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October 11, 2012

Dr. Andrew Rawicz
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Re: ENSC 440 Functional Specifications for Smartphone Voice Control Home Automation System

Dear Dr. Rawicz,

Attached to this letter are the functional specifications for our Smartphone Voice Control Home Automation System, also referred to as the EVA Controls. By implementing both voice recognition and smartphone control into our system, we will allow homeowners complete control over household devices regardless of the user's degree of mobility or any other disability. The added option of automatic lighting level control through daylight harvesting, will allow the user to save energy. Thus, we at EVA Controls believe anyone could benefit from having our system installed in their homes.

For the purpose of these functional specifications we have outlined five major sub systems that, when seamlessly integrated, make up the EVA Controls system. These five sub systems consist of the user interface, the voice control hardware, the microcontroller central processing unit (CPU), the daylight harvesting control, and the 120 V relays, switches, and outlets. The various requirements of each sub-system, as well as the overall system, will be outlined and prioritized based on proof-of-concept and commercialization implementations.

EVA Controls is composed of six engineering students from Simon Fraser University. The executive team consists of members from electronic, systems and computer engineering. If you have any questions or concerns regarding our product or these functional specifications, please contact us by email at contact@eva-controls.com

On behalf of the executive team,
Sincerely,

Adam Franklin, LEED® Green Associate
Co-founder and CEO
EVA Controls

Enclosed: EVA Control System – Functional Specifications

EVA Control System

Functional Specifications

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Date: October 11, 2012

Executive Summary

Helping disabled or elderly people through various modifications and automation has become common practice in today's technologically advanced world. Current solutions to obtain a higher standard of living can potentially involve costly and time consuming renovations that are needed in order to install facilities useful for disabled individuals. Technologies like INSTEON - one of the home automation systems currently out on the market - provide an alternative method to give control to the user by adding remote control and automation to lighting and other home controlled applications [1]. One problem with technologies such as INSTEON is that they force the user to purchase additional products from their company in order for their technology to function. Regular items like light bulbs or dimmer switches will not work with their technology and therefore must be replaced with compatible devices for their home automation solutions. It is evident that the cost of replacing regular usable household devices with more expensively limited technology can quickly become unaffordable for people that have a need for home automation.

EVA Controls introduces an innovative system, able to maintain the benefits of a home automation system at reduced cost compared to the competition. This system will allow users to easily control their working devices in their home through the use of a mobile device such as their cellphone or through spoken voice commands. The system will also offer users the option to fully automate the program and reduce energy consumption based on optimal environmental conditions.

EVA Controls focuses primarily on the control of home lighting systems, but future developments will incorporate other components and systems. The system can be broken down into three main components: Voice Control Hardware, iPhone User Interface, and Daylight Harvesting Control working in sync with our central microcontroller.
The company was co-founded by six engineering students from the Simon Fraser University. These individuals bring a wide range of engineering expertise, including electrical circuits, commercial lighting, as well as software and microcontroller programming.

Each of the three elements in EVA Controls will be developed based on the communication needs of the central controller. The individual testing of each part is important to ensure that all three elements are an option to communicate with the central controller. When the functionality of each element is ensured, EVA Controls will begin integration and aim to present a functioning prototype system by early December 2012.

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Glossary

EVA	Acronym for Eco Voice Automation
Daylight Harvesting	A control system that reduces the use of artificial lighting with electric lamps in building interiors when natural daylight is available, in order to reduce energy consumption.
120 V	Abbreviation for standard nominal household line voltage, 120 volts 60 Hz AC
DALI	Digital Addressable Lighting Interface
PCB	Acronym for Printed Circuit Board
SPDT	Acronym for Single Pole Double Throw light switch
LED	Acronym for Light Emitting Diode
iOS	Apple's mobile operating system
AC	Acronym for Alternating Current
DC	Acronym for Direct Current
ASHRAE	Acronym for American Society of Heating, Refrigerating and Air-Conditioning Engineers
ANSI	Acronym for American National Standards Institute
GUI	Acronym for Graphical User Interface
CPU	Acronym Central Processing Unit

1 Introduction

The main product of Eco Voice Automation (EVA) Controls is a voice controlled home automation system that enables the user to control lights through spoken voice commands or a Smartphone application. This innovative system is mainly intended to bring convenience to individuals with disabilities. The user must simply speak a key word – such as "EVA" - to activate the system. The user may then make a request such as "Living room lights on", and the lights in the living room would light up. Our product aims to compete with other products on the market through affordability and ease of use.

