



December 18, 2009

Dr. John Bird  
School of Engineering Science,  
Simon Fraser University  
Burnaby, British Columbia  
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**Re: ENSC 440 Capstone Project Post-Mortem for the CheckList™ Assistive Memory System  
by Mnemosyne Innovations Incorporated.**

Dear Dr. Bird:

Please find attached the Capstone Project Post Mortem for the product CheckList™ by our company Mnemosyne Innovations Inc. This report outlines the process our team went through in order to realize the final prototype of the CheckList™.

The goal of the project was to design an assistive memory aid device that could be used by individuals in households, by professionals, healthcare personnel, and essentially anyone and everyone. The CheckList™ alleviates the problem of forgetfulness by preventing important items from being left behind. The product is portable, easy to use, relatively inexpensive and fulfills a niche in the market, and thus Mnemosyne Innovations believes it has the potential to perform very well in the market.

Enclosed herewith is the final document for the project, the Post-Mortem. It outlines the proposed deliverables for the project, any deviations we encountered from the original design due to technical issues, our ideas for future development, budget & timeline considerations, and the experience of the Mnemosyne team members.

If there are any questions regarding the Post Mortem, please feel free to contact me by phone (778-995-0832) or email (pmd1@sfu.ca).

Thank you very much for your consideration.

Sincerely,

A handwritten signature in black ink that reads "Priyanka M. Deshmukh".

**Priyanka Deshmukh**

Chief Executive Officer, Mnemosyne Innovations Incorporated

**Enclosure:** Post-Mortem for Mnemosyne Innovations' CheckList™ Assistive Memory System

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## Post-Mortem

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# CheckList™: Post-Mortem

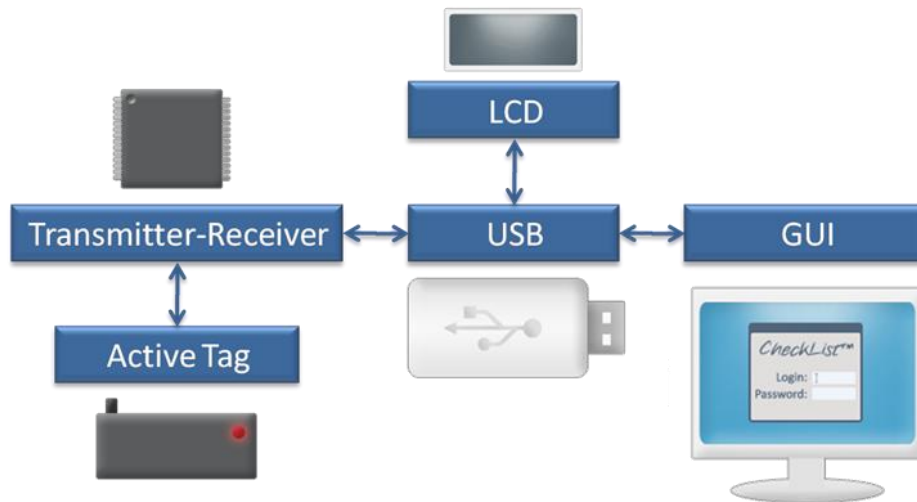
## 1 Introduction

In the following document, we at Mnemosyne Innovations Incorporated will outline the accomplishments made by the team during the past four months of developing the first prototype of the CheckList. This report will also address changes made to the design of the device since the submission of our previous documentation.

The purpose of this document is to provide the team at Mnemosyne to reflect on the progress and completion of the project and suggest improvements and plans of future development of the CheckList™.

