

2.8. Reliability Requirements

[R25-II] The rollator shall be able to withstand shock and vibration typically experienced by a standard rollator during normal usage.

[R26-II] The rollator shall not overheat during normal operation.

[R27-III] The rollator shall be resistant to physical and electronic damage caused by rain or other precipitation.

[R28-III] The rollator shall be able to remain on for at least 24 hours on a full battery charge.

[R29-III] The rollator shall be able to continuously adjust the braking force for 4 hours.

[R30-III] The MTBF of the rollator shall be no less than 20,000 hours.

[R31-III] The maintenance interval shall be at least once every 12 months.

2.9. Safety Requirements

[R32-II] The rollator shall not cause bodily harm to the user while the automatic braking is applied.

[R33-II] The rollator shall not spontaneously combust.

[R34-II] The rollator shall be able to safely support the stated weight capacity under normal usage.

[R35-II] The rollator shall not fold unexpectedly.

[R36-III] The electronic connections and mechanical components shall be enclosed.

[R37-III] The electronic components of the rollator shall not cause interference with electronic devices.

2.10. Performance Requirements

[R38-II] The rollator shall respond to manual adjustment user input within 200 ms.

[R39-II] The rollator shall indicate that it is on within 500 ms of activation.

[R40-II] The rollator shall respond to forward attitude change within 1 second.

[R41-II] The rollator shall respond to an exceeded speed limit within 1 second.

2.11. Usability Requirements

[R42-II] The rollator shall have an interface for manually adjusting the speed limit.

[R43-II] The rollator shall be light enough for the user to maneuver easily on typical cement surfaces.

[R44-II] The rollator shall allow easy access to door knobs when approaching a doorway.

[R45-II] The rollator shall be minimally obstructive to the typical user's walking gait.

[R46-II] The rollator shall allow easy steering on turns and corners.

[R47-II] The rollator shall be able to easily fold for storage and unfold for operation.

[R48-III] The firmware of the rollator shall be upgradeable by a service person.

[R49-III] The rollator shall have an interface for external connection to a PC for diagnostics.

3. Automatic Braking System

The automated braking system (ABS) is an electronically controlled feedback system that allows mechanical-braking on the rear wheels of the rollator. The purpose of the ABS is to allow dynamic braking on the rollator to complete the traditional mechanical mechanism of manually locking or unlocking the rollator's rear wheels. As shown in figure 2, the overall system of the ABS is dependent upon several input parameters which include the rollator's current speed, acceleration, incline angle (attitude) relative to a leveled ground and the user's chosen speed limit. By knowing these input parameters, the ABS can slow down and maintain a specific speed range comfortable for the user when he or she is operating the rollator on an inclined surface such as a trail along a hill.

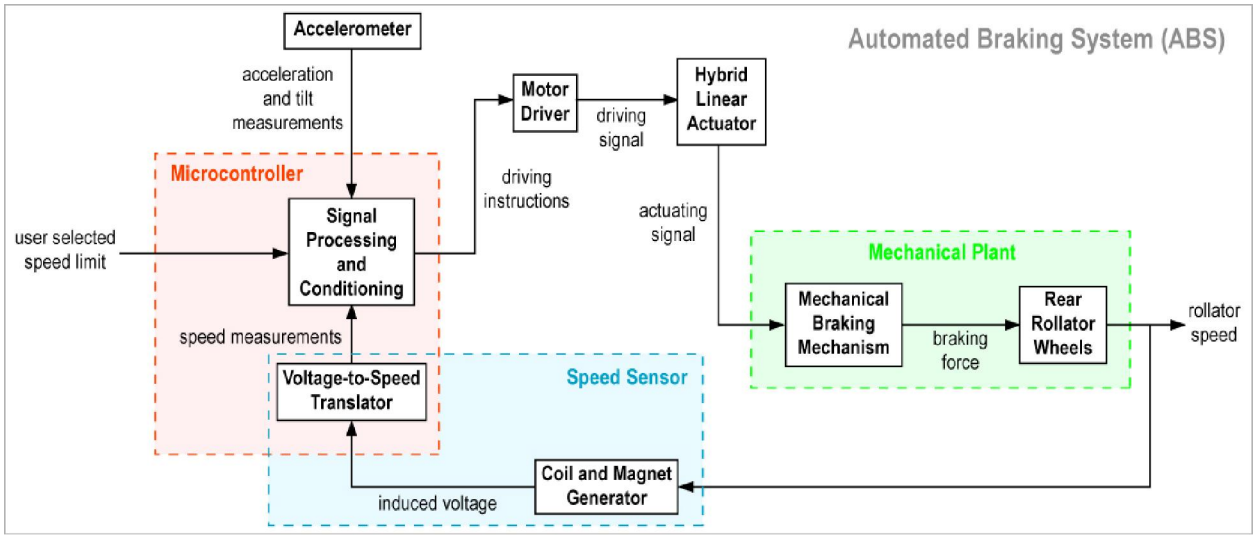

Figure 2 – ABS functional block diagram

3.1. General Requirements

[R50-II] The brakes shall automatically engage if the speed limit on the wheels is exceeded.

