October 13, 2011

Dr. Andrew Rawicz
School of Engineering Science
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Burnaby, British Columbia
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Re: ENSC 440 Functional Specifications for a Bed Side Assistance System

Dear Dr. Rawicz,

I have attached a copy of the functional specification documentation, Function Specifications for a Bed Side Assistance System. The document enclosed outlines the ideas, methods and requirements that our project must satisfy to meet the end goal. The goal of this project is to create and design a device that will assist a patient which is having difficulties positioning their lower body (leg region) into bed due to other alignments that prevents them from doing so comfortably on their own. The device is designed to allow the patient to start in a sitting position from the bed side and have their legs lifted up and over onto the bed where they are allowed to maneuver themselves as needed for their comfort. The device will then return back to its initial resting place for the next needed use. All of this is controlled by a controller unit which the patient uses to operate the device at their own pace so the patient is never put into a situation where they feel uneasy or uncomfortable during the process.

The high level specifications and requirements are outlined in this functional specification document which covers both the development and production phases of our project. These specifications will be the reference points that we will be using during the development stages of the project to ensure we are heading towards the correct goals set out.

AMMA Tech consists of the following members: Michael Quong, Martin Wong, Andrew Yip and Amer Kalla. For any inquires about the company, project or individuals, please feel free to contact us at mqa1@sfu.ca.

Sincerely,

Michael Quong

Michael Quong
AMMA Tech – CEO

Functional Specification for a Bed Side Assistance System

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Executive Summary

The Bed Side Assistance System is a device that is created to fill a specific role in an elderly user's life. The role which it plays is to assist an elderly individual into their bed easily and comfortably from a sitting position starting at the side of the bed to a sleeping position on the bed. To accomplish the task of transporting the elderly individual's legs from the initial position to the final positioning, we will be creating for them a type of leg lifting mechanism which will provide such a service with ergonomic features in mind. The hope is to be able to grant users the capability to do simple tasks such as getting into bed easier for them from their prospective and the capability to do the task themselves with little guidance from others.

The basis of the system operates in the following manner:

- System will be an attachment that rests on the side of the user's bed.
- It will take a user from the initial sitting position and slowly lift the legs upwards and slowly shift the legs towards the bed simultaneously.
- Once the leg lift system has brought the legs over and on to the bed, it will allow the user to adjust themselves comfortably before the system returns back to its initial starting position.
- All these actions will be controlled by the user through a secured handheld controller with only the most basic controls needed.

The hope of this product is to give the user independence in the most important daily activity people go through in life; having the ability to get into and out of bed safely and comfortably on their own.

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Glossary

Average user:

- Primary targeted patients are the elderly from the age 65 years and older.
- Secondary targeted patients are those that require assistance due to illness or disabilities which inhibits their lower body region movements.
- The average weight considered for our primary targeted patients or users (the elderly) is between the 5th and 95th percentile of white male individuals in America with a median weight of 169 lb. [1]
- The average weight considered for our primary targeted patients or users (the elderly) is between the 5th and 95th percentile of white female individuals in America with a median weight of 140 lb. [2]
- The average height considered for our primary targeted patients or users (the elderly) is between the 5th and 95th percentile of white male individuals in America with a median height of 177 cm. [3]
- The average height considered for our primary targeted patients or users (the elderly) is between the 5th and 95th percentile of white female individuals in America with a median height of 164 cm. [4]
- No technical knowledge required from users to operate the system.
- Simple recognition of symbols and words required from users to operate the system.

Standard bedding:

- Compatible up to North American standard double sized mattress beds with standard double sized framing: 1.37 m x 1.91 m. [5]
- Compatible with standard bed heights between 18 inches to 25 inches. [6]
- Expectation that the user's standard bedding will consist of a complete mattress set which includes a top and bottom mattress.
- Expected that the user's standard bedding is clear and free of obstructions along both sides of the bed.

Standard Operating Environment:

- Expected to be used indoors only.
- Expected to position bedding and Bed Side Assistance System on a sturdy and stable ground.

1.0. Introduction

The Bed Side Assistance System is a device made to help those that are unable to sufficiently bring their legs up and on to the bed under their own power. The reasoning behind their inability to do such an action themselves ranges from permanent disabilities to old age to chronic illness. We want to give these types of users the ability to help themselves in certain aspects in hopes of in stowing some freedoms and liberties that we have take for granted. Our device for this project is aimed at a low costing automatic method of transporting ones legs from the ground to the patient's bed with as little strain or discomfort from the patient as possible.