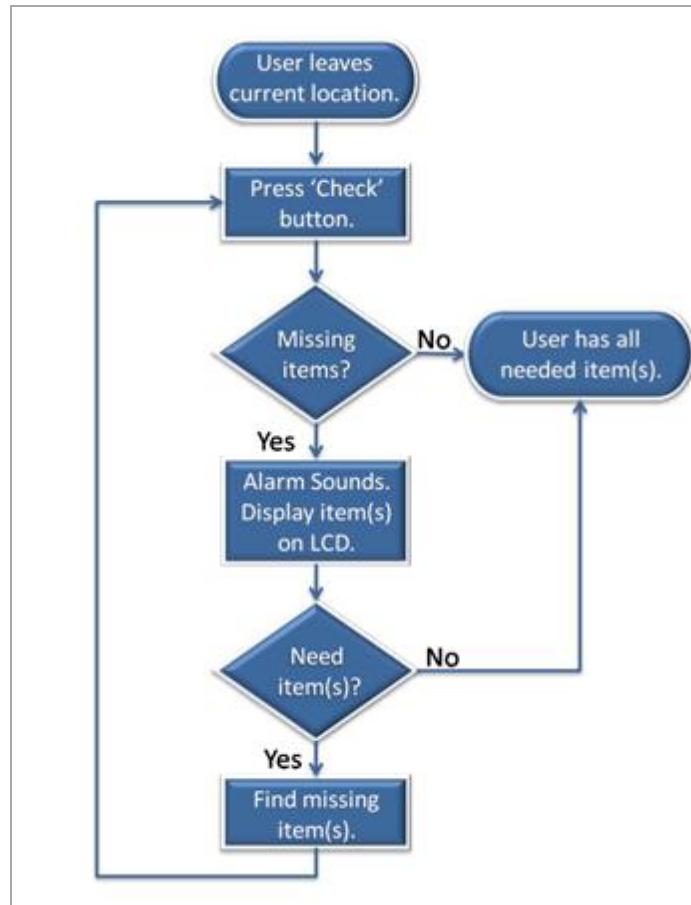
## 2 Project Overview

The Mnemosyne team decided upon designing and building a portable assistive memory aid device that helps users remember to take important items with them during their daily activities. Below is an overview of the system components.



**Figure 1: Overall System Components**

The LCD screen and the RF transmitter-receiver are mounted onto the USB key forming the detection unit device that is to be kept with the user. Each item needed by the user is tagged with its own unique active RF tag and the list of items can be added to the flash memory of the detection unit using the GUI. Once the list is saved, the user can then check at any time whether all the necessary items are with him/her. To do this, the user simply presses the 'Check' button found on the detection unit and then follows the steps outlined in Figure 2.



**Figure 2: Overall System User Flowchart**

The following four sections explain in more detail what we accomplished with the current device; issues we had while designing, testing, and implementing the various components; and potential future developments of the CheckList™ assistive memory aid device.

## 3 Physical System Design

### 3.1 Accomplishments

The final CheckList™ device is much smaller than specified in the design specification outlined by Mnemosyne. We were previously planning on using a 312cm<sup>3</sup> enclosure for the detection unit, mainly because of the large size of our initial LCD. However, once we switched to the second LCD, which is much smaller, we were able to fit the detection unit with AAA batteries in an enclosure that is approximately 160cm<sup>3</sup> and the same detection unit components with a coin cell battery in an

enclosure that is approximately 100cm<sup>3</sup>. The following figures show the final layout of the CheckList™ prototype.



Figure 3: CheckList™ Detection Unit

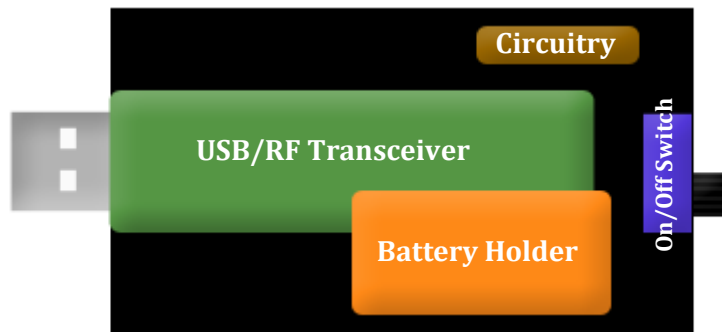


Figure 4: Inside of CheckList™ Detection Unit

## 3.2 Issues

Packing all the device components into the enclosures was a very difficult task. During the process, several pins from the LCD were broken off. We were able to solder leads back on to most of the pins. However, for one of the LCDs, the backlight's ground pin broke off and we were unable to reconnect it. As a result, one of our LCDs did not have a backlight function.

## 3.3 Future Development

It would be ideal to have all the circuitry on a printed circuit board rather than prototyping board or hanging loose, as they currently are in the proof-of-concept prototypes built for this project. In addition, smaller components can be incorporated. This would allow for a more lightweight and compact unit.

## 4 Software: Graphical User Interface

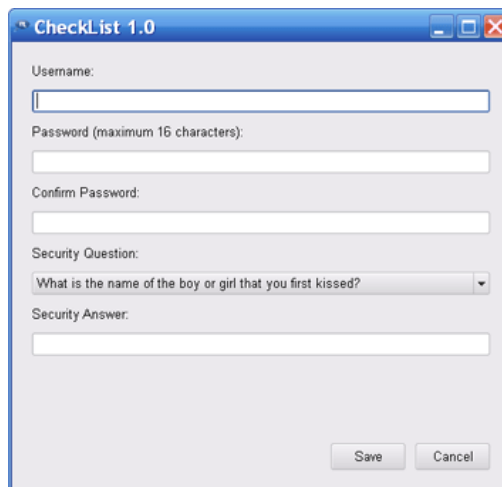
### 4.1 Accomplishments

In terms of the software for the CheckList™, all of the features promised in our functional specifications were met. The CheckList™ user interface includes six frames: welcome, login, new user, security verification, activate tags, and change label name windows. The application starts with the welcome window as shown in Figure 5.



