



Simon Fraser University,  
8888 University Dr.  
Burnaby, BC Canada  
Email: telemedix-440@sfu.ca

April 27, 2011

Dr. Andrew Rawicz  
School of Engineering Science  
8888 University Drive  
Simon Fraser University  
Burnaby, British Columbia  
V5A 1S6

**Re: ENSC 440 Post Mortem for a remotely controlled home care robot**

Dear Dr. Rawicz

Enclosed is our *Post Mortem for a Controlled Home Assistive Device*, which describes a remotely controlled home care robot. Telemedix's goal is to design a robot that will be controlled over Wi-Fi, to aid the elderly and/or people with disabilities, and those who live in remote locations.

This post mortem summarizes our project, lists some of the problems we encountered, and describes some of the things we have learned over the semester.

Telemedix is comprised of six senior engineering students from the systems, electrical and computing concentrations, with a broad range of skills and specialties. If you have any questions or concerns regarding our functional specification or product, please contact us by email at telemedix-440@sfu.ca.

Sincerely,

A handwritten signature in blue ink that reads "Robin Mahony". The signature is written over a horizontal line and is enclosed in a thin black rectangular border.

**Robin Mahony**  
CEO  
Telemedix

***Enclosure: Post Mortem for a Controlled Home Assistive Device***



Post Mortem  
for a Controlled Home Assistive Device

<b>Robin Mahony</b>	<b>Adrian Mocanu</b>	<b>Graham Holland</b>	<b>Vojta Prochazka</b>	<b>Rohit Thomas</b>	<b>Ravi Panchal</b>
CEO	CFO	CTO	Secretary	Managing Director	Director of R&D

**Contact Person:**

Robin Mahony  
telemedix-440@sfu.ca

**Submitted To :**

Dr. Andrew Rawicz-ENSC 440  
Mike Sjoerdsma -ENSC 305  
School of Engineering Science  
Simon Fraser University

**Issued Date:**

April 27, 2011

# Table of Contents

Table of Contents .....	i
List of Figures .....	iii
Glossary.....	iv
1 Introduction .....	1
2 System Design .....	2
1.1. System Overview .....	2
1.2. Structural .....	2
1.3. iPhone Control Software .....	3
1.4. CHAD Software System .....	4
1.5. Electrical and Mechanical .....	6
3 Business Aspects .....	9
3.1. Budget and Funding .....	9
3.2. Market Analysis .....	10
3.3. Project Timeline.....	11
4 Team Breakdown .....	13
5 Lessons Learned .....	14
6 Individual Contributions .....	15
5.1. Robin Mahony .....	15
5.2. Graham Holland .....	16
5.3. Adrian Mocanu .....	16
5.4. Vojta Prochazka .....	17



5.5. Rohit Thomas..... 17

5.6. Ravi Panchal..... 17

7 Conclusion ..... 19

8 References..... 20



# List of Figures

System Diagram .....	2
Actual CHAD Structure .....	3
iPhone GUI .....	4
BeagleBoard-xM Single Board Computer .....	5
Electro-Mechanical Subsystem Overview.....	6
8 Bit Word Map .....	7
Lynxmotion Micro Pan-Tilt Kit .....	8
Arduino Mega Backpack .....	8
Estimated Project Budget. ....	9
Final Project Budget.....	10
Predicted vs. Actual Timeline.....	12



## Glossary

<b>CHAD</b>	Controlled Home Assistive Device
<b>GUI</b>	Graphical User Interface
<b>iOS</b>	iPhone Operating System
<b>USB</b>	Universal Serial Bus
<b>Wi-Fi</b>	Wireless Fidelity, used in reference to WLAN (IEEE 802.11) technology. In simple terms, it is wireless Ethernet or internet.
<b>Client</b>	The person operating the controlling software
<b>Patient</b>	The person directly interacting with the robotic device



# 1 Introduction

Over the past twenty years, advances in medical technology and elderly home care services have substantially culled a large portion of the elderly population from requiring care in nursing homes, but there are still many people that require daily interaction with a nurse or physician to monitor and track vital stats. This situation forces them to be placed into a home which provides daily care or to hire a home care nurse, even though the person could potentially administer these simple tests themselves with minimal supervision.

Our objective was to provide these individuals with a product that would allow visual and audible communication with a nurse, physician, or home care specialist at a remote location. While the patient administered some simple tests to check vital states - such as blood pressure or blood sugar levels - the nurse would be able to simply monitor the patient to ensure tests results are in a healthy range. This would allow them to maintain their independence, while at the same time ensuring their well being.

The main aspect that distinguishes our product from similar products already on the market is cost and target customers. Similar products, mainly the RP-7 [1], are priced in the range of \$250,000 which is just simply not affordable for our target market. These devices however are designed for a hospital environment and their technical sophistication would not be fully used for someone in the situation we have described above. Our estimated unit price would be in the several thousand range, which we believe is easily affordable considering the service we would provide. Comparably, nursing home costs hover around \$206 per day [2] where as this one time investment would result in only paying a fraction of the total costs that would result from living in a nursing home. Our product will be able to have ample capabilities for our target consumer, the general public, while still remaining affordable.