1.1. Scope

This document contains all the details that describe the needed functional requirements for the Bed Side Assistance System. The requirements expressed here are mainly devoted to the development phase of our concept device but will also hold requirements that will be present in the final production version.

1.2. Intended Audience

The intended audience of this document is primarily addressed towards the AMMA Tech team to ensure that the end goals of the project are met. During development, this will serve as a written record of the necessary requirements that are needed to be met, and as a guideline for team members to analyze the progressions made.

1.3. Document Classification

The Functional requirements shown will be labeled with the following convention that distinguishes the type of classification that requirement holds.

Labeled Convention:

[F-#-C] The Functional Specification Requirement,

where **#** is the functional specification requirement number labeled in sequential order and **C** being the classification of that functional specification requirement (or priority).

The Classification of each functional specification requirement is denoted by the following values:

1. The requirement is part of the development system only (prototype)
2. The requirement is part of the development and production system (prototype + production)
3. The requirement is part of the production system only (production)

2.0. System Requirements

2.1. System Overview

The Bed Side Assistance System is a product that is there to fill a role that our team believes is something that cannot be easily filled with current market solutions. The main purpose of the system is to assist senior adults, aged 65 or older, to lift their lower body region (legs primarily) from the sitting position into the sleeping position in an ergonomically method if the senior patient is unable to do so under his or her own strength because of varying individual issues.

The product is built to mimic and capture the swinging motion, as good as possible, that most healthy adults use to lift their lower body up and into bed under their own strength. [7] This swinging motion is accomplished by placing a motor and a linear actuator in a special configuration which allows them to work in unison to mimic the desired motion described above.

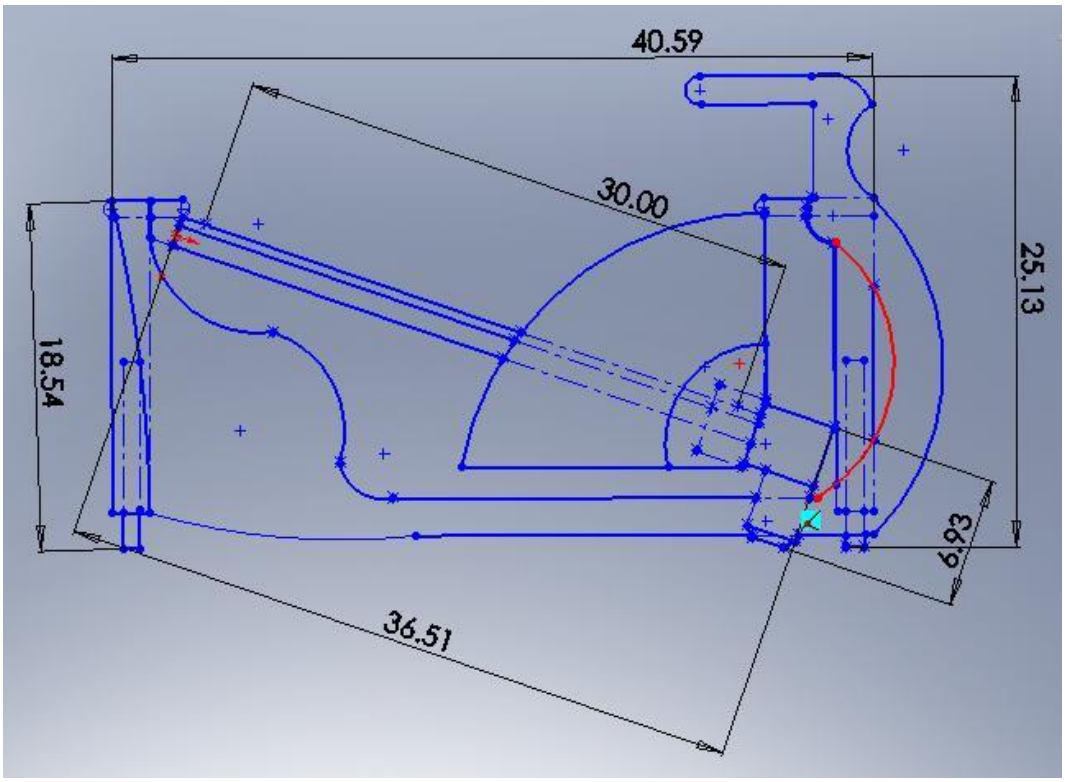

Figure 1: 2D outline sketch of the Bed Side Assistance System in the initial starting position

Figure 1 displays the simple sketch of our system design with accurate measurements of each piece required during development.