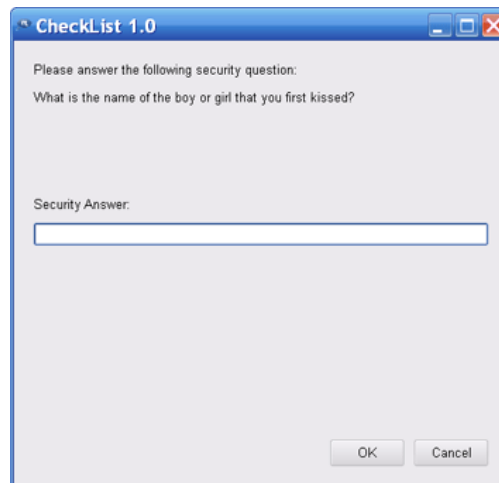
**Figure 5: CheckList™ Welcome Window**

From there the user can either login or create a new profile/replace an existing user. The GUI allows a single user to create a profile by filling out a user form which includes a username, password, security question and security answer as shown in Figure 6.



**Figure 6: CheckList™ New User Window**

There are two situations when the security question validation window will appear, as shown in Figure 7.



**Figure 7: CheckList™ Security Verification Window**

The first is if the user has forgotten his/her password. To recover the current username and password, the correct security answer must be provided. The second instance that the user will need to provide the security answer is when the user wants to create a new profile. Since only one profile is allowed to be saved at a time, in order to delete the previous profile the new user must provide the answer to the security question of the current user.

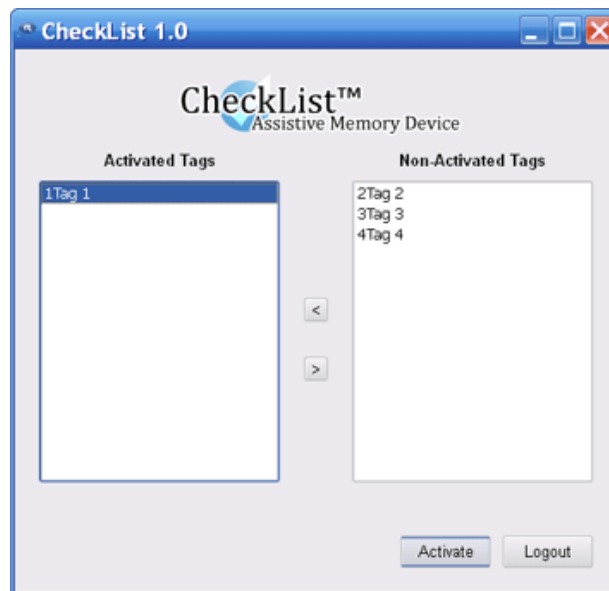
When a new profile is created or the user clicks the login button on the welcome window, the user can login to activate tags. Figure 8 shows the login window.



**Figure 8: CheckList™ Login Window**

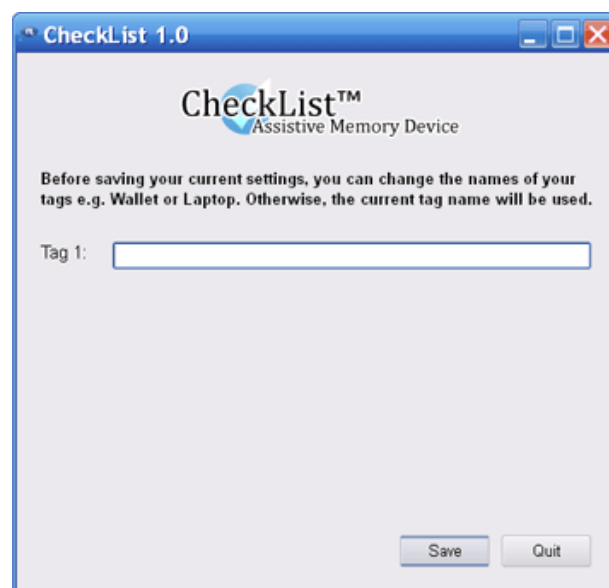


Once the user successfully logs in, the activate tags window appears and up to four tags can be activated for use by the CheckList™ as shown in Figure 9. The user can either use the arrows to pop tags from being non-active to active and vice versa or tags can be activated by dragging and dropping between the two tag lists.