## 2 System Design

### 1.1. System Overview

A system diagram of Telemedix's home assistive device (CHAD) is shown in Figure 1.1.1 below.

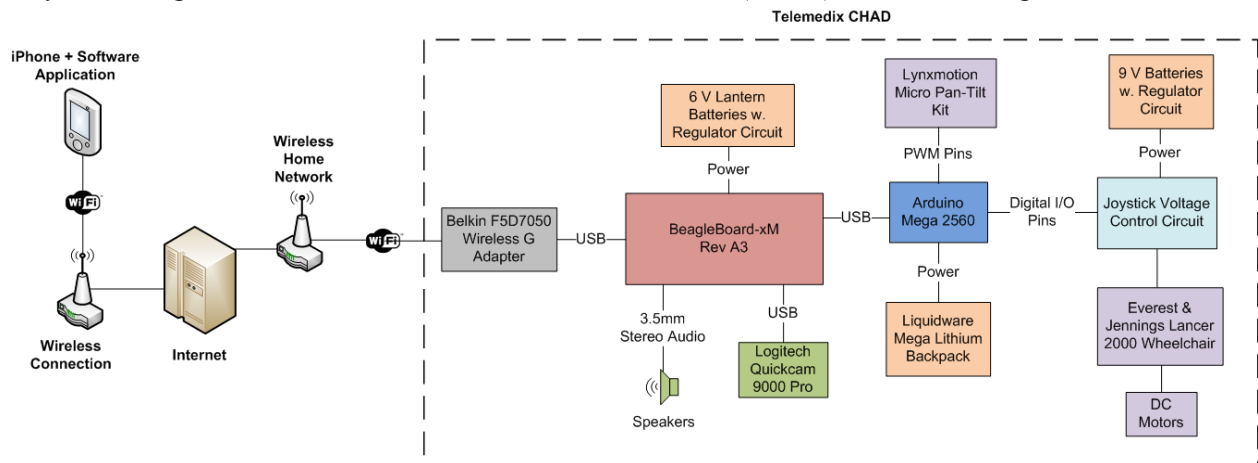


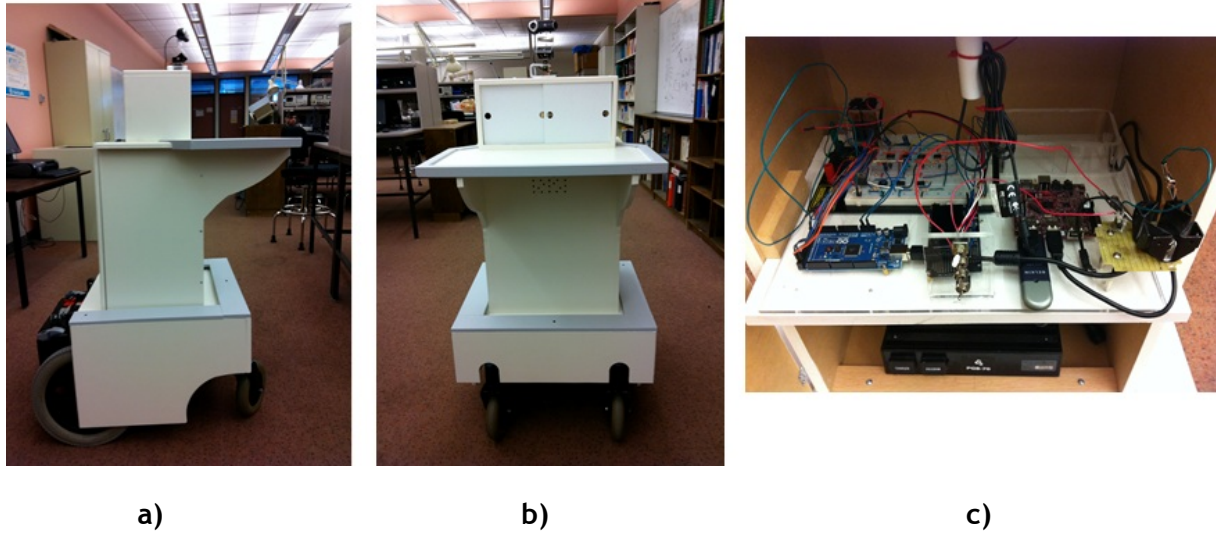
Figure 1.1.1: System Diagram

The above block diagram shows the interconnections between the various subsystems of CHAD and the controlling software application running on the iPhone. Also shown are the various sources of power for the different circuit boards and motors. The BeagleBoard is used for the high level audio and video processing and communication over Wi-Fi to the iPhone application while the Arduino is used for lower level motor control functions.

### 1.2. Structural

CHAD's was successfully built within our project timeline and adhered to the original prototyped we outlined earlier in the project's development. Figure 1.2.1 provides pictures of the completed device. Overall there were minimal setbacks during the construction phase of this project. The side skirt, which covers any protruding components of the wheelchair, caused maneuverability issues as it contacted the wheels but was adjusted before the final presentation. We also had problems with the table obstructing the camera's field of view. This was not fixed, as we were unable to modify the design in the last week of integration.