2.2. General Requirements

[F-1-3] The device shall be compact enough to be not intrusive to the user's living space.

[F-2-2] When the device is not in use, it will be folded as compactly as it can be.

[F-3-2] The system is activated based on user controls.

[F-4-2] The system is aimed to support the user's lower body (mainly the leg region) which alludes to roughly 20% of user's total weight.

[F-5-2] User functions will be user friendly.

[F-6-2] System will be compatible with the standard bed frames, sizes and setups most often seen in a typical user home.

[F-7-1] Will attempt to develop system under the $700 budget.

[F-8-3] System will be attachable on either sides of user's bed.

2.3. Physical Requirements

[F-9-2] System will be relatively portable.

[F-10-2]System will be relatively easy to setup and mounted onto user's bed.

[F-11-2]System will be relatively cushioned for user comfort.

2.4. Electrical Requirements

[F-12-3]System will be pulling power from the power outlet.

[F-13-2]Voltage required to power the actuators and moving parts of the system will exceed no more than 12 V

[F-14-3]System will be continuously powered to be accessible to use whenever it is required

2.5. Mechanical Requirements

[F-15-2]The system will not exceed a height of 19inches.

[F-16-2]The system will not exceed a height of 26 inches when safety handle bars are present.

[F-17-2]The system will not exceed a maximum adjusted height of 25 inches.

[F-18-2]The system will not exceed a maximum adjusted height of 31 inches when safety handle bars are present.

[F-19-2]The system will not exceed a length of 26 inches.

[F-20-3]The system will not exceed a width of 6 inches during its compacted form.

[F-21-3]The system will not exceed a width of20 inches when it is fully expanded.

2.6. Environmental Requirements

[F-22-3]System should not be struck or endure excessive impact beyond the regular day to day usage.

[F-23-3]System should be operable normally between the temperature ranges of -15 to +30°C.

[F-24-2]System should not be subjected to excessive liquids.

[F-25-3]Actuators/Motors used in the System should generate less than 45 dB of noise when active.

2.7. Usability Requirements

[F-26-3]Control access to activate the system will be always readily available when the user needs it.

[F-27-2]There can only be one input given to the system at a time.

[F-28-2]When using the system, the operator should always be in the correct positioning.

[F-29-2]The overall system should be easy to understand and used with little guidance needed.

[F-30-3]The system should only need to be setup and mounted once correctly unless repositioning is required.

[F-31-3]The user will be required to position themselves as needed when lower body region is brought up to bed level.

[F-32-3]The user is expected not to cause any sudden jerking motions or movements while the system is being actively used until the final position is reached.

[F-33-3] The user is expected to stay calm and remain steady while the system is in operation.

2.8. Performance Requirements

[F-34-2]The system should only respond to inputs from the controller while it has been initiated otherwise the system will maintain its current position.

[F-35-3]The system will retract back to its initial compacted position after its operations are complete.

[F-36-1]The overall system movements will be slow; will take between 10 seconds to 15 seconds to lift the legs of a user from the initial sitting position to the final sleeping position.

[F-37-3]The system will be able to adjust to fit tightly with varying bed sizes up to North American standard Double bed sizes.

2.9. Reliability and Durability Requirements

[F-38-3]The overall system design will have enough supports to hold up two times the body weight of an average white male 65 years or older.

[F-39-3]All electrical components will be enclosed and have proper ventilation to allow for any heat dissipation.

[F-40-3] Components can be swapped out and replaced as needed but should not be upgraded or serviced by the end user. Only qualified technicians should be given rights to perform such services.

[F-41-3]The system shall conform to CSA standards. [8]

[F-42-3]The system shall conform to ISO 9999:2007 – Assistive products for persons with disability – Classification and terminology requirements. [9]

2.10. Safety Requirements

[F-43-2]System will not cause any harm to the user when it is active.

