SUNLINK

8888 University Drive, Burnaby, BC V5A 1S6
Phone: 778-235-4757 Email: ensc440-sunlink@sfu.ca

October 19th, 2015

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

Re: ENSC 305W/440W function specification for a solar real time transit display system

Dear Dr. Rawicz,

Enclosed is our *Function Specification for a Solar Real Time Transit Display System,* proposed by Sunlink. Sunlink's goal is to design a solar powered device to be mounted at any existing bus stop that will provide pertinent transit information such as accurate next bus arrival times. We aim for our device to be inexpensive, reliable, and easy to install.

The purpose of the Functional Specification is to outline the functionality of the Solarity. This includes system overview, overall device requirements, engineering standards, as well as sustainability and safety issues of our product.

The founding partners of our company, Zachary Kaarvik, Rohan Thomas, Dejan Jovasevic, Karen Ly-Ma, Rob Cornall and Tim Nguyen would like to personally thank you for your interest in our proposal. For any reason, feel free to contact us at ensc440-sunlink@sfu.ca.

Sincerely,

Zachary Kaarvik
CEO
Sunlink

Enclosure: Function Specification for a Solar Real Time Transit Display System

FUNCTIONAL SPECIFICATION

SOLAR REAL TIME TRANSIT DISPLAY SYSTEM

SUNLINK INC.

Issue Date: October 19, 2015
Revision: 1.1

ensc440-sunlink@sfu.ca
778-235-4757

Simon Fraser University,
8888 University Dr.
Burnaby, BC

Contact Person: Zachary Kaarvik
zkaarvik@sfu.ca

Submitted To : Dr. Andrew Rawicz-ENSC 440W
Steve Whitmore -ENSC 305W
School of Engineering Science
Simon Fraser University

Date Issued: October 19, 2015

ensc440-sunlink@sfu.ca
778-235-4757
Simon Fraser University,
8888 University Dr.
Burnaby, BC

EXECUTIVE SUMMARY

"Even after all this time the Sun never says to the Earth, "You owe me." Look what happens with a love like that, it lights the whole sky." - Hāfez [1]

The sun is constantly shining down on, it provide an incredible source of energy that we have not taken full advantage of. Power is a fundamental part of life for humans. We must harness this free energy from the sun and use it to create a better world for ourselves and for the planet. Sunlink plans on exploring green technology solutions, in turn attracting people to greener options like public transit.

Do you find the current transit system lacking convenient time scheduling solutions for users, and real-time information on when your bus will arrive? Not everyone can plan out when to catch a bus in certain situations, and some may find it frustrating endlessly waiting at a stop for that bus to arrive; wondering where it is. Some of TransLink's busier bus stops in Metro Vancouver, have paper schedules of bus arrival times but are not usually accurate or convenient. Sunlink plans on upgrading this system with an eco-friendly solution.

This document will outline Sunlink's solution called Solarity which will easily be installed on every bus pole in Greater Vancouver and will provide real-time updates on bus arrival times for that particular stop. Each solar powered product will access TransLink's data periodically to check on each bus and calculate an estimated time of arrival. Our system will be a low power and cost-effective solution, allowing for our product to be installed without additional infrastructures like power and data cables. Nearby transit users will be able to see details on bus information and other pertinent information through a display screen. This convenience will encourage more people to take the greener way for traveling.

Sunlink is a company composed of six talented engineers with enthusiasm about new technology. We have extensive experience in microcontrollers, real-time systems, 3D design, and computer programming. A combination of these skills as well as weekly meetings and teamwork will assure a reliable and cost-effective final product in under 14 weeks, with a budget estimated at $750 CAD.

ensc440-sunlink@sfu.ca
778-235-4757
Simon Fraser University,
8888 University Dr.
Burnaby, BC

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ensc440-sunlink@sfu.ca
778-235-4757
Simon Fraser University,
8888 University Dr.
Burnaby, BC

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ensc440-sunlink@sfu.ca
778-235-4757
Simon Fraser University,
8888 University Dr.
Burnaby, BC