1.1 Scope

This document presents the functional specifications of the EVA Controls, providing the requirements that must be met by the final product. Although minor modification may be applied during the development of the proof-of-concept device, the majority of the requirements will be met.

1.2 Intended Audience

This functional specifications document is intended for the use of members of EVA Controls as a reference towards the development of the project. This document provides the members a measure of the completion as well as guidelines for the various features.

1.3 Conventions

A: Functional specification applies to both the proof of concept, and the final product.
B: Functional specification applies to the proof of concept only.
C: Functional specification applies to the final production system only.

2 System Requirements

2.1 System Overview

The EVA Controls system will be used to provide both people with disabilities and general homeowners the opportunity to control a variety of electrical devices through the convenience and simplicity of voice commands and/or the use of a common electronic device, such as a smartphone. A high level overview of the EVA Controls system can be seen in Figure 1.

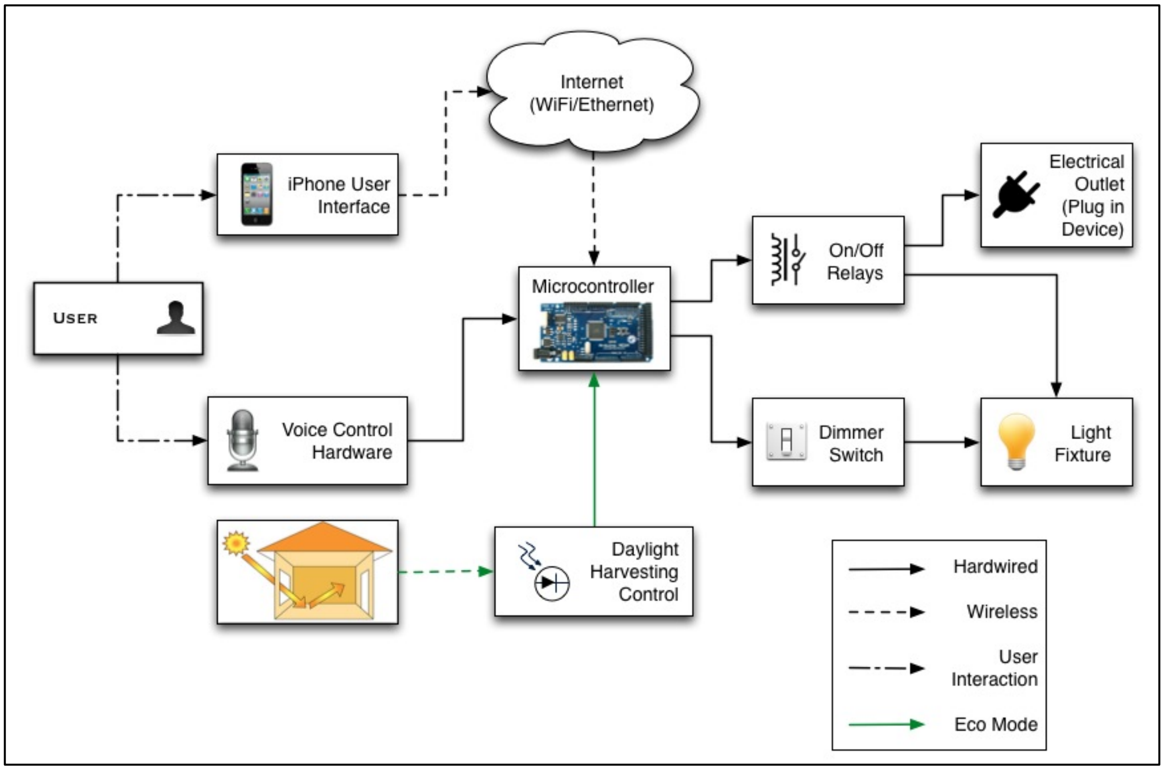

Figure 1: High Level System Overview

The system is broken down into five major components; the user interface, the voice control hardware, the microcontroller central processing unit (CPU), the daylight harvesting control, and the 120 V relays, switches, and outlets.

