REXOS

January 26, 2015

Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
V5A 1S6

Re: ENSC 440 Project Proposal for a Rehabilitation Exoskeleton Hand Device

Dear Dr. Rawicz:

The attached document, *Proposal for a Rehabilitation Exoskeleton Hand Device*, will describe our Capstone project for ENSC 440. The aim of our project is to design and build a product to provide power assistance to a person's hand through the use of an exoskeleton device. Such a device will vastly improve the quality of life for a user with limited hand mobility.

Our proposal seeks to provide an overview of our device, including rationalities and market needs for this product. Additionally, this document will outline technical details such as the system overview and proposed design solution as well as budget considerations. Lastly, the document will provide information on project scheduling and our organization.

Our team at Rexos is composed of several dedicated and experienced students of various engineering backgrounds: Anton Khomutskiy, Joshua Law, Tony Lee, Seungjun Lee, and Doug Tao. If you have any questions or concerns about our proposal, please do not hesitate to contact me at (604) 805-7561 or by e-mail at leetonyl@sfu.ca.

Sincerely,

Tony Lee
Chief Executive Officer
Rexos Ltd.

Enclosure: *Proposal for a Rehabilitation Exoskeleton Hand Device*

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## Proposal for a

# Rehabilitation Exoskeleton Hand Device


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***Submitted to:*** Dr. Andrew Rawicz – ENSC 440
Steve Whitmore – ENSC 305
School of Engineering Science
Simon Fraser University



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# Executive Summary


> ***December 23, 2012. She hangs the laundry over the rack as usual, but her left leg feels weak, shaky. Buckling under the weight, her leg gives out, she falls to the ground. The room goes blurry, her face feels numb. The sound of yelling, not angry but distressed. Flashing red and white, then black.***
>
> ***Two weeks in a coma. A month of paralysis. Three months confined to a bed. Six months of rehab.***

A grim and sobering experience don't you think? This is a situation that happens far more often than people would think. In fact, this story is the story of one of our member's mother, who had suffered a hemorrhagic stroke between both brain lobes. Two years later, she has fortunately regained speech and thinking and full functionality of her right side. However the effects of the stroke leave her left side severely disabled and unable to live independently. Inspired to help his mother, Rexos Ltd. was founded with the intention of developing a product to assist her everyday life as well as the other 37,500 a year who suffer strokes [1].

This document proposes to develop a product which fits over the hand. The potential user will use their remaining movement to control the device, which actuates motors to recover muscle sensation and augment residual capabilities. Using this device, the user will regain increased mobility, improving their quality of life.

Rexos Ltd. is founded by a group of young engineers, who seek to help people who have been affected by strokes, trauma, and nerve damage, to live healthy independent lives. We want to help people who have been affected by unfortunate circumstances, and assist them in returning their lifestyle to a level before the incident or better.

Our project will cover research, design, and prototyping of the exoskeleton hand, spanning a thirteen week period culminating in an operational product by April 15, 2015. The tentative budget is set at $1,166, with funding coming from a variety of sources.


 

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# 1. Introduction

Your hands are the most used part of your body to perform activities in your everyday life. When one loses the ability to use their hand, it severely impacts their lifestyle, downgrading their quality of life for days to come.

One of the possible effects of a stroke is weakness on one side of the victim's body, which will in turn limit their hand's functionality [2]. According to the 2014 Stroke Report from the Heart and Stroke foundation, a stroke happens every 10 minutes in Canada [3]. Additionally, data from that report shows that stroke is age related. Combined with data from Employment and Social Development Canada, the Canadian population mean age is rising [4]. Data collected in 2011 shows that the median age is 39.9 and with half the population being older than that, these findings suggest that we can be expecting more stroke victims than ever before.

Our projects aims to enrich the lives of stroke victims by helping them rehabilitate the use of their weakened hand. Although our device is targeted towards stroke victims, anyone with limited hand functionality can use our device towards rehabilitation. Statistics Canada reported that 17.3% of activity-limiting injuries in 2009-2010 were to the hand [5]. Further analysis reveals that the rate of hand injuries decreases as the sample size ages, while the rate of stroke victims increases as the sample size ages. This analysis suggests that our product would be suitable for a demographic ranging from the young to the old.

