



Simon Fraser University, Burnaby, BC. V5A 1S6

February 16, 2011

Dr. Andrew Rawicz  
School of Engineering Science  
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RE: ENSC 440 Functional Specifications for the Adjustable Toilet Seat System

Dear Dr. Rawicz,

Attached is a document outlining the functional specifications proposed by ErgoForm Design for the design of the adjustable toilet seat system. Our system will allow the elderly and persons with disabilities to be lowered and raised from the toilet with ease and comfort. With safety and innovation, the adjustable toilet seat will allow disabled users access to their own toilets in the privacy of their homes.

In this document, we will specify the high level details of our system and discuss the requirement for each component of the system. This document will also be used as a guide for development of the adjustable toilet seat.

ErgoForm Design is composed of five members: Seyed Abbas Jafari, Ashkan Mirnabavi, Feifan Jiang, Faraz Khan and Nickolas Cheng. If you have any questions or comments regarding our functional specifications, you can contact us through email at [nwc@sfu.ca](mailto:nwc@sfu.ca).

Sincerely,

A handwritten signature in blue ink, appearing to read "Nickolas Cheng".

Nickolas Cheng  
**President and CEO**  
**ErgoForm Design**

Enclosure: *Functional Specification for an Adjustable Toilet Seat*



# Adjustable Toilet Seat System

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## Functional Specification

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## Executive Summary

We all share experiences with the elderly and we know as individuals of the younger generation a lot of the conveniences are catered for our age group. In our daily lives, we rarely consider the difficulties that we may have when performing trivial tasks. This is in stark contrast to the elderly where they require significant supervised intervention to allow them to carry on with life. One task that we take for granted is going to the washroom comfortably. For most seniors and physically challenged this task is plagued with risks of injuries and the lack of privacy. Up until this point, most systems that offer a slightly less risky method of utilizing the toilet have been the *Commodes*. Their adjustable toilet seat is a self contained bedpan unit that is usually located in the vicinity of the sleeping area [1].

After careful research and considerations, we at ErgoForm Design have concocted a more effective adjustable toilet seat (AST henceforth) mechanism. Unlike the *Commode*, our seat will be able to be used with an existing toilet. This enables the user to have privacy as they use the facilities. Furthermore, the AST will have two buttons that will allow the user to adjust their heights according to their comfort level.

We are currently on schedule to complete the prototype ATS for early April 4th of 2011 and it should have the following functionalities:

- The overall structure should be able to accommodate at least 80 kilograms.
- Elevate vertically while carrying a static/active load of 80 kilograms.
- Include a shut off switch in the case of emergencies of malfunctions.
- Indicate whether or not the system is on via an illuminated LED for safe troubleshooting.

Once our prototype is completed we can expand on improving the ergonomics and usability of the overall unit. We will address those needs by introducing heated seats and a built in bidet. Those extra functions will allow the entire system to be more self-sufficient while empowering the users with greater comforts. Lastly we will be working in tandem with the CSA [2] during the final production phase to ensure that our device is able to uphold strict standards for society's most vulnerable citizens.

## Table of Contents

Executive Summary.....	ii
1. Introduction .....	1
1.1 Scope.....	1
1.2 Intended Audience.....	1
1.3 Classification .....	1
2. System Requirements .....	2
2.1 System Overview .....	2
2.2 General Requirements .....	4
2.3 Physical Requirements.....	4
2.4 Mechanical Requirements .....	4
2.5 Electrical Requirements .....	4
2.6 Environmental Requirements.....	4
2.7 Reliability Requirements.....	4
2.8 Safety Requirements.....	5
2.9 Performance Requirements.....	5
2.10 Usability Requirements.....	5
3. Jack lift and Motor Requirements.....	6
3.1 General Requirements .....	6
3.2 Physical Requirement .....	6
3.3 Electrical Requirement.....	6
3.4 Safety Requirements.....	6
4. Angled Seat Requirements.....	7
4.1 General Requirements .....	7
4.2 Physical Requirements .....	7
4.3 Electrical Requirement.....	7
4.4 Safety Requirements.....	7
5. User Interface Requirements.....	8
5.1 General Requirements .....	8
5.2 Physical Requirement .....	8
5.2 Electrical Requirements .....	8
5.3 Performance Requirements.....	8
6. Grab Bars Requirements .....	8
6.1 General Requirements .....	9
7. User Documentation.....	9
7.1 General Requirements .....	9
8. System Test Plan.....	10
8.1 Lifting Mechanism.....	10
8.2 Motors and Power System.....	11
8.3 Mounted controller .....	11
8.4 Proof of concept .....	11
9. Conclusion.....	12
10. References .....	13