The system will have two modes of operation; A "Manual Mode" will allow the user complete control over all the devices connected to the system and an "Eco Mode" will automatically adjust lighting levels to optimum levels for both comfort and energy conservation while still allowing users to control other devices. While operating in either mode, the system will provide the user two methods of control, one through audible voice commands and one through an interactive user interface which has the possibility to be implemented on a number of different devices. These two user interactions will be designed to be very user friendly, intuitive, and simple to use with the aim of not requiring the user to undergo any extensive training to be able to operate the system.

Based on the user's commands, the microcontroller CPU will determine which device needs to be controlled, what function needs to be executed, and if the command is valid. From these commands the CPU will be able to control a set of electrical relays for on/off device control and interact with digital dimming switches for adjusting lighting levels. While in "Eco Mode" the dimming switches for the lights will be controlled, via the CPU, by daylight harvesting controls based on the amount of incoming sunlight.

2.2 General Requirements

[R01-A] The EVA Control system must not alter the normal operation of existing systems and devices.
[R02-A] The total cost of the system must be less than $500 for a single room living space.
[R03-C] Different size modules must be available for different sized homes.

2.3 Physical Requirements

[R04-C] The system control unit must be installed into the wall with the main light switches.
[R05-C] Must have aesthetically pleasing faceplate.
[R06-A] Display/Faceplate must have LED status on/off indicators.

2.4 Electrical Requirements

[R07-A] The system must be powered by a 9-12V power source.
[R08-C] The system must be powered by an internal power supply (IPS) that converts the main 120V AC line voltage to desired 9-12V DC.
[R09-C] IPS must have minimum efficiency of 82% for meet ENERGY STAR requirements [2]

2.5 Environmental Factors

[R10-C] System must operate in standard ASHRAE indoor environmental conditions (ANSI/ASHRAE Standard 55-2010) [3].

2.6 Standards

[R11-A] Must meet all CSA Electrical standards (C22.1-12/C22.2-12) [4].
[R12-C] Should meet or exceed any applicable CSA Accessibility standards (B651-12) [5].
[R13-C] Must utilize DALI standards for lighting control (IEC 60929/IEC 62386).
[R14-C] Must meet requirements for ENERGY STAR certification [2]

2.7 Reliability and Durability Requirements

[R15-C] Must undergo a full system reboot of approximately 20 seconds after a power outage.

2.8 Safety Requirements

[R16-C] Must have 500mA fuse for to protect CPU from power surges and current overloads

2.9 Performance Requirements

[R17-A] Must be capable of operating 24 hour/day for one year after initial installation with a maximum downtime of 72 hours for servicing.
[R18-C] Idle power consumption must be less than 12 watts to meet ENERGY STAR requirements for thin-client computers [2]
[R19-C] Off mode and sleep mode power consumption must be less than 2 watts to meet ENERGY STAR requirements for thin-client computers [2]

3 Hardware Requirements

3.1 Voice Recognition

3.1.1 General Requirements

[R20-B] The cost for implementing the voice control system must be below $150.
[R21-A] There must be easy access to the voice control unit for servicing in the case of hardware failure.
[R22-A] The voice recognition receiver should be placed in the proximity of the light switches so that it cannot get blocked by other household tools in order to receive more clear voice command.

3.1.2 Physical Requirements

[R23-C] All components of the voice control system are intended to be installed and plugged into the wall, so should be protected from dust and dirt.
[R24-B] The prototype size should not exceed from 5 cm^2, in order to facilitate the installation process.
[R25-B] The PCB and microcontroller should communicate through USB 2.0.

3.1.3 Electrical Requirements

[R26-A] Microphone circuitry must have a frequency response of 20 Hz to 20 kHz.
[R27-A] Power supply of 3.3V and current of 50 mA

3.1.4 Environmental Factors

[R28-B] The system must operate in room temperature conditions of 22±20°C.
[R29-A] The system should operate in the humidity range of 5% to 95% [6].
[R30-A] The density of beep alert sound from the voice recognition system shall be less than 50dB.

3.1.5 Standards

[R31-A] Electromagnetic compatibility between radio apparatus and service of security services and communications for RFID Reader/Writer hardware with 13.56MHz ISO15693 standards for RFID tags.

[R32-C] Improve the quality of equipment under the direct TC 22/SC 3 code for sale in Canada.