**Figure 9: CheckList™ Activate Tags Window**

After clicking activate, the user can change the tag labels to whatever object the tags will be attached in the window shown in Figure 10.



**Figure 10: CheckList™ Change Label Names Window**



If the user chooses to leave the edit field blank, then the current tag label will be used. Once satisfied with the tag names, the user presses save and the application opens and writes to the COM port that is associated with the device. The application then quits when the tags are written.

## 4.2 Issues

Issues arising in the GUI started with the design of the various widgets or screens of the application. The first design simply involved the creation of a window when a specific button is pressed and the previous window is hidden. For example if the login button for the welcome window is pressed, the login window is created and shown while the welcome window is hidden. However, this could cause a shortage in memory since the windows are never destroyed. To address this issue, we changed the design of the GUI to make sure of the QWidgetStack class, which allows me to create a stack of widgets. Each window is created at initialization of the application and then when a certain window is needed, the program sets the window appropriately.

Another major issue was writing to the COM port. The writing function to the COM was provided by Texas Instruments and was only slightly modified for the purposes of our project. However, we were still unable to open the correct COM port successfully. While testing we had the sample TI GUI running in the background as well and it was because the COM port was being opened by the IO handling done in the sample GUI that we were unable to access the COM port for our own GUI.

## 4.3 Future Development

A limitation to the current GUI current design is that the system only allows a single user's tag lists can be saved at a given time. As suggested by Dr. Bird during the presentation of our prototype, the system should be modified such that the application would still only have one user, but allow for different profiles. Each profile would contain different tag names to meet the needs of the user. For example, a shopping profile for a shopping trip or a travel profile to use on a vacation. The next version of the GUI would facilitate several profiles for a single user so that tags do not have to be activated separately each time but rather activate the profiles instead. Also, we would like to have the additional capability for the user to add more than just four tags as limited by our current prototype.

# 5 Firmware: Tag Detection

## 5.1 Accomplishments

We were successfully able to label each of the individual tags with unique addresses that are recognizable to the access point (the detection unit). When the power switch on the access point is

turned on, the SimpliciTI RF network is initialized and the flags for each of the tags are cleared, indicating that the tag has not been detected. As the different tags join the RF network, they send information in the form of packets to the access point. Within each packet, the signal strength at which the packet is received, along with the device address of the respective tag, are included. If the tag address is recognized by the access point and the signal strength indicator is greater than 50 (signal strength is inversely proportional to distance from the access point), then the flag for that respective tag is set to one, meaning that the tag is within the detection zone (i.e. not missing). If the received packet fails to satisfy these conditions, then the devices are said to be missing, and the names of the tags whose flags are cleared will be displayed on the Liquid Crystal Display (LCD). The tag names are sent to the LCD via Inter-Integrated Circuit (I<sup>2</sup>C) communication in such a way that the hexadecimal values corresponding to each letter are sent in the form of bytes through the data bus line from the access point to the LCD.

## 5.2 Issues

The greatest challenge we faced in our project was succeeding in the I<sup>2</sup>C communication between the MSP430 F2274 microcontroller and the LCD. We first had to understand the functionality of the I<sup>2</sup>C connections and communication, and only then could we write the firmware code that would achieve the connection. We also found that the MSP430 F2274 microcontroller consists of an I<sup>2</sup>C controller, which meant that we had to first understand how data frame is sent from the I<sup>2</sup>C controller and how the LCD expects to receive the information from the MSP430 master in order for it to acknowledge the communication. We spent about a month and a half trying to successfully create this communication, until we finally decided to use a much simpler LCD than the one we had initially chosen. The main reason for this change in LCD was because we wanted to program the MSP430 to always be the master in the I<sup>2</sup>C communication, and for the LCD to always be the slave. However, the first LCD that we had chosen could sometimes behave as a master, which made the firmware programming much more complicated. Our second LCD was a little easier to program because it would only behave as a slave, and it did not have 'master' capabilities.

