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September 20, 2005

Dr. Andrew Rawicz  
School of Engineering Science  
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Re: ENSC 340 Project Proposal for an Auto-Conforming Ergonomic Chair

Dear Dr. Rawicz:

The attached document, *Proposal for an Auto-Conforming Ergonomic Chair*, outlines our project for ENSC 340. Our objective is to design and implement a task chair that will sense the dimensions of each user and automatically adjust to provide optimal support and comfort.

The purpose of this proposal is to provide an overview of our proposed product, and contains an outline of the design considerations, sources of information and funding, a proposed budget, as well as information on scheduling and team organization. This document also discusses our target user group and market potential.

Accomodarsi Solutions is comprised of six highly motivated, innovative, and enthusiastic students from a variety of disciplines. Jennard Dy, Stephanie Fung, Eric Lee and Eric Leung are SFU Engineering students, Daphne Leung is a SFU Kinesiology student, and Russell Booth is an Industrial Design student at the Emily Carr Institute of Art and Design. Please note, however, that only Jennard Dy, Stephanie Fung, Eric Lee and Eric Leung will use this project to fulfill the objectives of ENSC 305 and ENSC 340. If you have any questions or concerns about our proposal, please feel free to contact me by phone at 778-855-5940, or by email at [accomodarsi@gmail.com](mailto:accomodarsi@gmail.com).

Sincerely,

*Stephanie Fung*

Stephanie Fung  
Chief Executive Officer  
Accomodarsi Solutions

Enclosure: Proposal for an Auto-Conforming Ergonomic Chair

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## Proposal for an Auto-Conforming Ergonomic Chair

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**Date:** September 20, 2005

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## Executive Summary

At a busy call centre, Sally begins her shift as soon as her 6 foot tall colleague leaves his seat for football practice. Sally who is quite small and stands at 5 foot 2 inches, assumes the freshly vacated seat, spending a brief moment to lower the seat height before settling into her 8 hour shift. At the end of the day, she is perplexed at why her back is sore and her shoulders are aching.

The discomfort suffered by workers in office environments is not uncommon. In 1999 alone, nearly 1 million people took time away from work to treat and recover from work-related musculoskeletal pain or impairment of function in the low back or upper extremities. Conservative estimates of the economic burden imposed, as measured by compensation costs, lost wages and lost productivity, are between \$45 and \$54 billion US annually [1].

This document proposes development of an intelligent office chair that will adjust to the ergonomic needs of each user that sits on it. Shortly after Sally inputs her height and weight, the chair determines the correct adjustments for the backrest, seat, and armrest. Within the time it takes for Sally's computer to start up, the armrests have positioned themselves to comfortably support her forearms, while the seat and backrest have adjusted to accommodate her smaller frame.

Accomodarsi Solutions is a multi-disciplinary team comprised of four engineering students, a kinesiology student, and an industrial design student. Our members have a strong technical background in electronic circuit design, microcontroller applications, and development of software in both real-time systems and in assembly language. This set of skills, combined with our knowledge of ergonomics and industrial design, will allow us to draw on our diverse backgrounds to create a product that meets the needs of users well.

The engineering cycle for this project will span a 13-week period and encompasses research, design, construction and user testing. The scheduled date of completion is December 1, 2005 for a working prototype that has undergone user trials. Our budget of \$1800 will be primarily funded by the Engineering Science Student Endowment Fund, the John Wighton Engineering Development Fund and donations and samples from various sources.

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## Glossary

<b>Ergonomic</b>	Exhibiting good design so as to maximize productivity by reducing fatigue and discomfort [2].
<b>Work-Related Musculoskeletal Disorder (WMSD)</b>	An injury or illness to soft tissues such as muscles, nerves, tendons, ligaments, joints, cartilage, and spinal disks. Generally developing gradually over a period of time, they are primarily caused by sustained and repeated exertions or awkward postures and manipulations [3].