[F-44-2]System will be able to support the required weight of an individual's lower body safely when in regular use.

[F-45-2]System will not jerk or move at any excessive speed that could cause bodily harm to the user.

[F-46-2]The system will halt itself in the exact position if any obstructions or excessive resistance is felt during usage.

[F-47-2]The system will have safety support rails to aid users when needed and prevent bed fallouts.

[F-48-3]The electrical and mechanical components will be enclosed to ensure of user safety.

[F-49-3]System controls will be fastened securely to the unit such that it does not obstruct the user.

[F-50-3]The system itself will be fastened securely to the operator's bed such that it does not cause unwanted movements.

3.0. Leg Lift Mechanism

3.1. General Requirements

[F-51-2]The leg lift mechanism will stop its movements when it feels that there is no longer any weight while the lifting sequence as started.

[F-52-2]The leg lift mechanism will be cradling the calves of the user's legs while the lifting sequence is occurring.

3.2. Physical Requirements

[F-53-2]Linear actuator used will not exceed a length of 36 inches.

[F-54-2]Positioning of the linear actuator movements will not exceed a length of 30 inches.

[F-55-2]linear actuators must not flex or bend at any time during operation.

[F-56-3]Moving parts and frames will be concealed with plastic covers.

[F-57-3]Corners and edges must not have any sharp points or edges.

[F-58-2]The leg lifting mechanism area must be padded softly.

3.3. Performance Requirements

[F-59-2]The leg lifting mechanism must be able to lift at least 2x 20% of a human body mass.

[F-60-2]The motors of the lifting mechanism must lift at least a torque of 18 x 20% of a human body mass x 9.81 g.

[F-61-1]The linear motion of the actuators must move no more than 2 inches/second.

4.0. Lift Controller

The Lift controller is the main utility used to control the leg lift mechanism implemented in our system. The controller contains three possible commands: up, down, home.