Another issue that we had was that in order to be able to detect the tags, we needed to make use of the CC2500 antenna that was mounted on the target board of the access point. The MSP430 microcontroller was connected to the CC2500 antenna using a Serial Peripheral Interface (SPI) connection, but we needed to make use of the same pins in order to connect the microcontroller to the LCD using an I<sup>2</sup>C connection. This caused a problem because by enabling the I<sup>2</sup>C communication to the LCD, we could not initialize the RF network, which meant that displaying the tag name to the LCD and detecting the tags in the detection zone could not happen simultaneously. To deal with this problem, we decided that the tag name would only be displayed when the pushbutton is pressed, at which point the SPI communication to the CC2500 would be disabled and the I<sup>2</sup>C communication would be enabled. After the names of the missing items have all been displayed to the LCD, the I<sup>2</sup>C

communication is disabled and the SPI connection to the CC2500 is re-established such that tag detection can resume.

### 5.3 Future Development

At the moment, the detection unit and the tags are always turned on and are using maximal current consumption. In future, we plan on incorporating a battery-saving technique in which the detection unit will detect the tags for 30 seconds and then enter a low-power mode in which it is not detecting the tags for approximately one minute. This toggling between modes will hopefully allow our device to use the same battery for longer periods of time because we believe that current consumption will decrease considerably. Table 1 shows the current consumption values of the access point in the different modes.

Mode	Current Consumption
Transmit Mode	21.2 mA
Receive Mode	13.3 mA
Sleep Mode	400 nA

**Table 1: Current Consumption of Target Boards at Different Modes**

As can be seen from the table, during sleep mode, the current consumption is 400nA, and if the tags were to remain in this mode for one minute and then go into either transmit or receive mode for 30 seconds, it would mean that the average current consumption would decrease. This would mean that the battery life of our device would improve.

Alternatively, we could implement an “anti-theft” detection mode in which the access point is continuously checking for the presence of tags within the predefined range (i.e. detection zone). In the event that an item (or tag) is moved out of the detection zone, an audible alarm will sound, alerting the user that an item is now ‘missing’. It is our hope that such an extension of our project will prove to be a deterrent for pick-pocketing, and thus result is the CheckList™ serving as an ‘anti-theft’ device.

## 6 Hardware: LCD

### 6.1 Accomplishments

The CheckList™ currently is successful at detecting the missing items in the surroundings through the transmission and reception of RF signals, and displaying the names of these items as defined by the user (through the GUI) on the LCD panel present on the main handheld detection unit upon the ‘check’ pushbutton prompt.

There was a change in the LCD panel that was originally planned to be used and the LCD panel that was actually used in the end product – more details will be provided in the issues section. To make the original LCD work with the MSP, a dual output regulator, as well as a voltage level translator was constructed. However, in the end, these two circuits were not necessary as the LCD was changed – this helped us make the handheld detection unit even smaller.

## 6.2 Issues

Establishing the I2C connection between the Texas Instruments MSP430 microcontroller and the LK162-12 Matrix Orbital LCD proved to be quite challenging. The USCI (Universal Serial Communication Interface) module of the MSP430 was used for serial data communication and supported the UART, SPI and I2C connections. The UART and SPI connections were already in use by the tag detection mechanism i.e. processing of the RF signals. Therefore the I2C mode seemed to be the most apt mode for transmission of the data to the LCD. Keeping this in mind, the LK162-12 LCD was selected as it was able to operate in I2C mode (in addition to the RS232 mode). However, even after following the appropriate instructions in terms of hardware to set the LCD in I2C mode, communication between the MSP and the LCD could not be established.

One of the potential problems we identified was the difference in the voltage levels of the two difference operating units. The MSP required a typical input voltage of 3V, whereas the LCD's input voltage was 5V. Due to this fact, we feared that the 'high' signal of 3V that was being sent by the MSP was not being received by the LCD as it did not reach the minimum threshold detection level. Thus, a constant NACK (Not Acknowledge signal was being received when checked on the oscilloscope – i.e. the MSP did not recognize that there was an LCD slave attached, and thus even if data was being sent to the transmit buffer, the buffer was never being emptied, and therefore nothing was being written to the LCD.

A solution to this problem seemed to be the use of a voltage level translator, that would translate the lower voltage up to the upper voltage, and thus resolve the issue of the 3V not being detected as an 'high' signal by the LCD. The PCA 9306 by Philips fulfilled our desired voltage shifting specifications. However, despite correctly implementing this level translator, a NACK was still being received.

After trying numerous software and hardware solutions to solve the above problem, and consulting with various individuals, the most suitable plan of action was to look at an alternative to the current LCD. After some research we found that the LCD by New Haven Display was I2C compatible, much smaller in size, was a frequency follower (hence we did not have to worry about matching the LCD baud rate with the frequency of the MSP clock). With this new LCD, we were successfully able to form a communication channel between the MSP master and this slave device.