## 1 Introduction

In the modern workplace where an employee sits for 8 or more hours a day at his desk job, the risk for work-related musculoskeletal disorders (WMSDs) is excessively high. In British Columbia, WMSDs amount to more than half the industrial disease claims, while a study performed by Simon Fraser University revealed that over 30% of the workforce suffers from some form of WMSD [4].

Employers are responding with measures to lower the occurrence of WMSDs by providing their employees with ergonomic office equipment. Chairs with adjustable seats, backrests, headrests, and armrests and even adjustable-height desks are now commonplace in the office. It has been shown by several studies that a chair at work is the single most important tool for ensuring not only comfort and productivity but is also critical to reducing back pain and lower circulatory problems [5]. Although the American office chair industry rings up more than \$3 billion a year in sales, the purchase of adjustable office chairs does not necessarily translate directly into an increase in productivity and a reduction in compensation as employers would hope [6]. Why?

One reason is that many employees do not know how to properly adjust their chairs. Adjustable chairs commonly have a variety of different knobs and levers – one for each manually adjustable part of the chair. Users who are unfamiliar with, or even unaware of, the existence of these controls will not benefit from their use of such an ergonomic chair. As a result, adjustments are made only for the seat height, or sometimes improperly or not at all.

Our project goal is to develop a chair that will adjust itself to comfortably support anyone that sits in it. With minimal user input, our Auto-Conforming Ergonomic (ACE) Chair will sense the position of the seated user and adjust the backrest, seat, and armrests to provide the user with unparalleled ergonomic support and seating comfort. The ACE Chair will relieve the user of the inconvenience and difficulty of manually adjusting several controls. Shortly after sitting down, the user will input their height and weight and the ACE Chair will quickly adjust to the correct ergonomic position for the user, ensuring comfort throughout the workday. Benefits of the ACE Chair will be most apparent in workplaces where employees share office equipment, such as in call centers where shift work is performed. Use of the ACE Chair will ensure that the user will be able to perform his work without worrying about damage to his body, and will ensure that employers will reap the most benefit from the investment in their employees' health.

This proposal gives an overview of the product and discusses in detail both the possible and proposed design solutions. Also described are our sources of information and funding, along with a preliminary budget. The Gantt and milestone charts and information about our team are also included.

## 2 System Overview

Figure 1 shows how the ACE Chair will work. Sensors would be placed on the surface of the backrest, the seat, and the armrests. Actuators would be located beside or underneath the movable parts. When the user sits, the sensors will detect a change in pressure. Depending on the amount of pressure, the actuators will move the seat, backrest, and armrests to counteract the pressure that is sensed, positioning each component to best suit the user.