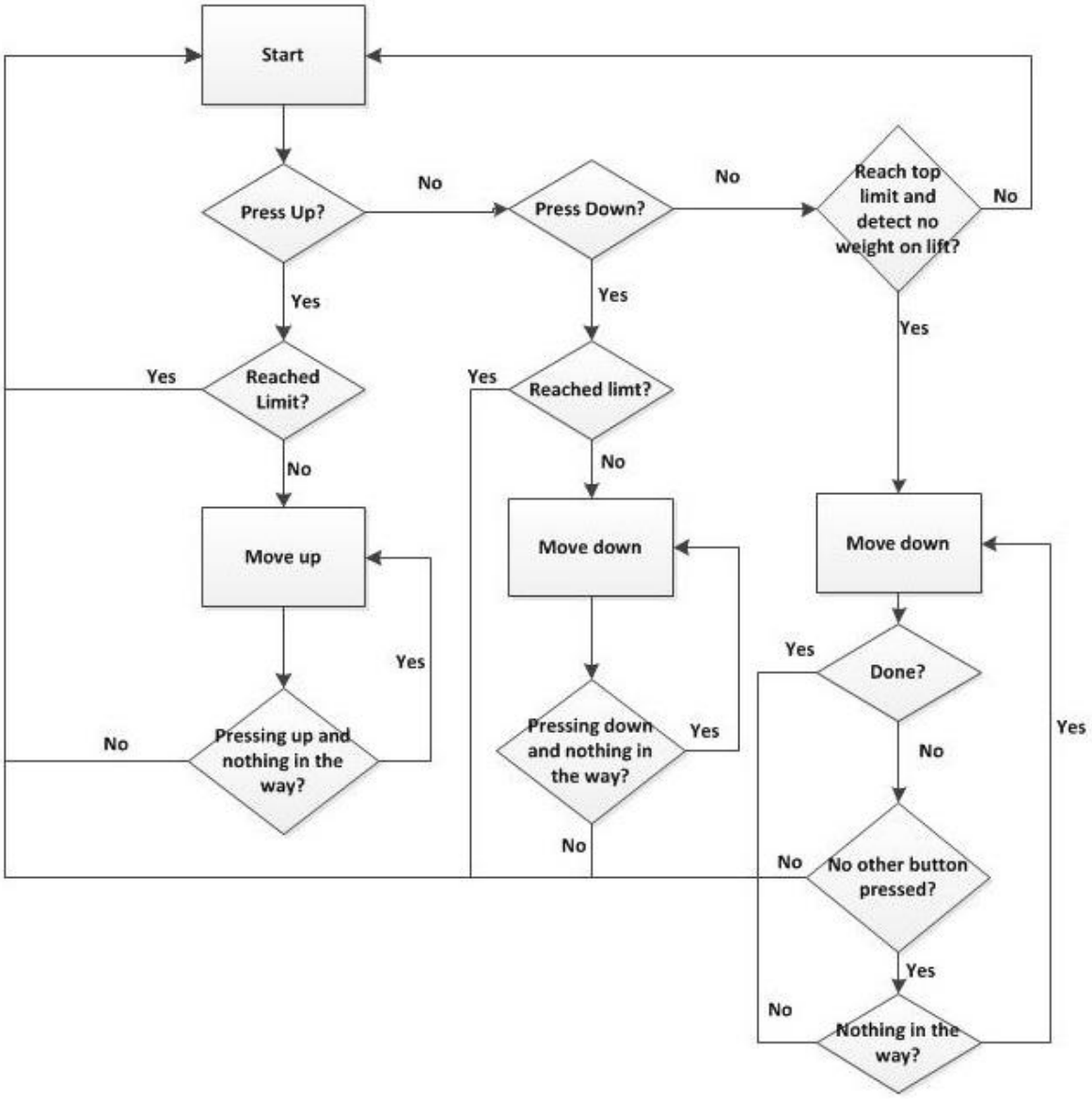

Figure 2: Flow chart of how the lift controller algorithm will operate.

4.1. General Requirements

[F-62-2]The lift controller will be user friendly and intuitive for elderly.

[F-63-2]The lift controller will be easy to use by a wide demographic, who may or may not understand much English; words and symbolism will be incorporated together.

[F-64-2]The lift controller will be easy to use by those with poor vision; characteristic colors that associate with starting (green) and stopping (red) will be incorporated on the controller interface.

[F-65-2]The lift controller will be easily accessible while the user is positioned in bed.

[F-66-2]The lift controller will have a failsafe mechanism which prevents accidental inputs.

[F-67-2]The lift controller will have large and easily accessible inputs incase the user is physically challenged. (Example: patients with Arthritis)

[F-68-2]Each of the inputs will have their own separate input signal. (Example up direction, down direction, and emergency stop will consist of their own separate button)

4.2. Physical Requirements

[F-69-2]The lift controller will be secured and attached to the Bed Side Assistance System.

[F-70-2]The lift controller will draw power from the system and not require any batteries.

[F-71-3]The lift controller will be ergonomically designed so its inputs will be easily reached and accessible to the user with a single hand.

[F-72-2]The lift controller will use graphical symbols, colors and be easy to understand.

5.0. Frame Support and Attachment

This is the method used to attach our Bed Side Assistance System to the users bedding of choice.

5.1. General Requirements

[F-73-2]The attachment mechanism must be strong enough to tie the Bed Side Assistance System securely to the user's bed without any doubt.

[F-74-2]The attachment system must be simple to assemble together for regular users.

[F-75-2]The frame of the system must be very sturdy to support at least twice the weight of our targeted user group for safety precautions.

[F-76-3]The Frame must be adjustable to be compatible up to the North American standard double sized bedding with standard double sized bed frame.

5.2. Physical Requirements

[F-77-3]Material used to strap the system to the users bedding must be made as thin as possible to not obstruct sleeping comfort.

[F-78-3]Strap used to secure the system must be flexible and able to span the width of the user's bed.

[F-79-2]Straps ends will have connector pieces that will secure the system to the user's bed tightly.

6.0. Motor

The system will consist of two motors that work in unison to give our lift mechanism the desired motion required to bring the user's legs from a sitting position to a sleeping position ergonomically.

6.1. General Requirements

[F-80-2]Motors will have set limits which it is not allowed to exceed.

[F-81-2]Motors will halt when it is signaled to by the user through controls or by sensors that detect abnormal pressure or obstructions when motors are active.

6.2. Physical Requirements

[F-82-3]Motors will be relatively small which enables our system to be compact.

[F-83-2]Motors will be able to perform the required task using a 12 V input DC voltage.