**Figure 1.2.1: Actual CHAD Structure**

There is much opportunity for improvement on CHAD's physical structure, although most concerns are addressed to its size. The use of an old electric wheelchair greatly influenced the final prototype as CHAD's structure had to be built around this. In a finalized production model we would need to develop a much more streamlined design and use lighter weight materials such as plastic composites for the body. Currently, CHAD is built with MDF and its body is also designed to be the supporting frame. This leads to a relatively heavy device. In a production model it would not be cost effective to use a stripped down wheelchair for its components. Instead we would implement custom drive motors and batteries which would be more efficient for our purpose. There were concerns during the presentation regarding the sharp edges of the prototype; this would again be addressed in the selection of build material for a potential production model.

### **1.3. iPhone Control Software**

The iPhone software was implemented as a way to control the camera and wheelchair motors. The final version of the controlling software had several key features. First, it can establish a socket connection with the BeagleBoard. Using this connection, it can send two types of data: control strings and audio. The control strings are used to direct the movement of the camera and the wheelchair. This control allows for simultaneous movement of the camera and wheelchair. Also, audio can be recorded and sent from the iPhone to the BeagleBoard. This only ended up being a one-way communication channel, and was not live. Instead the audio would be recorded first on the iPhone, and then upon completion of the recording it would be sent to the BeagleBoard, which would play it automatically. Also, a live video stream (the webcam mounted to CHAD) is streamed to the iPhone, and displayed in the controlling application. This would allow for the user to control CHAD from any location, simply using the webcam feed. This video feed can be occasionally disrupted, due to some problems in the implementation. Some other features included a check for Internet



connection, socket connection with the BeagleBoard and haptic feedback on the controls. Figure 1.3.1 shows a screenshot of the user interface. It features two D-Pads (for moving the camera and robot), a record button for recording and sending audio, and a refresh button to refresh the video feed in case of disruptions.



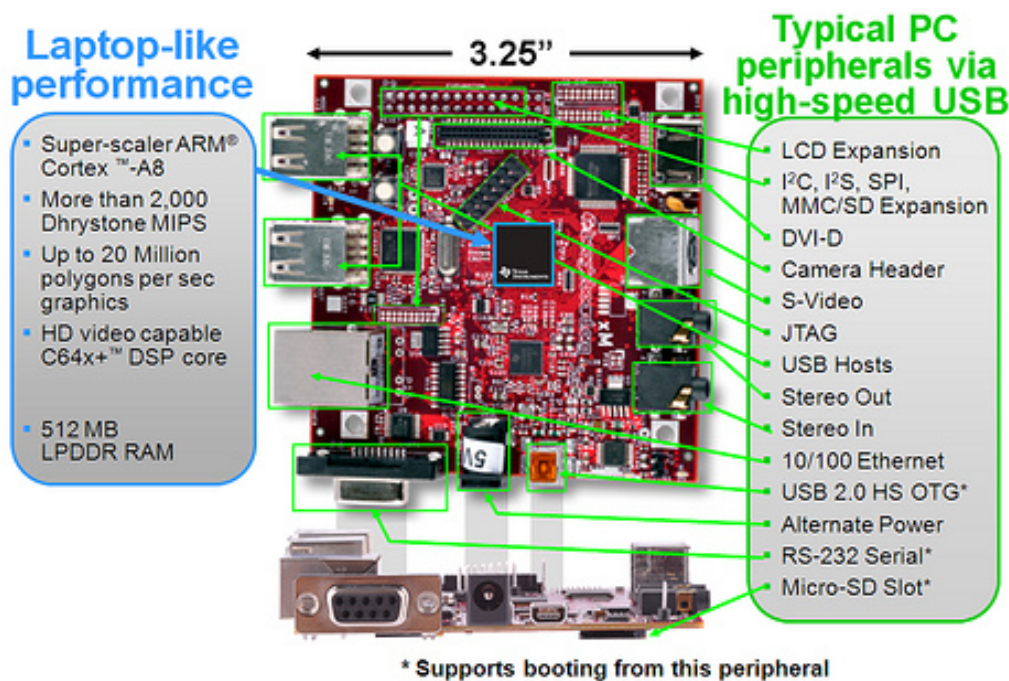
Figure 1.3.1: iPhone GUI

The major problems we encountered with the iPhone software were related to the live streaming audio and video. We did manage to implement live streaming video, with minimal (less than 1 sec) delay, however it may occasionally freeze and need refreshing. The video was limited by the iPhone, as it currently only supports one real live streaming audio/video protocol, namely HTTP Live. In the future, more protocols will likely be supported which would allow for us to better implement both the video and audio. In terms of the audio, we only managed to implement one-way, intercom style audio. This was due to the fact that we did not fully realize how complex live streaming protocols were. In order to have two-way live streaming audio communication, we likely would have had to implement our own protocol. Our team had minimal experience in this area, and due to this lack of knowledge and time, we could not fully implement this feature.

## 1.4. CHAD Software System

The majority of the software running on the CHAD robot runs on the BeagleBoard-xM single board computer shown in Figure 1.4.1.