To achieve this goal, we will be developing an exoskeleton device that will be worn over the user's hand. The exoskeleton device will provide power assistance when the user moves their finger up or down. Each individual finger of our exoskeleton will be powered individually, giving the user great dexterity to train each individual finger.

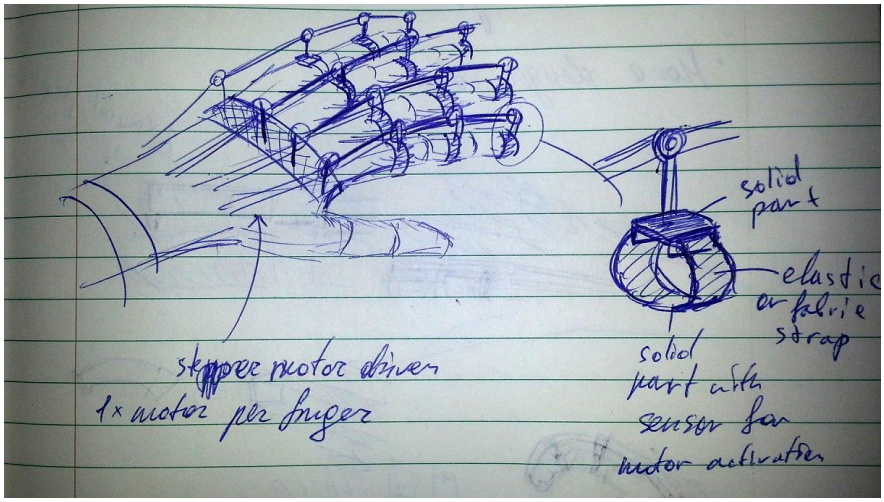


*Figure 1 - Preliminary Sketchwork of Device*

This project proposal will outline our plans for the development of this project, providing insight into our system overview and proposed design solution as well as market competition, project budgeting, and information about our company.

## 2. System Overview

Figure 2 below shows the connectivity of the components in our device. Our device will have the following core components: Arduino Uno microcontroller, linear stepper motors, microcontroller-motor motor shield interfaces, and finger sensors.

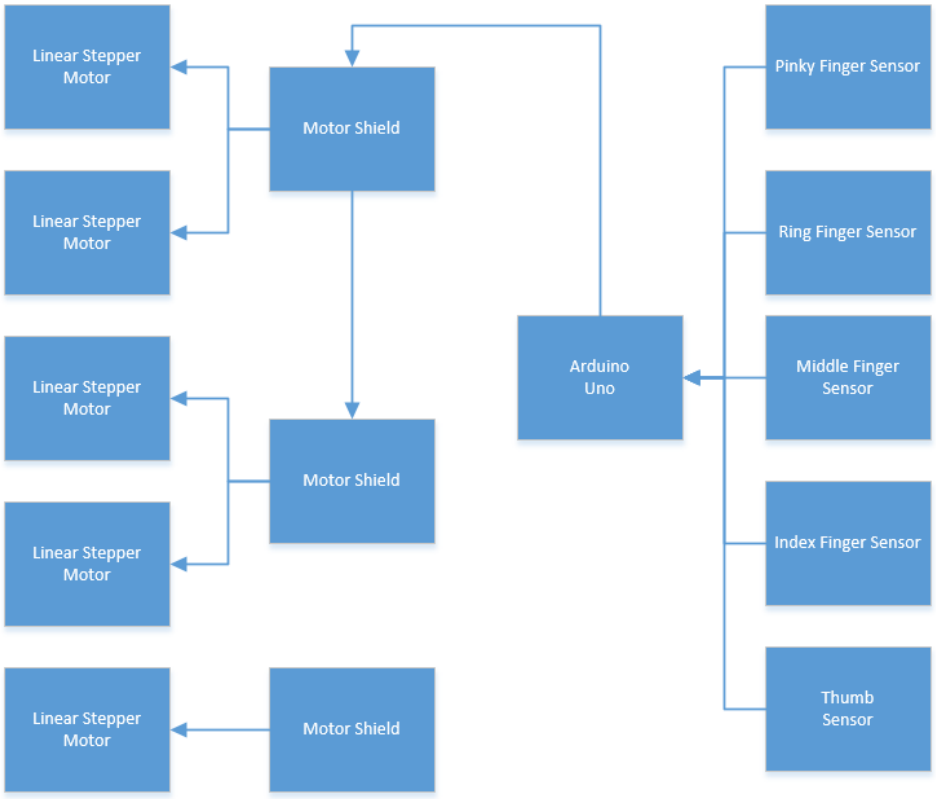


*Figure 2 - System Overview*

The flowchart in Figure 3 outlines the behavior of the system when the finger sensor is engaged.