3.1.6 Safety Requirements

[R33-A] The voice recognition should not be blocked by any household device to minimize chances of error and malfunction.

[R34-A] If the PCB reaches an internal temperature of 100°C the system will power off.

[R35-A] All the electrical wiring should meet building code regulations.

[R36-A] Ensure there is no open wiring.

3.1.7 Performance Requirements

[R37-A] The PCB must be able to filter out background noise.

[R38-B] The PCB must be able to recognize the commands spoken within 10 centimeter from the microphone, even in noisy conditions.

3.2 Microcontroller CPU

3.2.1 General Requirements

[R39-B] Prototyping cost for developing the microcontroller unit for the system must be below $100.

3.2.2 Physical Requirements

[R40-A] Must have a physical switch for when user is unable to control the lights via voice commands or iPhone.

3.2.3 Electrical Requirements

[R41-A] Must output power supplies of 3.3 V to 5.0 V.

[R42-A] Must be able to integrate an Wi-Fi/Ethernet input.

[R43-A] Must be able to integrate the Voice Recognition Unit input via USB 2.0.

[R44-B] Must be able to operate the Relay Switches, Dimmer Switches, and Daylight Harvesting Control.

3.2.4 Environmental Factors

[R45-A] The system must operate in room temperature conditions of 22±20°C.

3.2.5 Standards

[R46-A] C22.2 NO. 111-10 - General-use snap switches (Bi-national standard, with UL 20).

[R47-A] C22.2 NO. 184-M1988 (R2009) - Solid-State Lighting Controls.

[R48-A] C22.2 NO. 184.1-96 (R2006) - Solid-State Dimming Controls (Bi-National standard, with UL 1472).

3.2.6 Reliability and Durability Requirements

[R49-C] Must be capable of operating 24 hour/day for one year after initial installation with a maximum downtime of 72 hours for servicing.

[R50-C] Must continue to function after a shortage/blackout by rebooting in less than 20 seconds.

3.2.7 Performance Requirements

[R51-A] Must be able to output designated pins when issued an input from the Voice Recognition Unit.

[R52-A] Must be able to output designated pins when issued an input from the Wi-Fi/Ethernet.

[R53-A] Must be able to output designated pins when issued an input from Daylight Harvesting Control.

3.3 Daylight Harvesting

3.3.1 General Requirements

[R54-B] Prototyping cost for developing the Daylight Harvesting Control must be below $5.

3.3.2 Physical Requirements

[R55-C] Must fit within the standard dimensions of a single electrical wall switch/electrical box.

[R56-A] Must be automatically toggled on when in “Eco Mode” and off when in manual mode.

3.3.3 Electrical Requirements

[R57-A] Must be able to detect wavelengths of 390 to 750 nm.
[R58-A] Must output data that is proportional to the light intensity of the room.
[R59-A] Must operate on power supplies of 3.3 V to 5.0 V.

3.3.4 Environmental Factors

[R60-A] The system must operate in room temperature conditions of 22±20°C.

3.3.5 Reliability and Durability Requirements

[R61-A] Data output must have a ±5% error due to the environmental changes.

3.3.6 Safety Requirements

[R62-A] Internal operating temperature must be in the range 0-100°C.

3.3.7 Performance Requirements

[R63-A] Must be able to accurately detect the environment conditions for the microcontroller to set the optimal settings for the dimmer switch.

3.4 Electrical Relays

3.4.1 General Requirements

[R64-A] Must switch on and stay on when signal voltage is applied.
[R65-A] Must switch off and stay off when signal voltage is applied.

3.4.2 Electrical Requirements

[R66-A] Each relay must be rated to handle 120VAC (min) on switching side of coil.
[R67-A] Each relay must be rated to handle at least 20 amps AC.

3.4.3 Environmental Factors

[R68-A] Must operate in room temperature conditions of 22±20°C.

3.4.4 Standards

[R69-A] Must meet IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus (C37.90-2005) [7].

3.4.5 Reliability and Durability Requirements

[R70-C] Wear and tear must meet manufacturer specifications.

3.4.6 Safety Requirements

[R71-A] Must be shielded from the possibility of a short circuit.
[R72-A] Must safely isolate 120VAC side from signal (DC) circuitry.

3.5 Dimming Switch

3.5.1 General Requirements

[R73-A] Must be a digital dimming switch that can receive signals from microcontroller.
[R74-A] Must function as a manual dimming and on/off as well.