**Figure 1.4.1: BeagleBoard-xM Single Board Computer [3]**

This board features a 1 GHz ARM processor as well as a 4 port USB hub which was necessary to add peripheral devices including a webcam and wireless adapter. We used a Logitech Quickcam Pro 9000 webcam and Belkin USB Wi-Fi Dongle as mentioned in the design document to implement video streaming and wireless device control.

The CHAD software was implemented to meet the majority of our functional requirements. The software is fully automated meaning it requires no user input after powering up the device. Once the Linux operating system boots, the Wi-Fi adapter automatically connects to a local Wi-Fi hotspot that has been preconfigured. We made use of a free dynamic DNS service, DynDNS, to map the current IP of the BeagleBoard to the domain name telemedix.dyndns.org. This way the iPhone software is reliably able to connect to CHAD. As such, the software automatically updates the IP address using a free software client named inadyn, then waits for connections from the iPhone application. Once a connection is received, Webcam capture also starts automatically and the live feed is streamed to the iPhone using mjpg-streamer (an open source streaming package). Additionally, the software monitors the status of the shutdown button on the board as well. Two LEDs are used as indicators while the software is running and log files are generated by each of the various processors.

We faced some problems initially setting up the development environment due to some of the online documentation for the BeagleBoard being out of date. However upon finding an up to date demo image of Ubuntu compiled specifically for the BeagleBoard, we were able to begin software development in earnest.

Initially, we believed we that the BeagleBoard would not be able to provide the necessary current required to power all three USB peripherals (webcam, Wi-Fi adapter, Arduino) simultaneously. Due to this, we originally planned to communicate between the BeagleBoard and Arduino with the use of the I2C communication protocol. None of the team members had experience with this protocol, and in an attempt to implement it, we inadvertently supplied an incorrect voltage to some pins on the BeagleBoard, thus destroying it. As a result, we needed a new BeagleBoard to be able to continue with both aspects of Linux programming development. Afterwards, we decided to look into using USB communication instead of I2C, and after a little research determined it would be possible to provide the required current to all three peripheral devices simultaneously, and as a results USB communication was a superior method.

As mentioned previously in the discussion of the iPhone software, our major shortcoming was the failure to implement a fully live two way audio stream between the BeagleBoard and the iPhone software. This requirement caused us significant problems as we spent a great deal of time researching possible solutions before realizing that this area was beyond our abilities.

### 1.5. Electrical and Mechanical

This section is concerning the ability to control the mechanical components of CHAD and the power supply for the device. Below in Figure 1.5.1 is a subsystem diagram of the Electro-Mechanical Components.