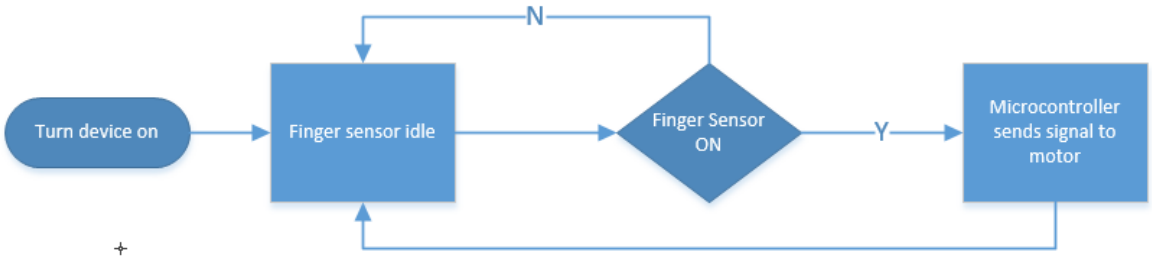


*Figure 3 - System Flowchart*

 

# 3. Market Research and Competition

## Product Market

As an emerging technology, exoskeletons are projected to grow into a $1.8 billion market by 2020 [6]. Our product would be targeted at two main demographics:

1. **Individuals**: Our target market for individuals would be those who have suffered from neurological damage resulting in loss of full hand movements, as well as people who have suffered physical injuries to their hand and now have limited flexibility. Our device will help in in rehabilitation as they strive to regain and strengthen their hands' mobility. For patients without the capability to improve, our device will offer power assistance for their daily use.
2. **Businesses/Hospitals**: Hospitals or rehabilitation centers will be interested in these devices to lease to patients who suffer temporary hand impairs. Ideally, these would be for patients who would not benefit from requisitioning the device for their sole use since their loss is only temporary, but is severe enough for them to need assistance to perform daily tasks.

## Competition

There are several products in development, among them is most notably a product called "ExoHand" by the company Festo [7]. Using pneumatic actuators to articulate movement, their device is bulky and non-portable.

A team led by Dr. Sanja Dogramadzi at the University of Bristol is also developing an exoskeleton hand, but by their own admission the technology is not available for distribution at this time [8]. Their device uses electromyography as the control mechanism [9].

# 4. Proposed Design Solution

## Design Philosophy

The following design plan for our rehabilitation device is intended to provide the potential user with as much motor functionality of the hand as possible, while being as discrete as possible. We must be considerate of our user's needs and capabilities, with flexibility to adapt from person to person. Our product is meant for people who have been affected by unfortunate situations, to help live a happy independent life. As such, our design must follow very strict design constraints and comply with all medical standards. These constraints include: lightweight frame, portability, safety, cost efficiency, and low profile design.

## Design Implementation

Frame design will be the first implementation of our overall product. The frame will be rendered and constructed using computer aided design software, and will then be 3D printed. This is necessary in allowing for flexibility in design and size fitting, as well as minimizing the overall production cost of small batches. 3D printing allows for a strong rigid frame, as well as being lightweight and having good tolerances during construction.

To enable power assisted functionality, we will be using linear stepper motors controlled by an Arduino microcontroller. Linear stepper motors allow for a lower profile design compared to rotary stepper motors, as well as having more precise movements and better torque output at low RPM when compared to DC motors. Arduino is chosen for its open source code and simpler motor control, which aids in faster and less error prone software development. Software controlling the motors will be custom designed in-house using the Arduino development kit.

### Design Testing

Before we can bring our product to market, we must test all functionalities of our product, as well as ensuring safety and reliability of potential users. We will be attempting to design and test for all standards outlined by the Canadian Standards Association.