## List of Figures

Figure 1 - Overall System Flow Chart.....	<b>2</b>
Figure 2 - Overlay of the seat on a standard toilet.....	<b>3</b>

## Glossary

<b>AC</b>	<b>Alternating Current</b>
<b>ATS</b>	<b>Adjustable Toilet Seat</b>
<b>CSA</b>	<b>Canadian Standards Association</b>
<b>DC</b>	<b>Direct Current</b>
<b>LED</b>	<b>Light Emitting Diode</b>

## 1. Introduction

The ATS is a product that aims to assist the elderly or disable with using the toilet. The ATS is a device that will be mounted over existing installations and will help in lowering and raising a disabled person to the toilet sitting surface. With simplicity and ergonomics, ErgoForm can target a wide, untapped market.

This document will outline the functional specifications of the adjustable toilet seat proposed by ErgoForm.

### 1.1 Scope

This document describes the functional specifications of the ATS. It will be used as the design guide and at any point in the future, can serve as evidence of production. The requirements stated in this document will be adhere closely and will be reflect in the final product.

### 1.2 Intended Audience

This document is to be used by all members of ErgoForm and the board members of ENSC 440/305. The board members will use this document as a reference to gage if all the functional specifications were met for this project. All members of the development team will refer to this document for guidance. Mechanical and electrical designers shall ensure that the product is designed accordingly. Furthermore, test engineers will ensure that the product performs the actions a laid out in this document.

### 1.3 Classification

In this document, the following notation will be used to define requirements:

**[Rn-p]** A functional requirement.

Where 'n' stands for the requirement number and 'p' is the priority of the functional requirement. The priority levels are shown below:

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

## 2. System Requirements

The overall function of ErgoForm Design’s adjustable toilet seat is outlined below in the following sections.

### 2.1 System Overview

Our system is constantly powered from a wall outlet and this allows the seat to be adjusted when specific buttons are pressed. Our simple design approach includes two unique buttons that either raises or lowers the entire mechanism. The system is entirely current driven such that the longer a button is pressed the longer the action occurs until the minimum or maximum heights are obtained. A high level flowchart is shown below and illustrates the overall function of the ATS.