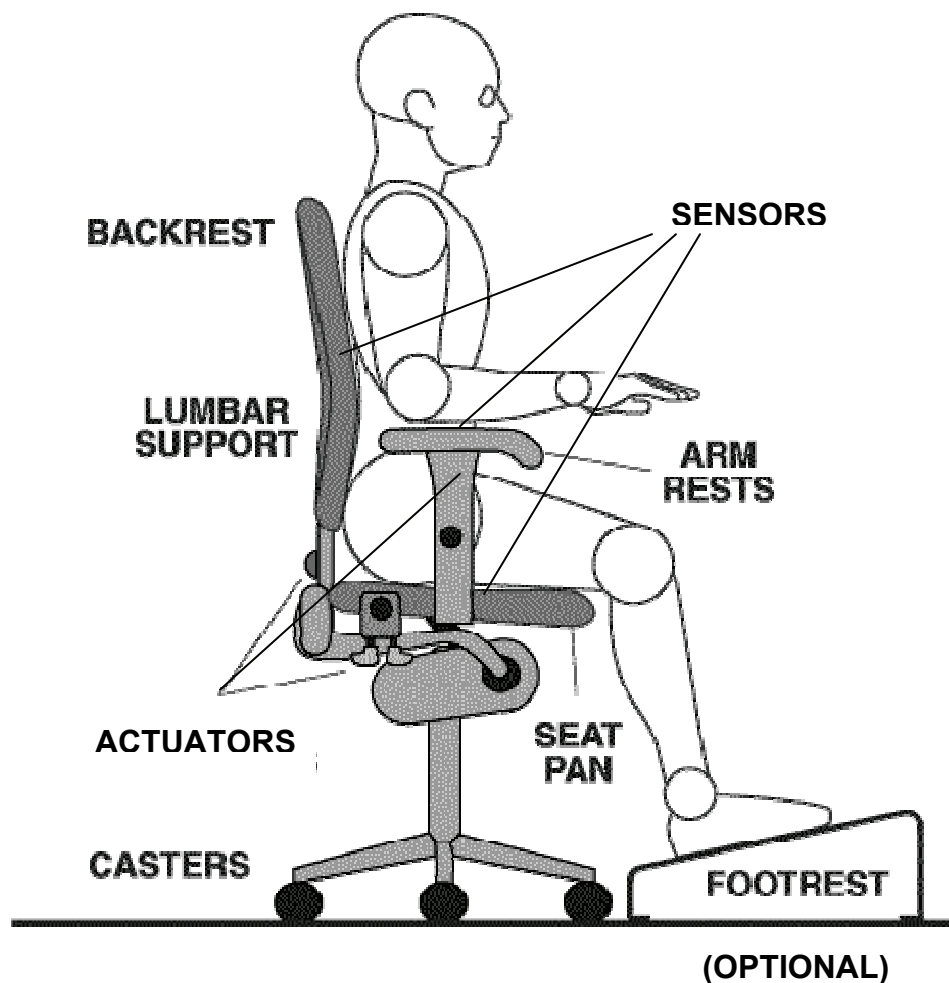


Figure 1: Conceptual Overview (Original Image Courtesy of YSU) [7]

Figure 2 shows a flowchart illustrating the automatic operation of the chair. The system also allows for manual operation of the chair so the user can make fine-tuned adjustments to his or her preference.