Throughout the design process, we will be modeling and testing our design in real scenarios and environments. With the consent of a patient, who has unfortunately suffered a stroke, she has agreed to help us test and implement our product to market. With her assistance, we can be sure to thoroughly test and model all expected uses that arise from our product.

## 5. Budget and Funding

### Budget

Table 1 below outlines the tentative budget for our exoskeleton hand. We have included a 10% contingency factor for unexpected costs associated with procuring components.

*Table 1 - Tentative Project Budget*

| Equipment | Estimated Cost | |
|---|---|---|
| Arduino Board | $ | 25.00 |
| Motor Shield [x3] | $ | 60.00 |
| Motor [x5] | $ | 425.00 |
| Power Supply [x4] | $ | 120.00 |
| Fuse Box | $ | 20.00 |
| Switches | $ | 10.00 |
| Scrap + Frame Assembly | $ | 100.00 |
| 3D Printing | $ | 300.00 |
| **Total Cost** | $ | 1,060.00 |
| **Total Cost with 10% Contingency** | $ | 1,166.00 |

### Funding

We are currently in the process of procuring funds from the Engineering Science Student Endowment Fund, having applied for and presented our proposal to the committee. At the end of the term we will also be looking to the Wighton Development Fund to recuperate expenses, and any remaining costs will be covered by the members of our company.

# 6. Schedule

Figure 4 below shows the chart of expected duration for each major stage in our project as well as the dates for documentation due as milestones.