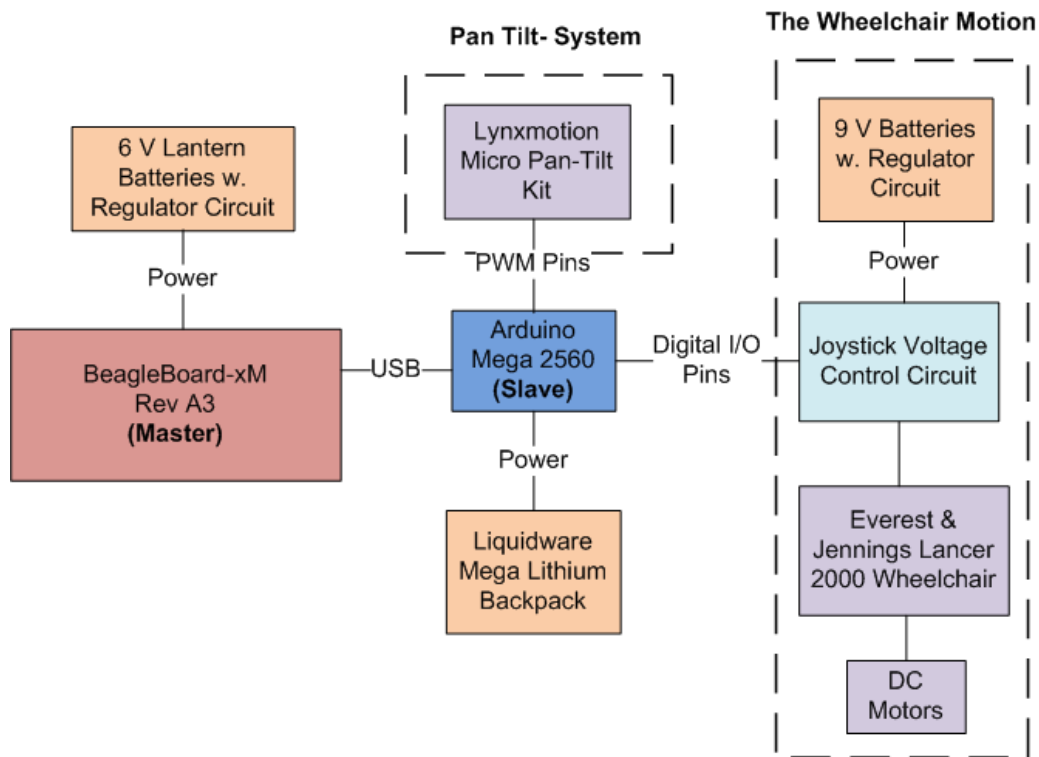


Figure 1.5.1: Electro-Mechanical Subsystem Overview

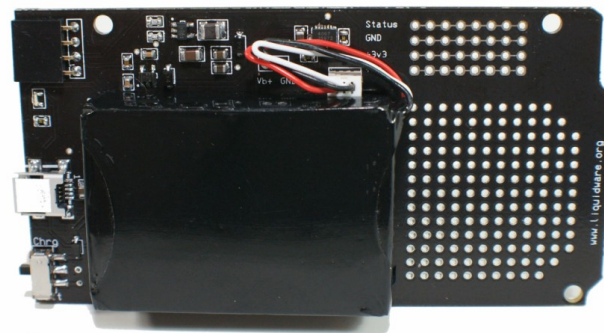






**Figure 1.5.3: Lynxmotion Micro Pan-Tilt Kit[4]**

In order to power CHAD, we used different sources of power for each component. To power the Arduino Mega 2560, we used a specialized battery pack called the Arduino Mega Backpack shown in Figure 1.5.4. This backpack is a Lithium Battery built for the Arduino Mega Series. To power the Beagleboard, we used two 6V Energizer Lantern batteries which are regulated to 5V. The Joystick Circuitry is powered by two 9V Duracell batteries regulated to  $\pm 8.6V$ . For powering the wheelchair we used the already existing wheelchair batteries since they were functional.



**Figure 1.5.4: Arduino Mega Backpack[5]**

## 3 Business Aspects

### 3.1. Budget and Funding

The initial estimation of the project budget as of January 26<sup>th</sup>, 2011 is summarized in table 3.1.1.

**Table 3.1.1: Estimated Project Budget.**

Components	Price
2 Development Boards	\$300
Chassis	\$200
Motors	\$500
Pan Tilt Camera System	\$100
Wi-Fi Equipment	\$30
Batteries	\$100
Contingency Fund	\$120
<b>TOTAL</b>	<b>\$1350</b>

As shown in the table above, we planned to purchase two development boards. This would allow for simultaneous development of the video streaming and motion control software. The majority of the project budget was dedicated towards the motors required to move CHAD.

The table below lists the final cost of the project





**Table 3.1.2: Final Project Budget.**

Components	Price
<b>Development Boards</b>	\$448.32
• 2 BeagleBoard xM	• \$305.36
• BeagleBoard c4	• \$142.96
<b>Arduino Mega 2560</b>	\$72.80
<b>Pan Tilt Camera System</b>	\$146.52
• Pan Tilt Servos	• \$86.70
• Logitech Webcam	• \$59.82
<b>Belkin Wi-Fi Adapter</b>	\$44.79
<b>Batteries</b>	\$163.42
• Arduino Mega Backpack	• \$104.82
• Custom Battery Supply	• 58.60
<b>Miscellaneous</b>	\$254.02
<b>TOTAL</b>	<b>\$1120.87</b>

From Table 3.2 above, it is evident that there are some differences between the initial estimation and the total spent on the project. The first discrepancy is the purchase of a third Beagleboard, and this is because we fried one of the initial two. Another discrepancy is the underestimation of cost for camera system and Wi-Fi adapter. This is due to the fact that not all USB peripherals are compatible with the Linux operating system being run on the BeagleBoard. The devices that are compatible are more expensive. There was also an underestimation in the contingency fund. As shown in the table above, we spent double what we expected on miscellaneous supplies. These supplies include: Shipping and customs fees, USB to serial adapters for debugging, AC/DC adapter, connectors, construction material and supplies, as well as power supplies that were purchased and returned (with a return fee) since we decided to use a different power source.

The biggest difference between the total spent and the initial budget estimation is the fact that we did not have to purchase motors. We were very fortunate to have found a used working wheelchair. It significantly reduced the cost of the project, and as a result, we were under budget despite the addition of unforeseen costs.

### 3.2. Market Analysis

As a brief market analysis, we will go over the target audience and expected competitors. There are three key consumers that we will be targeting CHAD towards. The first is the elderly and homebound patients. With CHAD, we will be providing a means through which family, friends, and health care specialists can communicate with the individual. The second target consumers are people who live in remote locations and do not have immediate access to physicians and nurses. They will be able to use our product to consult with doctors remotely. Lastly, doctors, nurses, and specialists can use CHAD to remotely diagnose and consult their patients.



The second aspect of the market is the analysis of our competitors. There are three main competitors we are expecting to face. The first is the InTouch RP-7 [1]. This isn't a direct competitor since it is designed for use in hospitals, and also has medical peripheral attached such as vitals monitors. The cost for this device is \$250, 000, and is therefore significantly more expensive than CHAD. Another competitor is the VGO telepresence robot [6], which is most likely to be a direct competitor. This is a general purpose device which costs \$5000 with a \$1200 yearly service fee. The last competitor is the iRobot AVA Telepresence Robot [7]. This device is new and still in the development state, so there are yet not enough details for a thorough comparison to CHAD, but we know that it will be a telemedical robot.