### 6.3 Future Development

Currently, Mnemosyne Innovations is happy with the I2C connection that is being used to communicate between the MSP and the LCD. After the complications of getting it to function properly initially, the I2C connection is quite simple to work with – especially for low data transfer applications such as the CheckList™.

In general, the handheld detection unit portion of the device needs to be made smaller in size, and hence would require a change in the size of the LCD. However, the current LCD is already very compact and thus it might even be possible to continue using the same one.

To improve power consumption in the future, the handheld device could have an ON/OFF switch for the backlight of the LCD – i.e. the user is free to turn the backlight off when they do not feel the need for it, therefore conserving power. Alternatively, a ‘smart’ backlight system could be used that is able to detect the difference in environmental brightness levels and adjust the intensity of the backlight accordingly.

## 7 Budget and Timeline

At the beginning of this project, we proposed expenses of \$850. We were slightly under budget, spending a total of \$778, broken down in the table below.

COMPONENT	COST
LCD	\$169
RF Transmitter/Receiver	\$138
RF Tags	\$149
Other Components	\$68
Power Supplies	\$73
Miscellaneous	\$181
<b>TOTAL COST</b>	<b>\$778</b>

**Table 2: Realized Budget**

We ended up not using several components that we bought, including our initial LCDs (\$136) and the level shifters (\$10) and voltage regulators (\$5) that we bought to use with those LCDs. In addition, we bought extras of everything just in case we needed a new component at the last minute and did not have time to order one. If we were to build the exact same unit knowing what we know now, we would be able to do so with approximate \$80.

Below is a Gantt chart of when we completed various project tasks during this semester.

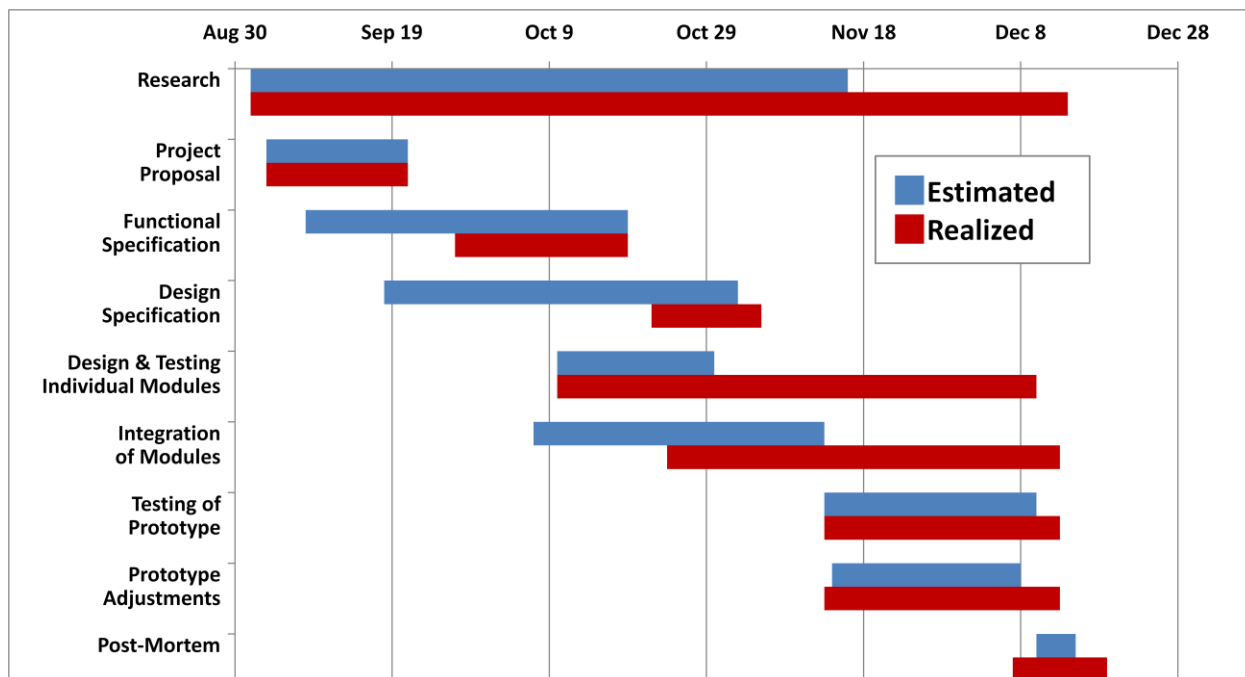


Figure 11: Estimated and Realized Timelines

For the most part, we managed to stay with our proposed project timeline. We submitted all documentation by the deadlines and our prototype testing and adjustments were relatively on track. Where we did take much more time, however, was during the design, testing, and integration phases of the individual modules of our device. This was when we were unable to utilize our LCD and ended up deciding to purchase a new one. Also, we realized that researching was very important and that task did not end until the project was complete.