GLOSSARY

2G	Second-Generation Wireless Telephone Technology
API	Application Program Interface
AT	ATtention
AVL	Automatic Vehicle Location
CSA	Canadian Standards Association
DCS1800	Digital Cellular System, an frequency band from 1710 to 1784 MHz
EGSM900	Extended Global System for Mobile Communications, an extended frequency band of GSM from 880 to 960 MHz
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communications
GSM850	Global System for Mobile Communications, an frequency band from 824 to849 MHz
HTTP	Hyper Text Transfer Protocol
I/O	Input/Output
IEEE	Institute of Electrical and Electronics Engineers
PCB	Printed Circuit Board
PCS1900	Personal Communications Service, an frequency band from 1850 to1909 MHz
PV	Photovoltaic
RoHS	Restriction of Hazardous Substances
RTTI	Real Time Transit Information
SIM	Subscriber Identification Module
SPI	Serial Peripheral Interface
TransLink	Corporation Responsible for Metro Vancouver's Transportation Network

ensc440-sunlink@sfu.ca
778-235-4757
Simon Fraser University,
8888 University Dr.
Burnaby, BC

1 INTRODUCTION

The Solarity Real Time Transit Display System is a relatively low cost system that easily mounts onto transit stop poles for the use of public transit commuters. The display system provides a convenient and precise method for checking the real time waiting durations of a given transit vehicle passing through that respective transit stop. It is compatible with information and data provided by TransLink. This document contains an extensive list of requirements and specifications that Sunlink will implement in the Solarity prototype. Each requirement has been categorized based on applicable subcomponents and prioritized based on feature priority.

1.1 SCOPE

This document describes the functional requirements for the Real Time Transit Display System. It provides a detailed description of the required functionality for a proof-of-concept model and partially describes the required functionality for the production model. The requirements laid out in this document will be relied on during the design and implementation of the proof-of-concept device, though minor modifications may be needed during development or after testing.

1.2 INTENDED AUDIENCE

The functional specification document is intended to be used by the members of the Sunlink team throughout the design and development stages to ensure that the design adheres to the required specifications. This document will also be used to measure project progress and to aid in user documentation and test plan creation.

1.3 CLASSIFICATION OF REQUIREMENTS

The follow convention has been established and will be utilized throughout this document to differentiate between different categories of functional requirements:

[R#-n p]

where *#* denotes the section number, *n* denotes the requirement number and *p* denotes the priority of the specification. The priority can have one of the following values:
P1 - critical priority; must be adhered to in the prototype.
P2 - secondary priority; will be adhered to if time permits.
P3 - tertiary priority; completion not planned for prototype, but would be necessary for the production quality product.

ensc440-sunlink@sfu.ca
778-235-4757
Simon Fraser University,
8888 University Dr.
Burnaby, BC

2 SYSTEM OVERVIEW

2.1 USAGE

The majority of user interaction with Solarity will be by transit customers who are waiting at a transit stop with Solarity installed. These customers can view the information presented on Solarity's display regarding next bus schedules and other pertinent information about the transit system. Our aim is to have our device as simple as possible to understand for a transit user, and as such we do not require input from an end user. The user will solely need to observe the information from the display which is updated automatically.

Solarity has proximity sensors to tell when people are nearby. When the transit customer is near the device their presence is detected and if the device is in sleep mode it will awaken and retrieve fresh data. When no users have been detected by the system for an appropriate length of time it will re-enter power saving sleep mode.

The other main, but less common, usage scenario is that of the person configuring Solarity. The person configuring the device must be able to input the number or ID of the transit stop that Solarity is installed at in order for the correct stop data to be displayed.

2.2 HIGH LEVEL DESIGN

Solarity consists of four subsystems.

The first subsystem involves the interface of bus numbers and times onto a low power e-paper display. The bus numbers and times are retrieved from a backend server which obtains the data through Translink's RTTI Open API system. Solarity's backend server sends the data to the device through a cellular data line. This cellular connection is provided by a GSM/GPRS modem which the microcontroller can use to access the internet. The microcontroller will be interfaced with a display where the information will be presented in a user friendly format.

The second subsystem is the power module. The system will require a battery large enough to power the microcontroller, the GSM module and the display throughout the daytime and nighttime. The battery capacity will have a high dependency on the active time of the device and will be charged continuously with a solar panel mounted on top of the bus pole. A battery charge controller will be wired between the batteries and the solar panel to prevent overcharging and pose as a safety measure.