3.5.2 Electrical Requirements

[R75-A] Must be capable of pulse width modulation for dimming of LED lamps.
[R76-A] Must be a 3-way SPDT switch for interconnection with regular light switches.

3.5.3 Standards

[R77-A] Must be CSA certified.

3.5.4 Safety Requirements

[R78-A] Must pose no risk of short-circuiting or shocking.

4 Software Requirements

4.1 iPhone User Interface

4.1.1 General Requirements

[R79-A] Must communicate with microcontroller wirelessly.
[R80-A] Must be able to control each device independently.

[R81-A] Must be able to switch between "Manual" and "Eco" modes.
[R82-C] Must be capable of organizing devices by room.
[R83-A] Must have a master button that turns all devices off.
[R84-C] Must be capable of running on any iOS 5 or 6 iPhone device.
[R85-C] Capable of running on other iOS 5 or 6 devices such as iPad.
[R86-C] Software made to be expandable to other devices such as Android and PC.

4.1.2 Performance Requirements

[R87-C] Must not significantly reduce battery life of device.

4.1.3 Usability Requirements

[R88-A] Application must be user-friendly, written in natural language with intuitive icons.

5 System Test Plan

We will test our product with a three-stage test plan: feature, regression and smoke testing. This will ensure that, during development and integration, each module has been tested individually and as a final prototype. Following testing, verification will be performed to make certain that the final product functions according to specifications and any existing bugs are fixed.

Defects found during testing will be logged. To ensure that there is traceability for defects, we will document the testing environment details and as well as step by step instructions to reproduce the defect. A priority level will be assigned for each defect to determine the level of importance of fixing the defect.

Figure 2 below is a template of our method for logging defects.

Defect #
Description: <description of defect>
Code version: xxxx.xxxx.xxxx.xxxx
Steps to Reproduce: 1. <step1> 2. <step2> 3. ... n. <step_n>

Expected Behaviour: .... Actual Behaviour: ....
Priority Level:

Figure 2: Defect Report Template

5.1 Feature Testing

During the developmental stages, we will consistently test each module's features and verify that they meet the specified requirements. To do this, we will simultaneous write/review and run test cases as we develop each module. This approach is appropriate because features can change and so, test cases will change along with it.

5.2 Regression Testing

When all features have been fully developed and integrated we will run full regression testing to ensure that they continue to operate properly. At this stage, features will not change and all test cases have been finalized. We will perform a full regression test in which all test cases are run. If and when defects are uncovered, we will log and fix the defects. After this, we will move into smoke testing

5.3 Smoke Testing

Smoke testing is performed to ensure stability in the product after defect fixes. It will not be as intensive as regression testing but will provide us with enough coverage for the weak areas of the product. This type of testing will be performed at every iteration of defect fixes.

5.4 Verification

After each iteration of defect fixes, verification is required to ensure that the defects are indeed fixed. We will run tests based on the steps documented in the defect logs. If further coverage is needed for weak areas, we will run additional tests to verify that stability is achieved.

Figure 3 below shows a flow chart illustrating the testing process of our product.