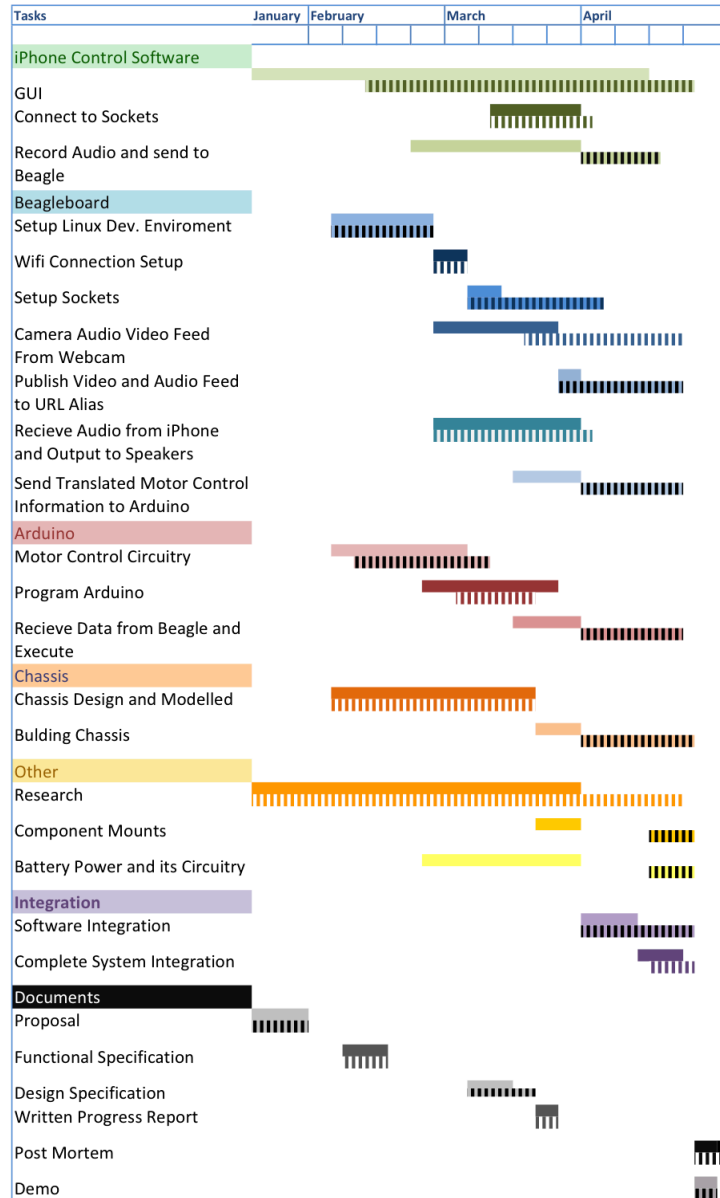
We believe that we can make CHAD a very competitive product, but to determine a final production cost, we would need to more extensive market research in order to better understand the demand for the product. There are also essential features that still have to be implemented, and until this is done, it is not possible to estimate a production cost of CHAD.

### **3.3. Project Timeline**

The diagram below compares the initial timeline (solid line) to the actual timeline (dashed line) of the development process.



**Table 3.3.1: Predicted vs. Actual Timeline.**



As you can see, there is a concentration of dotted lines in April for the final push for the demonstration. This is due to exams and prior commitments. Since we originally planned on finishing CHAD two weeks early, we were still able to finish the project on time.

## 4 Team Breakdown

Team Telemedix consists of members with a variety of skills and strengths. For this project, we delegated tasks according to these strengths. A brief overview of the duties assigned to each member follows:

### **Robin Mahony (CEO)**

- In charge of managing overall team dynamics and progress
- Developed iPhone controlling software implementation

### **Adrian Mocanu (CFO)**

- Handles the budget and finances
- Performed Electro-Mechanical work

### **Graham Holland (CTO)**

- Managed technical data sheets, wiki, repository
- Worked on Linux development on BeagleBoard

### **Vojta Prochazka (Secretary)**

- Kept track of meeting minutes
- Worked on Linux development on BeagleBoard

### **Rohit Thomas (Managing Director)**

- In charge of schedule management
- Performed Electro-Mechanical work

### **Ravi Panchal (Director of R&D)**

- In charge of all mechanical work

Team Telemedix met weekly over the course of this project, and also had frequent email correspondence. In terms of conflicts, no significant problems arose within the group over the course of the semester.



## 5 Lessons Learned

We learned many lessons over the four months time spent working on our project. We quickly realized that research needs to be performed early as it tends to take a substantially amount of time, and that we should continue to research to the point where exact implementation is known. We also learned that it is very difficult to implement protocols that we know very little about so we need to stick to protocols we are familiar with and have prior experience using. We also realized that dealing with manufacturers or retailers isn't always as easy as it sounds, as a lot of manufacturers don't keep data sheets for old and obsolete products, and new products don't always work as expected.



## 6 Individual Contributions

### 5.1. Robin Mahony

Over the course of the semester, I have worked extremely hard and acquired a variety of new knowledge. In terms of my contributions, I had two major concerns. The first was related to my position as CEO. This entailed keeping track of the project, ensuring team members kept on track and did their tasks in accordance with our design, and facilitating team communication. My other major task involved developing the iPhone software. With some outside help, I implemented the controlling software that controlled the movement of the camera, movement of the robot, and displayed the live video feed within the iPhone application. I also helped with some of the Linux development as I have some experience with C programming in a Linux environment from previous classes.