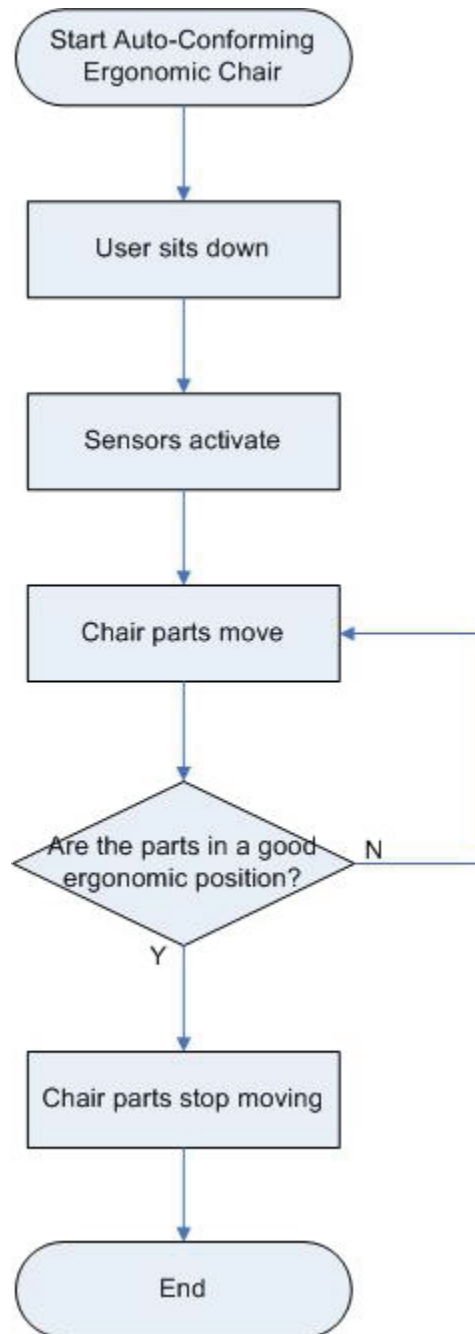


Figure 2: System Operation Flowchart



### 3 Possible Design Solutions

#### 3.1 Forward Sloping Chair

The forward sloping chair has a mechanism that allows the forward adjustment of the seat pan by  $5^{\circ}$  to  $10^{\circ}$ . This chair provides a good alignment for the spine and improves the visual distance and angle to a worktable. On the other hand, the forward sloping chair may cause clothing, especially women's clothing, to ride up legs and may cause the body to slide forward [8]. Figure 3 shows an example of a forward sloping chair.



Figure 3: Forward Sloping Chair (Image Courtesy of CCOHS) [8].

#### 3.2 Kneeling Chair

A kneeling chair has a fixed seat that slopes  $30^{\circ}$  forward and padded support for the knees. This chair also provides proper alignment for the spine and provides considerable comfort for short periods of time. The main disadvantages of the kneeling chair are causing the shins to bear the weight of the use, causing fatigue to develop earlier and making ingress and egress from the chair difficult [8]. Figure 4 shows an example of a kneeling chair.



Figure 4: Kneeling Chair (Image Courtesy of CCOHS) [8].

### 3.3 Modern Chairs

Accomodarsi Solutions is not the only company that has attempted to build a better chair. Humanscale [9] offers their Freedom chair, Steelcase Inc. [10] produces the Think chair and Herman Miller Inc. makes the Aeron [11] chair. While each chair is different, collectively they share many characteristics. Modern chairs tend to have many adjustable features including armrests, headrests, lumbar support and seat height. As well, these chairs attempt to automatically adjust, conform to and support various aspects of the body. Adjustable back support while reclining is another common feature. Modern chairs are also built using environmentally friendly materials.

In general, these chairs attempt to automatically adjust to the human form via mechanical means through counterbalances, advanced materials and mechanical linkages. These chairs do not have to carry a battery, electronics or motors. However, their main downside is the lack of complete automatic adjustment of all features. For some things like the armrests, the user still has to manually adjust the chair. The modern chairs have made these manual adjustments intuitive, but some user education and action is still necessary. The ACE Chair attempts to reduce this user education and action to virtually none as all user interaction with the chair is through a simple keypad. It remains to be seen if our electromechanical approach will be superior to the existing purely mechanical products.

## 4 Proposed Design Solution

We propose to create an ergonomic chair that autonomously adjusts to fit the user while requiring minimal user input. Our proposed system will benefit a wide range of users that sit for extended periods but have not correctly adjusted their chairs to fit properly. The ACE chair will help prevent pain and other health complications resulting from sitting and working in an improper posture for extended periods of time. Furthermore, employers will be able to benefit from increased productivity due to a decrease in the number of workplace injuries resulting from incorrect posture.

One might ask what advantages our solution has over conventional chairs. After all, a user can simply adjust their personal chair during the first sitting and not worry about adjusting the chair again. However, environmental constraints sometimes bring unintentional complications to chair adjustments. An example is in a busy office environment where shift work implies that chairs will have multiple users. Having to manually adjust a chair every time you start your shift is an annoyance that can be avoided with the use of our chair. Overlooking the adjustment of certain factors such as armrest height is another common issue.

To ensure that our solution does not directly compete with regular ergonomic chairs, we will target organizations in which chairs are used in a multi-user environment. Potential users will sit for extended periods of time in environments such as libraries, internet cafes and certain office environments where chairs are shared amongst different people as they come and go. With a focus on this user base, implementing automatic adjustment only for commonly neglected parameters can help reduce the development time to within thirteen weeks and ensure that our solution is priced competitively against other chairs.