## 8 Personal Experiences

The following is the team's individual assessment of the development and completion of the CheckList™.

### *Priyanka Deshmukh: Chief Executive Officer (CEO)*



The Mnemosyne Innovations group was formed the semester prior to which any of the group's individuals took ENSC 440. We each shared a goal at the start and that was to come up with a novel project idea before the 440 semester actually started, so that this would give the group enough time to complete the design and testing processes. The entire semester prior, we met up at least every three weeks (and even more as



the semester came to an end) to discuss possible solutions. I am glad that everyone in the team was just as committed to the project and that the idea selection process was well done. I do strongly believe that technically spending 8 months on the project was necessary in order for the project to be completed to the degree that it was.

After the idea of creating an assistive memory aid device was selected, researching the electronic components that would best suit our need took significantly longer than expected. However, once again, I am not at all regretful of this fact. I would rather conduct thorough research and start working on an area that has the potential of being successful than on something that was chosen in a rush. In addition, through the research portion of the project I learned a great amount about related projects that are currently in the market, as well as the capabilities of the various microcontrollers, LCDs, and other electronics components. At the end, the original design changed from passive tags to active RF tags, however I am very glad that our team was flexible to this change.

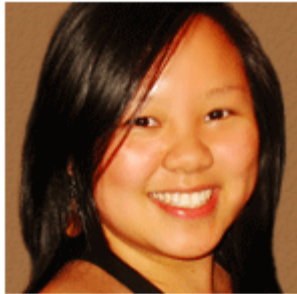
From a technical perspective, I increased my knowledge of radio frequency operated technology and in what applications it is used in nowadays. In addition, I learned a great deal about the MSP430 microcontroller platform and the SimpliciTI Networking protocol. I have a much better appreciation for the intricacy involved on the MSP board.

The biggest challenge I found throughout this project was establishing communication between the microcontroller and the LCD through the I2C connection. After communicating with technical support from Texas Instrument at the point when the MSP430 was ordered, it was decided that for master-slave interaction, the I2C mode would be most appropriate as opposed to RS232 for example. However, even after ensuring the correctness of the hardware to establish I2C, and attempting at firmware programming for several consecutive weeks, the first LCD we had purchased did not result in a positive result. It was difficult for me to move forward because so much time and effort was already spent on the current LCD, however, I learned to accept it and move to plan B – i.e. ordering another LCD. We did not encounter any of the problems with this new LCD that we did with the old one. In retrospect, I can see that all the time I spent on making the old LCD work was not time wasted, but rather well spent! Otherwise, I would not have had the need/opportunity to research the technology in so much detail. Hence in conclusion, I believe what happened, happened for the best!

In terms of interpersonal skills and team dynamics, I have learned to be patient and accepting of the differences in our team. It is very important to be accommodating of each other's needs and methods of functioning. Communication was key and to me being respectful of one another is paramount. I am glad that the Mnemosyne group was able to function properly together till the end, and that we all remain friends. Overall, I thoroughly enjoyed the ENSC 440 Capstone project – we had our ups and downs, but the overall result was positive, and the learning process was like no other.



***Rachel Cheng: Chief Operations Officer (COO)***



I had many expectations prior to undertaking this project. I was told that it would be an emotional roller coaster along with many sleepless nights but that in the end, I would feel relieved and glad when it was all over. To some extent I felt the entire spectrum of emotions. Even though I was on many occasions frustrated with our project, I gained a lot of experience and knowledge with creating a user interface. Having never designed a GUI before, it was a fun challenge learning how to use the GUI building platform QT as well as learning how to write with the COM port to facilitate communication between the software and firmware. Upon the completion of the project, I developed a deep respect and admiration for the fine ladies that I had the pleasure of working with. There were times where I felt that I couldn't solve a glitch or issue and it is with the help of my team that I was able to and I could never thank them enough for their hard work. It is because of our teamwork that we were able to complete our project on time with the required deliverables. Not only have I learned from this experience, I gain three friends for life.