Through the completion of my duties, I have learned a great deal. Firstly, as CEO I have furthered my leadership experience. Being the leader of a team, especially one performing as complex a task as we did, presents many challenges. Sometimes decisions need to be made, and being the CEO I would have to make them. I also improved my management abilities over the semester. In terms of technical abilities, while I have previous experience developing on the iPhone, this project furthered my abilities in this area. I learned how to use different aspects of the Objective C language, such as using Interface Builder (a tool used to develop user interfaces for the iPhone), and I also learned some more subtleties that come with experience with developing for the iPhone. I also learned a lot about socket communication and streaming protocols (specifically TCP). In helping with a bit of the Linux development, I also gained more knowledge about the Linux operating system. This includes general Linux commands, basic shell scripting principles, and many other things.

Lastly, I have learned some important general lessons. The most important one I learned was that assumptions always cause trouble, and that words such as “should”, “probably” and “I think” should be treated as red flags.

Working for Team Telemedix over the past 4 months has been a great experience. I have worked long hours, and dealt with great frustration in finishing our project, but this was all to complete a project that I really enjoyed and believed in.



## 5.2. Graham Holland

For this project I was primarily responsible for implementing various parts of the CHAD software on the BeagleBoard. This was due to my experience working within a Linux operating environment and familiarity with the Linux command line. Additionally as CTO, I was also responsible for maintaining the wiki hosted on our Google code website as well as the repository used to manage our source code.

I have learned many things during the course of this semester including what it is like to work towards deadlines and supplementing project with appropriate technical documentation. I also learned a great deal about software development on Linux, including using parts of the GNU toolchain for compilation. Also I learned more about how the Linux kernel itself functions to abstract hardware in an embedded system.

Additionally this project served to refresh my knowledge of C and C++ programming and improved my knowledge of bash scripting. While working on solving the problem of audio and video streaming, I learned a great deal about different protocols and basic networking principles and also that assumption is the mother of all evil, as parts of this project that I assumed would be easy to implement often proved to be the most time consuming.

## 5.3. Adrian Mocanu

Throughout the semester, I worked on hardware and software components of CHAD. I worked on designing the external circuitry for the wheelchair joystick, as well the custom battery supply for the BeagleBoard. In addition to hardware, I also worked with software development on the Arduino so that it could control the motors, and also communicate with the BeagleBoard. I also helped with the integration of the software on the BeagleBoard's Linux environment. My role within the team as the CFO also meant that I was responsible for the finances and financial documentation of the project. All purchases were done through me, and all grants and funding will go to me.

I learned a great deal over the course of this project. By making many purchases, I learned that it is very easy to underestimate the cost of projects. The shipping and customs fees of equipment ordered online can very quickly drive up the cost of the device. I also learned a great deal throughout the hardware design process, such as the importance of characterizing existing equipment. Most importantly, I learned that lots of testing should be done on electrical devices before connecting them, as was the case with the BeagleBoard that we killed. Hopefully its death will not have gone in vain, and I plan to not have it happen again. The software design process also gave me a great deal of experience with Linux. I feel very comfortable using this operating system now. My software skills have also improved as a result of programming the Arduino, as well as programming various components of the BeagleBoard throughout the integration process.



## 5.4. Vojta Prochazka

During my time in ENSC 440, I have learned a great deal about myself, my colleagues, and most importantly, various aspects involved in the engineering design procedure. I am extremely happy with what we have achieved with our project. We had very ambitious goals at the start of the semester, and although not all of them were reached, we have designed a very good proof-of-concept model of our product.

One of the most important experiences I have gained from this entire process is how to work effectively and properly in a dynamic team situation. When working as a team, there will always be situations where people have different ideas and solutions on how to approach problems, but it is important to respect individual team members and their suggestions. At the same time, it is important as an individual to be able to handle constructive criticism. I also learned the importance of time management and planning.

I also refined my programming skills through a Linux development environment, using a variety of skills gained from numerous engineering classes. I developed knowledge of a few communication protocols, including I2C and USB, and how to use them to interface to peripheral devices.

## 5.5. Rohit Thomas

As part of the Telemedix team, I helped in the electrical and mechanical work for CHAD. With the help of Adrian, we designed all the electrical circuits and power supplies. We also programmed the Arduino software. I also helped Adrian debug the serial code written from the BeagleBoard. As one who did research before the project began, I helped advise the group on what components we needed to get. Furthermore, since I was the managing director, I developed and updated the project schedule.

From the past 4 months working on CHAD, I was able to take many things away from doing this project. I learned how to design power supply circuitry and learned how different electrical devices worked. I learned how to do clean wiring for a large system like CHAD. Also I learned how to program an Arduino Microcontroller and how serial communication works via USB. More importantly, I learned its best to test, measure, and double check repeatedly to prevent things from being blown. Lastly, this project refreshed some of my C coding.

Since working with group members, I learned how to work within a team of a large size. I learned to be more open minded and definitely improved my listening skills.