[F-84-3]Motors will be hidden away from user's sight for overall system design and safety.

6.3. Performance Requirements

[F-85-2]Motors will be able to lift up to 40% of the average weight of a user's body mass. (The weight of an average patient's legs is roughly estimated to be 20% user's total body mass. [10] The percentage is doubled for safety reasons.)

[F-86-2]The speed of the motors is relatively slow to ensure that not too much stress is placed upon the user.

[F-87-2]Motors will be able to remain fixed in a position when no inputs are applied.

7.0. Software Component

One of the main functionalities of the software components in our project is to give the user the ability to give inputs to our system through the controller mechanism described earlier. The function that it supports is monitoring the usage of the system; if it is used safely and correctly while also managing the motor controls.

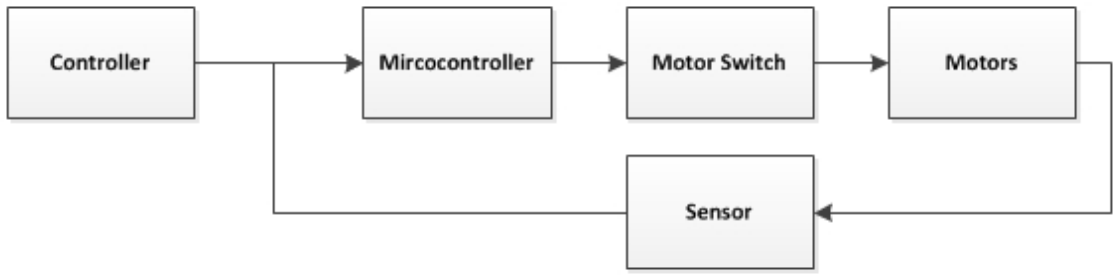

Figure 3: Block diagram of the software and hardware components needed to make up the system and how they will interact.

7.1. General Requirements

[F-88-2]Software will respond to inputs from the lift controller and move the leg lift mechanism in real time.

[F-89-2]The software will return the system back to its initial compact position when it recognizes that it is no longer in use.

[F-90-2]The software will maintain its position if it recognizes that the system is being used.

[F-91-2]The software will be able to detect if there are any obstructions while the leg lift mechanism is active; if there is obstructions, it will halt the system in place completely otherwise move as usual.

[F-92-2]The software will keep the motors from exceeding physical limits.

7.2. Performance Requirements

[F-93-2]Software will only respond to a single input that is applied to the system at a time.

[F-94-2]Software should be about to function quickly without any delays or start up time when powered on.

8.0. Conclusion

The requirements outlined in this document specify the required attributes our team feels our system needs to be a successful project. This document will serve to be our team's guideline and reference page throughout the development and construction phases of the term. The target completion date of this project is projected to be before or on December 7th, 2011 and we hope it is still an achievable deadline with all our functionality requirements listed here. If time begins to be a limiting factor during the course of our project development then we will focus primarily on the highest prioritized items first.

9.0. References

[1] Steven B. Halls, John Hanson. “Men’s Weight Chart.” Internet: http://www.halls.md/chart/men-weight-w.htm, May 26, 2008. [Date accessed: October 10, 2011]

[2] Steven B. Halls, John Hanson. “Women’s average weight chart and percentage distribution.” Internet: http://www.halls.md/chart/women-weight-w.htm, May 26, 2008. [Date accessed: October 10, 2011]

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[7] Julie Mount, Leslie Kresge, Gabrielle Klaus, Lynn Mann, Caitlin Palomba. “Movement patterns used the elderly when getting out of bed.” 2006. Department of Physical Therapy Faculty Papers. [Link: http://jdc.jefferson.edu/ptfp/2]

[8] CSA Standards. “CSA Standards – Making standards work for people and businesses.” Internet: http://www.csa.ca/cm/ca/en/standards, 2011. [Date accessed: October 12, 2011]

[9] ISO. “ISO 9999 International Standard: Assistive products for persons with disability – Classification and terminology Fourth edition 2007-03-01.” Internet: http://www.ifap.ru/ictdis/iso001.pdf, March 1, 2007. [Date accessed: October 12, 2011]

[10] Wikipedia. “Human Leg.” Internet: http://en.wikipedia.org/wiki/Human_leg, August 4, 2011. [Date accessed: October 12, 2011]