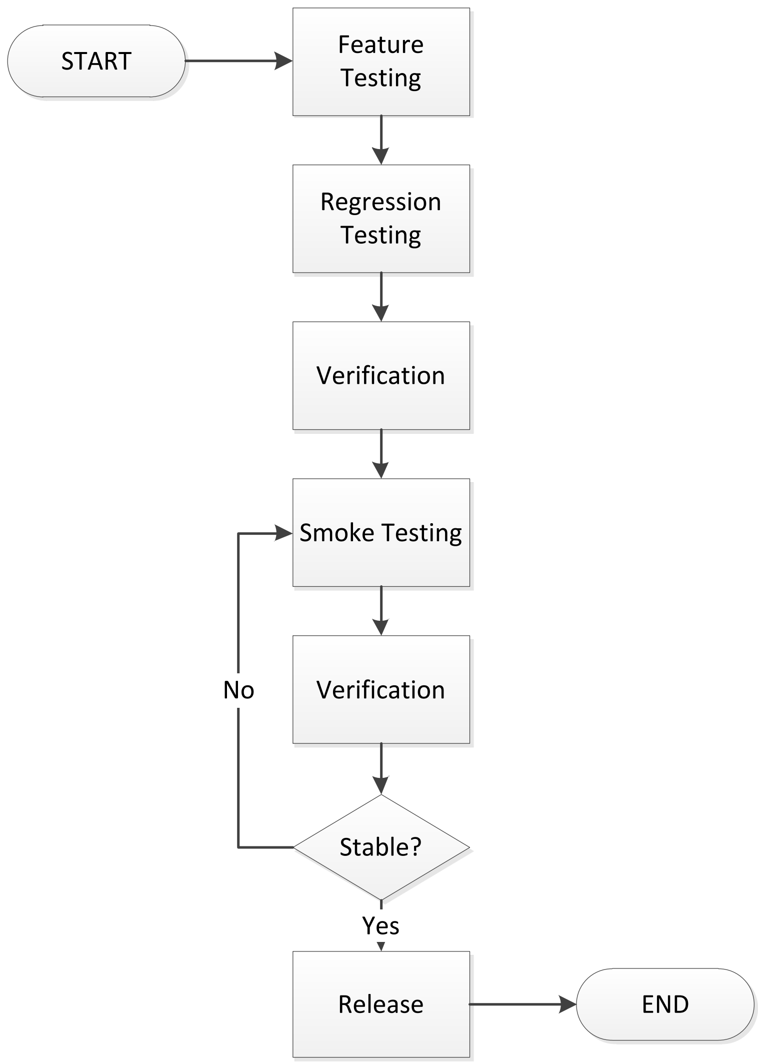

Figure 3: Testing Process

5.5 Unit Testing

EVA Control consists of three main modules: Voice recognition, iPhone app and Microcontroller unit. In order to minimize the error, each module will be tested and conducted separately prior to the whole system integration. For this part each, modules have to pass successfully all the physical, electrical, environmental factors, standard and safety requirements prior to the whole system integration.

5.5.1 Voice Control Module

- The module will be tested against voice commands to ensure they are accurately recognized.

5.5.2 iPhone Control

- GUI controls are tested to ensure user inputs are properly read into the microcontroller unit.
- Data sent through WiFi/Ethernet needs to be tested at the receiving end.

5.5.3 Microcontroller Unit

- Inputs from the iPhone and Voice Control module need to be tested to verify the accuracy of the data. We will monitor the data read into the microcontroller unit and ensure that they reflect the correct action intended by the user.
- Based on inputs from the Daylight Harvesting Control Unit, the Microcontroller Unit must dim lights to appropriate levels.
- Outputs from microcontroller based on the user inputs needs to properly switch/dim the correct lights.

5.5.4 Daylight Harvesting Control

- The module will be tested against different light intensities.
- The data outputted by this module needs to reflect the correct light intensity of the room.

5.5.5 Dimmer Switch

- We will test this module by sending inputs via the microcontroller unit and verifying that the lights are dimmed to the correct level intensity.

5.5.6 Electrical Outlet

- Similar to the Dimmer Switch, this module will be tested via inputs from the microcontroller unit and verified that the plugged in lamp turns off/on to the right commands.

5.6 Integration Testing / Simulation

Once individual unit tests satisfy all the necessary requirements, all parts must be integrated into the final product to test and solve any possible failures or functionality issues. Once proper functionality is achieved, the system must be checked for all safety requirements since that is a main concern. Integration testing focuses on the real time response between all the components from the voice command all the way to dimming and on/off lights.

The system is likely to be installed in the house with all the disturbing noises, so the system needs to be tested against all different levels of noise density and check the functionality in a noise pollution environment.

EVA Controls team has been searching for a testing site, and we may need room ASB9898 to test our final product. EVA Controls will contact applied science building manager to reserve the room regarding this issues.

Conclusion

Wireless controlling of electrical house device can be viewed as a three-tiered system consisting of person command as an input then receiving and processing it. For this project EVA control has to face three challenging phases to achieve successfully the goal of prototyping this unique project. The first phase is to design receive and processing units that are iPhone app, voice recognition and microcontroller units. Second, implement and test these three designs separately and get the desired output. Finally, we will integrate the whole system with all the relays, dimmer, daylight harvesting control and light wiring and test the overall system for the safety and reduce any unacceptable risks from the electrical connections to minimum. Mid-November of 2012 we have planned the implementation and testing the first prototype with a final production model to be developed in December.

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