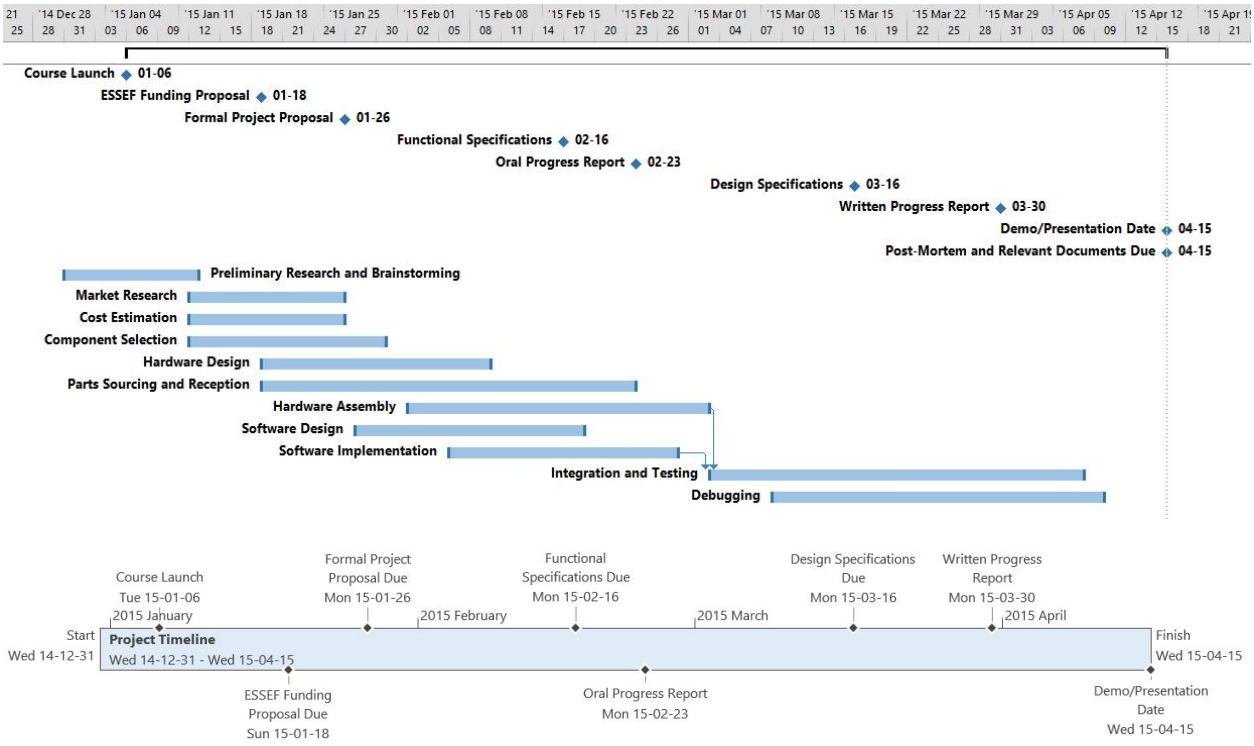


*Figure 4 - Gantt & Milestone Charts*

# 7. Enterprise Summary

## Company Profile

Rexos Ltd. is comprised of five engineering students at Simon Fraser University: Anton Khomutskiy, Joshua Law, Tony Lee, Seungjun Lee, and Doug Tao. Tony Lee, Chief Executive Officer (CEO), is responsible for the general overview of the system, as well as ensuring the team stays within the milestones set for this project. Our Chief Operations Officer (COO), Joshua Law, will be looking after documentation and software design. Doug will be our Chief Technology Officer (CTO), where he will be in charge of the mechanical designs. Anton Khomutskiy, our appointed Chief Financial Officer (CFO), will handle finance, budget balancing and acquisitions. Seungjun Lee is our Chief Risk Officer (CRO) and will be responsible for doing market research and analysis of existing products.

Our team at Rexos schedules two informal meetings and one formal documented meeting a week to discuss current project progress and to assign future tasks.

 

## Team Organization

**Tony Lee – *Chief Executive Officer***

Tony is a Systems Engineering student in his final year at Simon Fraser University. Up until the past year he was majoring in Electronics Engineering, where he had taken courses in communications, digital design, and embedded systems. Hus most current co-op experience was at Thales Canada as an Information Technology Security intern, where he independently researched and implemented security projects to strengthen Thales' cyber security. His expertise in both majors, along with his experience in independent project management makes him the ideal candidate to be the Chief Executive Officer.

**Joshua Law – *Chief Operation Officer***

Joshua is a fifth-year Systems Engineering student at Simon Fraser University, with experience in a multitude of fields. He has extensive practice with programming in C++ and assembly in different environments, as well as experience with physical modelling tools such as AutoCAD and Solidworks. His broad knowledge of different fields related to this project make him well suited to being the Chief Operations Officer of Rexos.

**Doug Tao – *Chief Technology Officer***

Doug is a fourth-year Electronics Engineering student, currently studying at Simon Fraser University. His focus of interest, specifically in design of analog circuits, digital design, and embedded systems, brings a strong set of hardware and software skills to the team. With formal industry experience gained from his co-op term at Blackberry Ltd, Doug is well versed in Test System design, Research and Development, and Mechanical Design, making him well suited for this project as our Chief Technology Officer.

**Anton Khomutskiy– *Chief Financial Officer***

Anton is a fifth-year Electronics Engineering student at Simon Fraser University. He has various interests such as high frequency electronics, communications and certain fields of physics. Interest in physics affected his choice to apply for his previous co-op term at TRIUMF – Canada's national laboratory for particle and nuclear physics. There Anton worked with in-house designed and created beam position monitors (BPM) and applied and solidified his knowledge in hardware and software design, as well as gained experience in PCB design and FPGA programming.

**SeungJun Lee – *Chief Risk Officer***

SeungJun is currently a fifth-year Electronics Engineering student at Simon Fraser University. He had worked for one year international co-op experience at Siemens Healthcare as an Application Engineer for medical imaging devices. He is knowledgeable in electronic circuit design and hardware analysis, and is also an expert in database analysis with interests in hardware design and computer aided design drawing. He is passionate about excellent teamwork for the company in the position of Chief Risk Officer.

 

## 8. Conclusion

Every passing day the median age of Canada is increasing. With a shift to an older population and the largest aging population in history, it is apparent that the risk of stroke is ever increasing. As such, the need for a solution in assisting affected people with their daily lives becomes ever more apparent.

Rexos Ltd. is committed to making a difference with technology that can help to greatly reduce the lasting effects of stroke and trauma. Our goal as a company is to provide a product that can benefit and help people in an emerging market of products that is geared towards improving the quality of life. Such a product will place an emphasis on independent living for these stroke and trauma victims.

The proposed design is not only the first of its kind, but is designed from the ground up to maximize dexterity and function, while minimizing costs in a price sensitive market. Completion of our device will not only serve in assisting people, but also as a proof of concept for devices in regards to other joints in the human body.

Our team at Rexos Ltd. is confident in our abilities to complete a prototype within the allotted time.

 

## 9. Works Cited

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