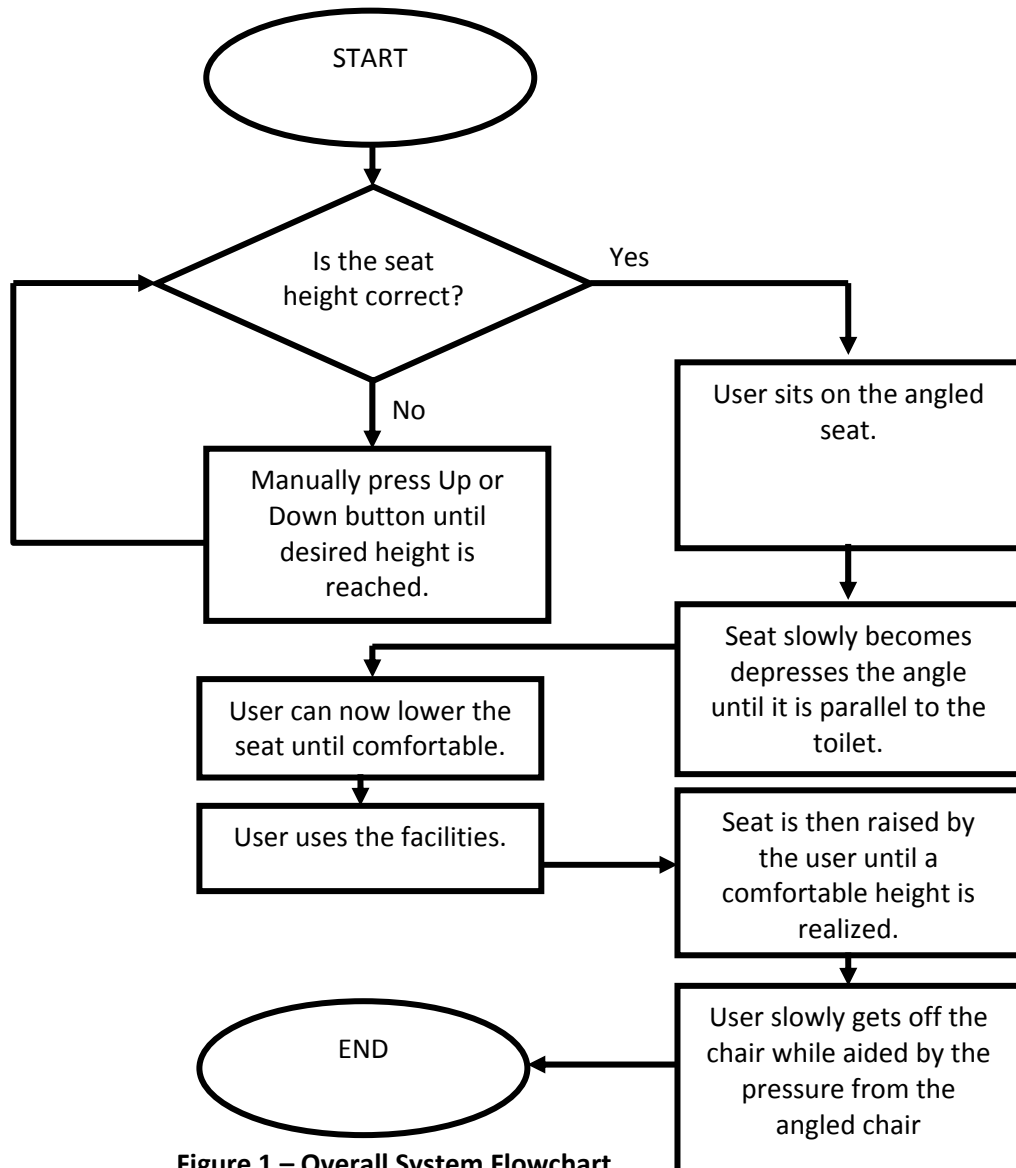
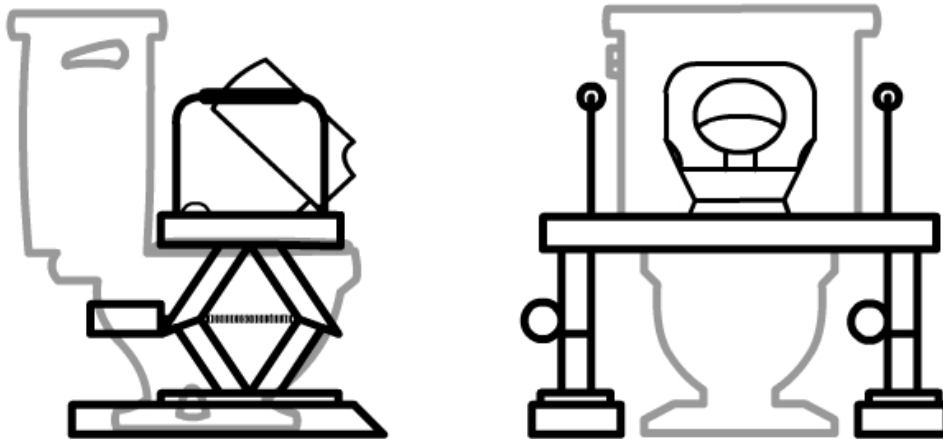


Figure 1 – Overall System Flowchart

The diagram below illustrates our device superimposed on a standard toilet.



**Figure 2 – Overlay of the seat on a standard toilet**

From the image above, the height of the mechanism is changed by the powered jack lift. This lifting mechanism is similar to the jacks found in an emergency kit in a vehicle. Handle bars are also included in our mechanism to allow the users to slowly ease themselves onto the angled seat.



## ***2.2 General Requirements***

- [R1-II] The system must be constantly powered such that users have a minimal wait time.
- [R2-III] The system should not cost more than \$1000 CAD.
- [R3-III] The device must be simple to maintain.

## ***2.3 Physical Requirements***

- [R4-II] The ATS should occupy only a space of one cubic meter.
- [R5-II] The angled seat should be placed at a sixty degree angle for optimal sitting.
- [R6-II] The ATS should weigh less than 50 kilograms.