***Ana Namburete: Chief Technical Officer (CTO)***



About a year ago I received an e-mail from one of my teammates asking me if I would like to be a part of her ENSC 440 team. At that point, I did not know what to expect, and I also could not understand why she would have wanted to form a team so early. I agreed to join the team but did not think about the project until last semester. It was at this point that the entire team started to meet on a regular basis to get to know each other and decide on the project idea that we would be working on for the next 7 - 8 months. As we got to know each other, I was relieved to find that we all had similar goals and our enthusiasm for working hard and excelling at the project were high. After having gone through the ENSC 440 experience, I would say that this team-building was what formed the glue that held us together throughout the semester because we were able to establish strong communication ties and become comfortable enough with each other to bring up any issues and deal with them appropriately.

When the fall semester started, I was responsible for the firmware portion of the project and for the integration between the hardware and the software. It was a big task to take on, but I was very excited about it and curious to see how much knowledge I had acquired from my other courses, and how they would help me in ENSC 440. As time progressed, I realized that every single course that I had taken in my engineering career contributed to my understanding of and ability to creatively solve the problems faced in ENSC 440. For instance, the computing science courses (CMPT 128 and 225) prepared me for writing the code in C language, ENSC 151 prepared me for understanding the

different registers in the microcontroller, how the memory was organized, and how the instructions were accessed from the RAM. A combination of engineering courses helped me be able to understand how to interface between the LCD and the microcontroller, and thus how to check if the code I had written was in fact behaving as we intended it to. They also helped me understand how to integrate voltage regulators and voltage shifters into our design, and the importance of signal timing.

In terms of the soft skills, I learned that your initial design is not necessarily set in stone, and that it is important to be flexible and open to creative solutions. I also got to understand the importance of effective communication (both written and spoken), and also that when designing a product, we sometimes need to think like “the user” as opposed to “the engineer”.

I am thrilled that we were able to successfully complete the prototype, but I must admit that there were moments in which I felt like giving up, or that I thought we would not succeed, but my teammates kept me going and always maintained a positive attitude towards the end goal. It made me appreciate the experience, overcome the obstacles, and realize that ENSC 440 was worth all the hard work.

### *Surbhi Seru: Chief Marketing Officer (CMO)*



Completing this 440 project was not an easy or straight-forward task, both in terms of the technical aspects as well as dealing with team dynamics. I was warned by the many that had taken 440 before me that, despite all my planning, I will be sleep deprived, frustrated, and living in Lab 1 by the end of the semester. Of course, all of the above came true. Since I was mainly responsible for integrating all the hardware components in the device, I spent most of my time in Lab 1. Along with designing, building, and testing all the preliminary circuitry for the various components of our device, I also assembled the two complete prototype systems we used for our demonstration. My circuit building experience from previous ENSC classes as well as through my workplace laboratory was a great asset for this project. Although some of the components were quite small and the enclosures for the prototypes required the devices as a whole to be constructed very tightly, I was able to complete the tasks. I learned how important it is to test at every single step to save myself from unnecessary extra work at the end when something is not connected properly. My attention to detail was tested greatly while working on this project. In addition, I was exposed to two areas that were completely new to me: I<sup>2</sup>C communication protocol and RF tag detection. I did not work on these areas in detail but I learned enough to understand the overall processes and found them quite interesting.

Through working with this project team, I have learned how important communication is in a team; more specifically, the consequences of not communicating effectively with all group members.



Furthermore, I have realized that it is not possible please everyone; sometimes agreeing to disagree is the best solution. There were several times during the semester when I was ready to give up on this project because I was frustrated with my team members. However, by the end of the semester, we were able to look past our differences and managed to get the job done. I have learned tremendously from working on this project, both technically and interpersonally, and I am confident that I will be able to use all this knowledge and experience in my future endeavours.

## 9 Conclusion

Mnemosyne Innovations Inc. has successfully completed the prototype for the CheckList™, and as a team, we were able to maintain the levels of communication that were salient to the completion of our project. We were also able to achieve the goals that we initially set out in the initial design stages, and we succeeded in abiding by the contract that we all signed. It is for this reason that the CheckList™ is currently working as intended, and we look forward to implementing additional features based on the suggestions provided by Dr. John Bird, Steve Whitmore, and Jason Lee.

Although we managed to work well as a team, and we put a lot of work and effort into the prototype, the success of our project would not have been achieved without the help of Kourosh Khosraviani, Brandon Ngai, Thomas Watteyne, Pranav Gupta, and the support team of engineers at Texas Instruments. At Mnemosyne Innovations Inc., we felt that ENSC 440 was a valuable experience that will adequately serve to prepare us for working in the industry.

*All you need to remember is your CheckList™.*