A more detailed market research and a preliminary user study are currently underway to tailor our product to the market. With more funding and development, future improvements such as automatic adjustments for all seating parameters and temperature management of the seat surface will make our chair more appealing to a broader market.

In addition to office chairs, our technology can be extended to provide extra comfort in medical seating devices such as wheelchairs. In such applications, the ability of the chair to make periodic minor adjustments can provide chair-confined individuals with enhanced comfort and reduce the severity of ailments caused by prolonged seating in one posture.

## 5 Sources of Information

Throughout the course of this project, we will obtain information from various sources. The Internet has already proved useful in helping us to conduct market research and will continue to be an invaluable resource for locating industry contacts and component manufacturers' specification sheets, as well as other technical information.

Through our initial contact with Anne-Kristine Arnold, an ergonomics professor at Simon Fraser University and the Emily Carr Institute, we are able to welcome two team members with enthusiasm: Daphne Leung and Russell Booth. Their training in ergonomics and in industrial design will considerably aid us in performing market research and in designing a product that will meet the target user's needs.

Ms. Arnold will also be able to connect us with chair manufacturers willing to donate or lend their products, as well as with a contact that has developed a similar product to ours.

Industry standards must be met before we can bring our product to market. We will obtain the documents describing these standards from organizations such as the Canadian General Standards Board.

Finally, we recognize that our project contains a considerable focus on mechanical aspects and will look to the support of staff in the metal shop at the SFU Faculty of Science for advice concerning mechanical design.

## 6 Budget and Funding

<b>Monetary Funding</b>	
ESSEF	250
Wighton Fund	750
<b>Other Component Sources</b>	
Group Allotment From Fred	50
Vendor Samples	N/A
Chair Company Contacts From Ms. Arnold	N/A
Surplus Equipment	N/A
<b>Potential Areas Of Spending</b>	
Sensors	350
Electronics + Processors	200
Battery	100
PCB Manufacturing	200
Actuators	500
Chairs	100
Mechanical Parts	100
Miscellaneous	250
<b>Total Spending</b>	<b>\$1800</b>

Accomodarsi Solutions is embarking on an ambitious and potentially expensive project. As such, we have prepared a tentative budget identifying sources of monetary funding, sources of components and potential areas of expenditure. Since we are only in the beginning stages of development, the budget is sure to be refined in the future.

Our primary sources of funding are the Engineering Science Student Endowment Fund (ESSEF) and the John Wighton Engineering Development Fund. “The purpose of the ESSEF is to enrich the educational experience of SFU undergraduate engineers by providing funds to support innovative projects, entrepreneurial ventures, and representation at engineering conferences and competitions.” [12] Based on previous grants from the ESSEF, Accomodarsi Solutions is expecting \$250. The Wighton Fund was set up to help students develop their ideas [13]. Based on previous grants from the Wighton Fund, we are expecting \$750.

In addition to monetary funding, we are expecting to obtain support in the form of components and materials. Many electronics vendors offer samples of select products to students in need. When designing our project, if possible we will attempt to choose a component that can be obtained via samples. In addition, each ENSC 340 team is allowed \$50 worth of purchases from the ENSC Lab Stores run by Fred Heep. As mentioned in Section 5, Ms. Arnold has contacts with chair manufacturers and is willing

to assist in obtaining sample chairs for our use. Lastly, Accomodarsi Solutions is well acquainted with recycling old equipment for parts.

Although we have not begun the design stage, Figures 1 and 2 show a high level overview of the ACE chair. At this early stage, several areas of spending can be identified. The primary costs are due to sensors and actuators. Preliminary research into force and load sensing technologies has led to three types of sensors: strain gages, load cells, and force-sensing resistors (FSRs). Load cells are by far the most expensive sensors, costing hundreds to thousands of dollars for a single sensor. Their only apparent upside are the sturdy construction and capacity to sense weights of more than 10,000 pounds. However, for our application, this is most likely overkill. Strain gages are in the middle of the road for pricing, costing between \$50 and a few hundred dollars for 5 to 10 sensors of varying qualities. At the moment, force-sensing resistors hold the most promise as they can be obtained relatively cheaply – a 24-inch strip costs \$20. Our estimate for sensors is conservative to be on the safe side.