## ***2.4 Mechanical Requirements***

- [R7-II] The user must have easy access to the up and down buttons
- [R8-III] The ATS must not impede the user during usage

## ***2.5 Electrical Requirements***

- [R9-II] The 12 volt DC motor will be powered by a battery and charged via an AC adapter.
- [R10-II] The chosen battery must be durable for long-life use

## ***2.6 Environmental Requirements***

- [R11-II] The toilet must be of a standard shape. This excludes one piece toilets.
- [R12-II] The toilet must have the existing seat cover and seat removed.
- [R13-II] The ATS must be operational in humid environments

## ***2.7 Reliability Requirements***

- [R14-II] The ATS must be able to translate vertically with a load of at least 80 kilograms.
- [R15-III] The components of the ATS must be durable and able to last at least two years of usage.
- [R16-III] Components of the ATS must be modular and easily replaceable during times of failure.
- [R17-III] The ATS should be able to endure physical trauma and minor misuse.

## ***2.8 Safety Requirements***

- [R18-III] The electronic components of the ATS must be housed in a watertight casing  
[R19-II] A power kill switch must be located in the rear of the ATS for safe shutdown during emergencies.

## ***2.9 Performance Requirements***

- [R20-III] The ATS shall bring a user to their desired height in a timely manner.  
[R21-III] The ATS shall not generate more than 70dB of noise when translating vertically.

## ***2.10 Usability Requirements***

- [R22-II] The mechanism shall be intuitive and simple to use.  
[R23-III] A user manual shall be created in English for the elderly.

### **3. Jack lift and Motor Requirements**

The jack lift will be driven by an attached DC motor. As outlined in the electrical requirements above, it will require a 12V power adapter. The performance requirements were also outlined above such that the vertical translation occurs in a timely manner.

#### ***3.1 General Requirements***

- [R24-II] The jack lift and motor pair must work in sync with each other.
- [R25-II] This mechanism must be able to elevate at least 12 inches.

#### ***3.2 Physical Requirement***

- [R26-II] The position of the jack lift and motor must be parallel to the ground.

#### ***3.3 Electrical Requirement***

- [R27-II] The mechanism shall be powered by a 12V AC Adapter

#### ***3.4 Safety Requirements***

- [R28-II] The screw shaft of the jack lift must be concealed by a chassis.
- [R29-II] All sharp edges must be beveled and rounded.
- [R30-II] The overall jack mechanism must be resistant to oxidation.

## **4. Angled Seat Requirements**

The angled seat is a purely mechanical system that utilizes a spring to force it into an angled position.

### ***4.1 General Requirements***

- [R31-II] The seat must have a normal position with an angle of 60 degrees
- [R32-II] The seat must depress to a final position that is parallel to the toilet as pressure is applied to it.
- [R33-III] The seat must be made out of hypo-allergenic materials

### ***4.2 Physical Requirements***

- [R34-II] The seat must be the same size as a standard toilet seat.
- [R35-III] The seat must be a single solid piece with no seams for easier cleaning

### ***4.3 Electrical Requirement***

- [R36-II] The seat will not require electricity to function.

### ***4.4 Safety Requirements***

- [R37-II] The spring mechanism must be able to support a static load of 40 kilograms.
- [R38-II] The seat must depress at an acceptable rate of at least 5 degrees per second when a load exceeding 40 kilograms is applied

## 5. User Interface Requirements

The user interface will be composed of two buttons on a small square console. The buttons will be responsible for the vertical movement of the jack lift. The longer the button is pressed the longer the correlated action will occur.

### 5.1 General Requirements

- [R39-II] The user interface shall have a basic design that is intuitive.
- [R40-II] The buttons must be encased in a water-tight chassis.
- [R41-II] The buttons shall depress with minimal pressure
- [R42-II] The up and down buttons must be illuminated to show the user that the ATS is on.
- [R43-II] The buttons must be 0.02 m x 0.02m with a unique appearance that matches their function.

### 5.2 Physical Requirement

- [R44-II] The button must be of the push button type.

### 5.2 Electrical Requirements

- [R45-II] The buttons shall be controlling the current flow to the motor
- [R46-II] The lighting units under the buttons are composed of LEDs and must be powered by at least .5 watts.

### 5.3 Performance Requirements

- [R47-II] Buttons must be responsive when depressed

## 6. Grab Bars Requirements

The grab bars are responsible for giving the user extra leverage when positioning themselves onto the angled seat.

## ***6.1 General Requirements***

- [R48-II]**            The bars must be corrosion resistant and able to hold up to 60 kilograms of static weight
- [R49-II]**            Soft plastic shall be used for the grips to allow users to maximize their grasp without injuring their hands

## **7. User Documentation**

As we will be trying to market this to seniors we will be ensuring that the documentation that is created is as simple as possible to understand. Large diagrams will be imperative to conveying the correct messages.