[R51-II] The brakes shall release upon returning to a level below the speed limit.

[R52-II] The braking resistance shall automatically adjust to an appropriate level according to the forward tilt angle of the rollator with respect to gravity.

[R53-II] The brakes shall provide no braking resistance when the rollator is level and the wheel speed is within the speed limit.

[R54-II] The brakes shall minimize power consumption when providing braking resistance.

[R55-II] The braking mechanism must provide smooth and non-twitching resistance on the wheels during normal usage.

[R56-III] The brakes shall be disengaged when the system is turned off.

[R57-III] The brakes must release upon overriding the system by means of a manual push button.

3.2. Physical Requirements

[R58-II] The speed limit shall be manually adjustable by the user through a knob on the rollator.

[R59-II] The speed limit shall be adjustable within the range of 1 km/h to 10 km/h.

[R60-II] The maximum braking force that can be exerted on each wheel is no less than 200 N.

[R61-II] The wheel speed sensors shall not interfere with normal operation of the rollator wheels.

[R62-II] The wheel speed sensors shall consume under 1 mA of current at 5V during use.

[R63-III] The braking mechanism shall be compact in size and not be physically or visually obtrusive to the user.

3.3. Performance Requirements

[R64-II] The braking mechanism shall begin to adjust to a change in forward tilt angle within 5 seconds if deemed necessary.

[R65-II] The braking mechanism shall complete the adjustment for a constant tilt angle within 10 seconds.

[R66-II] The braking mechanism shall begin to reduce the wheel speed within 2 seconds upon detecting the exceeded speed limit.

4. Obstacle Detection System

The obstacle detection system (ODS) is an early warning system designed to warn user ahead of time of uneven elevation changes along the user's travelling path such as a ditch or a sleeping cat. The purpose of the ODS is to aid the user in avoiding unexpected physical objects blocking his or her travelling route. If an obstacle is caught by the ODS, the user will be warned by an audible beep. The beeping rate will increase as the nearest tracked obstacle becomes closer to the front of the rollator. Conversely, the beeping rate will steadily decrease as the user moves away from the obstacle.

4.1. General Requirements

[R67-II] The system shall alert the user using an audible signal if an obstruction is detected within 0.75 m.

[R68-II] The system shall not emit the audible signal if the rear wheels are detected to be at rest.

[R69-II] The audible signal shall be emitted more frequently as the distance from the obstruction is decreased from 0.75 m.

[R70-II] The audible signal shall be at least 30 dB in loudness from 0.5 m of the sound source.

[R71-II] The audible signal shall be at most 45 dB in loudness from 0.5m of the sound source.

4.2. Physical Requirements

[R72-II] The sensors shall be placed so that the user will not cause interference during normal operation.

[R73-II] The beeper shall be placed close to the user to conserve transmission energy and increase efficiency.

5. Handles

The rollator handles' function is to help the elderly with holding onto and operating the rollator. It is located in the midway between the front end and the rear end of the rollator.

The following definitions are used in this section's requirements:

- The handle length is the measured size of the handle grip.
- The handle height is measured from the ground level to the top of the handle.
- The handle angle is the angle between the main handle frame and the perpendicular angle of the ground.

The brake lever's function is to allow users to control the brake and to lock the wheels from rolling. It is placed underneath the handle for an easy access to hands.

5.1. General Requirements

[R74-II] The handle shall be located behind the front wheels and in front of the rear wheels.

[R75-II] The handle shall have a standard rollator handle lever for manual wheel lock.

[R76-II] The handle shall be comfortable and easily gripped by the user.

[R77-II] The brake lever shall be placed underneath the handle.

[R78-II] The amount of the force applied on the brake lever shall be proportional to the amount of the brake force.

[R79-II] The brake lever shall lock the wheel when pushed downward.

5.2. Physical Requirements

[R80-II] The handle height shall be adjustable with a range of at least 40mm, including the range from 75-120 mm.

[R81-II] The lockable height increments shall be no longer than 25mm.

[R82-II] The handle angle shall be 5 degrees from the perpendicular angle of the ground.

[R83-II] The handle length shall be within a range of 100mm - 150mm.

[R84-II] The brake lever shall be within a distance of less than 30mm away from the handle.

6. Lighting System

The lighting system is a set of LED's placed around the rollator in order to improve the user's visibility and to increase others' awareness of the rollator in low-light environments. The system acts as a flashlight as well as a blinker. The light intensity of each LED can be enhanced by surrounding light reflective tape. The lighting system includes an automatic flashlight with a manual on/off switch. A light-sensitive switch will automatically turn on the lighting system when the ambient light in the surrounding environment is too low. However, a manual override switch allows the user to control the lighting system.