The other primary area of spending is in the actuators. We are considering DC gearhead motors, servomotors and stepper motors. Although there is a wide range of prices for these motors, from previous project experience, we are tentatively estimating \$100 per motor. If we require many motors, the actual budget could increase considerably.

From previous project experience, the other categories of spending are more accurately estimated. We do not anticipate having a large computational load with the ACE Chair and likely an 8-bit or 16-bit microcontroller will be sufficient. Electronics and Processors also includes the user interface. At this point, we are planning to use sealed lead-acid batteries. PCB Manufacturing is an optional cost based on the pricing from [www.pcbexpress.ca](http://www.pcbexpress.ca). As an alternative, we have experience manufacturing our own PCBs. We are relying on obtaining sample chairs for free or at a greatly reduced cost, thus justifying the small amount for the Chairs section. Mechanical Parts accounts for any screws, metal materials or anything else that may be necessary when constructing our chair. Lastly, miscellaneous costs include replacements for broken parts and the cost of shipping our components.

## 7 Schedule

Figure 5 shows a Gantt chart involving major tasks and various stages of the project. Milestones are represented as black diamonds marked by the date on which the various stages should be complete. A more detailed Gantt chart can be obtained upon request.

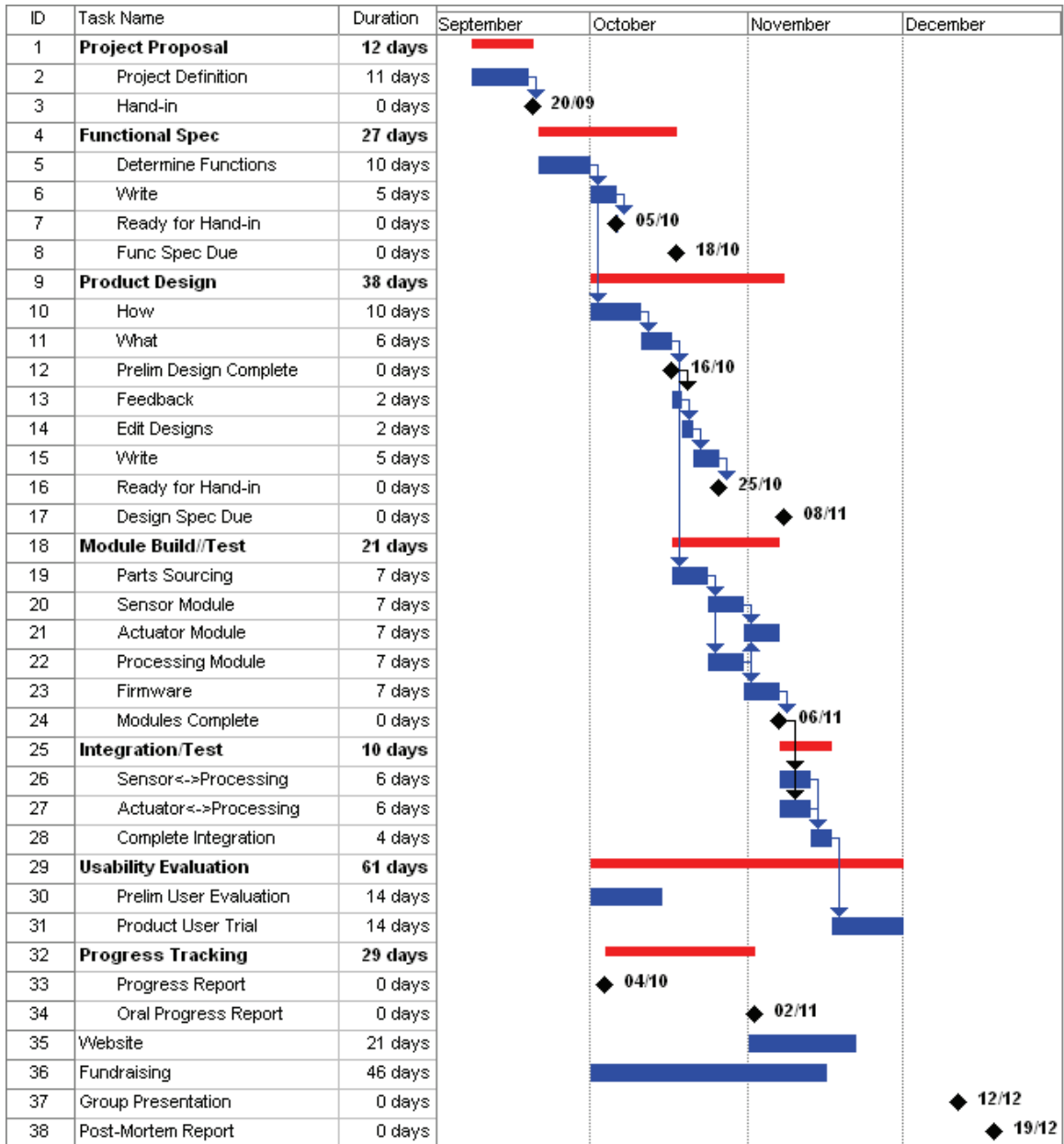


Figure 5: Gantt Chart with Milestones

## 8 Team Organization

Accomodarsi Solutions<sup>1</sup> is a multi-disciplinary team of six senior undergraduate students with expertise in engineering, industrial design and kinesiology. Together, our group incorporates different perspectives and unique experiences from previous project work and co-op work terms. Armed with this well-rounded skill set, Accomodarsi Solutions has an advantage towards designing innovative solutions.

Accomodarsi Solutions is an interactive organization encouraging individual responsibility and participation. With a considerable group size, each member will assume a formal role overseeing and analyzing a certain portion of the project. Stephanie Fung, Chief Executive Officer (CEO), will oversee the general progress of the project and ensure that the project flow is heading toward a positive direction. Eric Lee will be acting as