### ***7.1 General Requirements***

- [R48-II]**            Documentation will be included for the end-user
- [R49-III]**          Documentation will be available online
- [R49-III]**          Documents will be available in multiple languages of specific target markets

## 8. System Testing Plan

In the field of medical assisted devices, testing and verification is of paramount concern. If the device fails even once in a 1000 attempts, the result is a failed product. Therefore, we must be confident that our product will perform as specified above. To ensure this, subcomponents are tested in isolation first and then integrated together and tested again. Once all components are tested, the device as a whole will undergo extensive end-user trials to identify faults.

The test approach will be tree method. That is, starting with the smallest components—the leaves—and eventually moving down to the whole device—the root.

The system individual components to be tested are:

- Lifting mechanism
- Motors and power system
- Mounted controller
- Proof of concept

Since the design is heavily mechanical based, the final design must be compared to the proposed drawings specifications. Each component is measured to ensure that it complies with the range of motion and weight lifting requirements.

### 8.1 Lifting Mechanism

The lifting mechanism is the most crucial test as it will determine whether or not our prototype succeeds. Our evaluation of the lifting mechanism must be able to accommodate the design requirements of height and stability. The mechanism must extend at least 12 inches above the toilet bowl. After completing this test the lifts will be integrated with the electric motors. At this point the lift system will be tested again. The motors must be able to lift a static load of a predetermined mass in kilograms in a “comfortable” manner.

The test will be based on lifting speed, lifting weight, motor disparity, and power consumption. For the speed test, the motors are to move at a rate such that the user is not thrown about while on the seat nor do they get impatient while waiting for the lift to get into the desired position.

The weight test will be straight forward. According to Statistics Canada, an average Canadian ranges from 58.5 kg to 79kg with overweight being 94.8 kg [3]. Therefore, the lifting mechanism will be tested with a 58.5 kg weight and a 94.8 kg weight. The two weights are required as so to ensure users or all weight ranges have the same experience while using the product.

## ***8.2 Motors and Power System***

The motor disparity test is conducted to ensure if one of the two motors in the system fails, no injury will result. A failure will be simulated by removing power from one motor and observing the results. In the event of power loss, the system should remain stable. The lifts should not release and go down if the lift is in the erected position. Furthermore, the two motors must be measured to see if they spin at the same rate. This ensures that both lifts are raised and lowered at the same rate.

The power consumption test is to ensure that when the unit is operating power does not become an issue. The test should verify that no circuits are activated during operation. In addition, there is no excess heat buildup anywhere in the system.

## ***8.3 Mounted controller***

The mounted controller (console) test to be conducted once the motor and lift mechanism is verified and operational. To ensure the proper and reliable operation of the device, the remote be robust. It must resist physical shocks as well as electrical (static). It will be tested with both buttons depressed simultaneously. Completion of remote test will be complete once the testers are satisfied once the console has experienced all the corner cases.

## ***8.4 Proof of concept***

The final test is conducted when all of the components of the system are integrated into one complete unit. This implies that all the components will be assembled and that the preliminary individual testing has occurred and that they were deemed successful. Our test then will focus more on physical abuse and general misuse of the product.

Examples of such behavior include tipping the device and overloading the seat. For instance, during the tipping test force will be applied to different points on the sitting surface. The application of forces at random positions will change the center of gravity such that the jack lift may fail to operate correctly. Once we have verified that the product has a very low percentage of failure we will conclude the testing phase.



## 9. Conclusion

The functional specifications laid out in this document are fundamental to the development of the ATS and must be followed closely at all stages of development. The project is divided into three main components: lifting mechanism, sitting surface, and testing. The development of the first two components is well under way and we are on schedule to finish by March 1, as per our proposal document. Once we have a functioning prototype, we will commence testing and verification. If need be, enhancements will be made at that time.

## 10. References

- [1] "Home Care Products." Internet:  
<http://www.selfcarehome.com/Product.aspx?I=1766&C=24>, Feb. 02, 2009 [Feb. 16, 2011].
  
- [2] "The Canadian Standards Associations", Internet:  
<http://www.csa.ca/cm/ca/en/membership/becoming-a-member?tn=sustaining-members>, Sept. 23, 2010 [Feb. 16. 2011]
  
- [3] M. Tjepkema. "Measured Obesity Adult obesity in Canada: Measured height and weight." Nutrition: Findings from the Canadian Community Health Survey, vol. 1, pp.8-9, Nov. 2008.