## 5.6. Ravi Panchal

During the course of this project I've had a great opportunity to work with 5 highly skilled individuals. Though the project was deemed extremely ambitious, our excellent team





dynamic led us to the successful completion of our ENSC 440 capstone project. I have learned a great deal of technical skills, which will be invaluable towards my degree.

Being responsible for the mechanical aspect of this project I was able to exercise my previous SolidWorks skill to design a prototype. This greatly helped when constructing CHAD since I had created all the reference drawings for the Design Specification document. I also supported my fellow team members in integrating the Arduino microcontroller and learned how develop communication protocols such as USB implementation to the BeagleBoard. It was a fun experience to work with the camera servo motors and seeing them fully implemented and working was a great accomplishment.

I've learned that much more time needs to be taken into research and development in order to minimize potential issues such as the ones we ran into close to the end of our project. In terms of prototype modeling, it is important to remember that it is not always possible to build what you had initially designed due to physical constraints.

My time with the Telemedix team has been a memorable one. This project course is one of the most valuable classes of my Engineering degree at SFU. Everything we have previously learned is tested in this course and I am looking forward to applying the skills I have learned towards future projects.

## 7 Conclusion

Over the past semester Team Telemedix has developed a fully functioning proof-of-concept model of CHAD. The only major discrepancy between our final product and our original proposed product is that the audio is only one-way, and not live (compared to two-way live audio as originally desired). In order for our product to be marketable, there are still many features left to implement. The major feature that would be necessary would be to have two-way live streaming audio and video. This would be crucial in facilitating simple and comfortable communication between the nurse (doctor, etc) and the patient. Another crucial improvement would be that the movement control would have to be improved to remove delay, and we would need to ensure that no conditions could result in a potentially catastrophic loss of control of CHAD. Also, the electrical design of CHAD would need to be made more compact, ideally being placed on a single PCB and powered by a single power source. Some other features that would be necessary would be things such as making CHAD more compact, to allow for easier movement within a home, minimizing blind spots of the camera to allow for safe remote operation, and other features such as adjustable table height. In the end, CHAD has been completed on under budget, and on time, and Team Telemedix is extremely happy with the final product they have developed. As for the future of CHAD, Team Telemedix has yet to decide if they wish to continue with the development of CHAD. After taking some time away from the project, it will be decided if CHAD will continue development or not.



## 8 References

- [1] Larry Greenemeier, "Who Needs a Doctor When There's a Robot in the House, er, Hospital?", *Scientific American*, Dec. 2008. [Online]. Available: <http://www.scientificamerican.com/article.cfm?id=robot-telemedicine&page=2>. [Accessed Jan. 26, 2011]
- [2] Genworth Financial, Inc., "Genworth 2010 Cost of Care Survey", *Genworth Financial, Inc.*, April 2010. [Online]. Available: [http://www.genworth.com/content/etc/medialib/genworth\\_v2/pdf/ltc\\_cost\\_of\\_care.Par.14625.File.dat/2010\\_Cost\\_of\\_Care\\_Survey\\_Full\\_Report.pdf](http://www.genworth.com/content/etc/medialib/genworth_v2/pdf/ltc_cost_of_care.Par.14625.File.dat/2010_Cost_of_Care_Survey_Full_Report.pdf). [Accessed Jan. 26, 2011]
- [3] "BeagleBoard-xM Product Details," BeagleBoard.org - hardware-xM, Sept 14, 2010 [Online] Available: [http://farm5.static.flickr.com/4068/4644432552\\_4d3d5d4d29\\_o\\_d.png](http://farm5.static.flickr.com/4068/4644432552_4d3d5d4d29_o_d.png) [Accessed: Mar 13, 2011]
- [4] SERVOCITY. *HS-85BB+ Might Micro* [Online]. Available FTP: [http://www.servocity.com/html/hs-85bb\\_\\_mighty\\_micro.html](http://www.servocity.com/html/hs-85bb__mighty_micro.html)
- [5] "Mega Backpack", liquidware.com, 2011 [Online] Available: <http://www.liquidware.com/shop/show/BPM/> [Accessed: Mar 13, 2011]
- [6] "VGO Telepresence Robot", botjunkie.com, June 2010 [Online] Available: <http://www.botjunkie.com/2010/06/01/vgo-telepresence-robot/> [Accessed: April 25, 2011]
- [7] "CES: Pilot iRobot's AVA telepresence bot with iPad", ces.net, Jan 2011 [Online] Available: [http://ces.cnet.com/8301-32254\\_1-20027701-283.html?part=rss&tag=feed&subj=Crave](http://ces.cnet.com/8301-32254_1-20027701-283.html?part=rss&tag=feed&subj=Crave) [Accessed: April 25, 2011]

[Cover Page] stock.xchng (July 30, 2007). "838151.jpg," at stock.xchng [Online] Available: <http://www.sxc.hu/photo/838151> [March 09, 2011].



# TELEMEDIX

TELEMEDIX  
Simon Fraser University,  
8888 University Dr.  
Burnaby, BC Canada  
Email: [telemedix-440@sfu.ca](mailto:telemedix-440@sfu.ca)