the Chief Financial Officer (CFO) and will analyze the financial situation involving sponsorship and check if expenses are within the proposed budget. Jennard Dy, Chief Operations Officer (COO), will assess inter-group communication and day-by-day progression of the project, ensuring deadlines are met and evaluating project performance. Eric Leung will act as the Chief Technical Officer (CTO) and will examine the development of the product and follow up on the technical progress of the system.

Accomodarsi Solutions has two consultants. Russell Booth will be a Design Consultant and Daphne Leung will act as an Ergonomics Consultant. Together, they will manage the market and usability research and evaluation portion of the product. Daphne and Russell will also be contributing their expertise on ergonomics and design. A summary of skills and experiences offered by each member is provided in the next section.

Although each member is appointed a formal role within the company, the majority of the workload and decision-making required for this project is shared amongst the group. This flexible approach maximizes personal development, promotes creativity and minimizes common group dynamics crises that may occur.

Recognizing the importance of maintaining positive group dynamics and effective communication, various methods of communication are being utilized for information sharing and discussion. A weekly formal meeting time has been allocated to plan, discuss progress and evaluate and review past performances and important decisions in an “open forum” fashion. Informally, the group corresponds through the SFU Caucus where each member can post important information and messages in a private conference room reserved for team members.

Due to the diverse composition of our team, task assignments based on team members’ field of expertise will lead to an asymmetric and unbalanced division in the type of work

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<sup>1</sup> Accomodarsi is Italian for “make yourself comfortable”, and “have a seat” [14].



assigned. We will instead be forming various subgroups or committees to handle various major tasks to take advantage of different perspectives and skills offered by team members. As the workload increases during the semester, each member will be involved in multiple smaller tasks and will have more exposure to different problems, leading to a better understanding of how different parts fit together.