6.1. General Requirements

[R85-II] The unit shall automatically turn on the lights if the ambient light is detected to be low.

[R86-II] The unit shall include a manual switch that is able to override the automatic circuit.

[R87-II] The unit shall provide illumination of an area in the front of the rollator to the user.

[R88-II] The unit shall have blinking lights at the front and sides of the rollator.

6.2. Usability Requirements

[R89-II] The unit shall not have lights pointed directly at a user's eyes during normal operation.

[R90-II] The blinkers shall be visible from at least 125 m head-on in ideal nighttime weather conditions.

[R91-III] The unit shall have sufficient energy to power all the lights for 24 hours on a charge.

[R92-III] The electronics of the unit shall be concealed to the user and protected against outdoor conditions.

7. Door Wheel

Door wheels are a set of miniature wheels attached to the exterior of the rollator so the users can control the rollator while passing through a door and travelling along a enclosed surface. The door wheels shall be made with low-friction materials in order to minimize damage on both the contacting surface and the wheels themselves. The door wheels shall be located on the rollator so that they do not cross with the user's field of vision when travelling normally.

7.1. General Requirements

[R93-II] The door wheel shall be attached on the exterior of the rollator.

[R94-II] The distance between the rollator's frame and the door wheel shall be from 10mm - 50mm.

[R95-II] The door wheels shall be orientated in parallel with the rollator's main orientation.

[R96-II] The door wheel shall have a spring for flexibility.

7.2. Physical Requirements

[R97-II] The door wheel's thickness shall be at most 50mm.

[R98-II] The door wheel's radius shall be from 20mm - 40mm.

[R99-III] The door wheel shall be replaceable when worn out.

8. Seat

The following requirements are based upon the CSA International guideline [2] and "Office Ergonomics" lecture provided by Anne-Kristine Arnold [3]. The seat pan is designed for the user with the following ergonomic requirements:

- A "waterfall" front edge (i.e rounded, downwards-curving) to reduce pressure on the underside of the thighs.
- To maintain lumbar curve when sitting down.
- Seat depth must be long enough to provide support for the thighs and buttocks, but constrained to prevent the front edge from pressing into the backs of the user's legs.

8.1. General Requirements

[R100-II] The seat pan's depth shall be a medium standard length ranging from 420mm to 460mm.

[R101-II] The seat pan's cover material shall be waterproof.

[R102-II] The seat pan shall be able to fold up.

8.2. Physical Requirements

[R103-II] The seat pan's width shall be at least 450mm wide with an additional 25mm for clothing.

[R104-II] The seat pan's design shall have a "waterfall" front edge.

[R105-III] The seat pan shall support up to 350lbs.

9. Basket

The basket allows the users to store or place any materials and objects. It can be detachable from the rollator.

9.1. General Requirements

[R106-II] The basket shall be positioned in front of and under the seat.

[R107-II] The basket shall be detachable.

9.2. Physical Requirements

[R108-II] The basket's height shall be at most 200mm.

[R109-II] The basket's width shall be at least 400mm.

[R110-II] The basket's length shall be at least 250mm.

[R111-III] The basket shall be replaceable.

10. Battery and Electronics

10.1. General Requirements

[R112-II] The unit shall automatically turn off when idle for a long period to conserve power.

[R113-III] The unit shall automatically turn on when it detects a user.

[R114-II] The battery and electronics shall not overheat or explode under normal rollator usage.

[R115-II] The unit must not be submersed in water.

[R116-III] The battery weight shall not cause a hindrance to normal operation of the rollator.

10.2. Usability Requirements

[R117-II] The unit shall be easily rechargeable using a power adapter and conventional power outlets.

[R118-III] The recharge time shall require under 2 hours.

11. Conclusion

The functional specifications of Rolada clearly describe the requisites to be met and functions to be implemented. The proof-of-concept model will realize the requirements marked by I or II and is expected to be completed by April 5, 2010. Requirements which are indicated by III are to be implemented on the final production model in the future.

12. References

[1] A. E. Chapman. (2008). *Biomechanical Analysis of Fundamental Human Movements*. (1st edition). [Online]. Available: http://books.google.ca/books?id=YqxDzfyr3k4C&lpg=PA104&ots=3eK66H1Izn&dq=walking%20downhill%20stress&pg=PA104#v=onepage&q=walking%20downhill%20stress&f=false [Accessed February 1, 2010].

[2] Canadian Standards Association International, CAN/CSA-Z412-M00 – *Guideline on Office Ergonomics*. Toronto: Canadian Standards Association, 2000.

[3] A. Arnold. KIN 180. Class Lecture, Topic: "Office Ergonomics." AQ 5034, Faculty of Kinesiology, Simon Fraser University, Burnaby, British Columbia, Nov. 10, 2008.