Accomodarsi Solutions aims to combine synergy and hard work to deliver a quality product. With our unique team offering open minds and a great combination of skills, we believe that we can deliver exciting solutions to interesting problems. Look forward to our products coming to a chair near you.

## 9 Company Profile

### **Stephanie Fung – Chief Executive Officer (CEO)**

Stephanie is a Computer Engineering student in her final year of studies at Simon Fraser University. She has had previous co-op terms at HSBC Canada Group Development and at NTT Network Innovation Laboratories in Japan. Stephanie's interests and strengths lie in software and digital systems design. Long hours sitting in uncomfortable chairs have given her the determination to see this project from inception to completion. Her strong communication skills and ability to work in a team will prove to be invaluable to the success of this project.

### **Eric Lee – Chief Financial Officer (CFO)**

Eric is a fourth year Computer Engineering student at Simon Fraser University. He has previous project experience working on an autonomous ground robot where he gained skills in microcontroller programming and digital device interfacing. From his education, Eric brings to the group knowledge in computer graphics, artificial intelligence and microelectronic circuit analysis. Eric's problem solving attitude and strong work ethic, coupled with the ability to work long nights, will be helpful to the team.

### **Eric Leung – Chief Technology Officer (CTO)**

Eric is a fourth year Engineering Physics student at Simon Fraser University with project experience in various fields. He has experience with PCB layout and etching in addition to working with PLCs and HC12 and AVR microcontrollers. His wide range of interest stems from past course work which includes image processing, boundary value problems and numerical analysis. As well, Eric will be bringing in his problem solving and communication skills gained from different projects.

### **Jennard Dy – Chief Operations Officer (COO)**

Jennard is a fifth year Computer Engineering student at Simon Fraser University with previous co-op experiences in Correctional Service Canada and HSBC e-Commerce Centre of Excellence. He has coding experience in both C++ and Java, working individually and in a team. Past projects that he was involved with include a system prototype using HTML and JavaScript, a digital scrapbook system implemented using Java and vegetable sorting by using image processing techniques. He also has circuit design and implementation experience gained from doing numerous labs in various electric circuits and microelectronics courses. In addition to these skills, he is also organized and can communicate and work well with others.

**Daphne Leung – Ergonomics Consultant**

Daphne is a senior Kinesiology student at Simon Fraser University, concentrating in Ergonomics and Human Factors. Her experience in office ergonomics is obtained from her previous co-op placements. She is keen in applying her knowledge to the design team and hopes to gain practical experience in conducting user trials and other usability tests.

**Russell Booth – Design Consultant**

Russell is a third year industrial design student at Emily Carr Institute, studying ergonomics, electronic design and material/production technologies. He has extensive experience in manufacturing from both the marine and textile industries. Russell will be part of the ergonomic assessment team and hopes to further his understanding of user-based design through in-depth usability trials.

## 10 Conclusion

Accomodarsi Solutions is committed to producing a chair that is comfortable and good for the body, while usable for any activity the user engages in. Our self-adjusting chair is ideal for use in environments where multiple users share one chair. Everyone can rest assured that their body will feel great throughout the day without worrying about the seat settings.

The proposed solution would help ensure that employees do not suffer from unnecessary back discomfort and, in turn, work more efficiently. Employers would then benefit from the increased productivity of their workers. Unlike existing chairs that have to be adjusted manually every time a new user sits down, the ACE Chair adjusts parts that are often overlooked by users. With respect to adapting to a wide range of user sizes, our chair would be superior to other chairs.

The schedule and funding sections show our commitment to complete the project on time within the budget presented. With our sources of information and the diverse talents of a good mix of team members, we have the all the resources we need. With these resources and a well-defined strategy, we are confident in seeing the project through from conception to completion.

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