The third subsystem utilizes sensors. In order to minimize the power consumption, proximity sensors will be added to the system to help detect when transit users are nearby. Solarity will generally remain in sleep mode during the night when busses are

ensc440-sunlink@sfu.ca
778-235-4757
Simon Fraser University,
8888 University Dr.
Burnaby, BC

no longer in service and traffic is low. In addition, Solarity requires a light sensor. The e-paper display does not contain a backlight and will be difficult to see with low ambient light. The light sensor will be used to track when to turn on the backlight for the screen to aid with visibility.

The fourth subsystem involves Solarity manager backend server. Each Solarity device will be assigned a unique ID and a bus stop location for installation. The backend server will store the locations of all installed Solarity devices and the corresponding device ID. When a request is sent, the server will look up the ID and location and relay the appropriate bus numbers and times back to the device.

Figure 1 shows a block diagram of the overall architecture of Solarity.

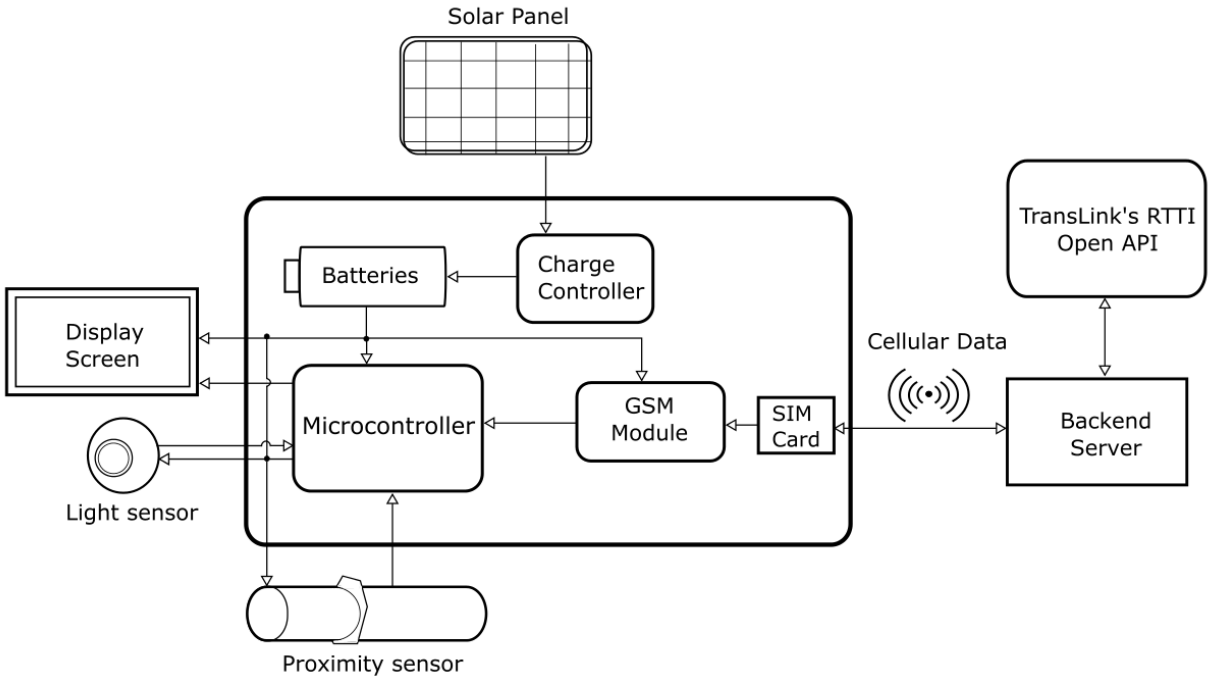

Figure 1: The block diagram of the overall architecture of Solarity.

ensc440-sunlink@sfu.ca
778-235-4757
Simon Fraser University,
8888 University Dr.
Burnaby, BC

3 SYSTEM REQUIREMENTS

3.1 GENERAL REQUIREMENTS

[R3.1-1 P3] The retail price of Solarity shall be under $600.

[R3.1-2 P1] The device shall be easy to assemble and disassemble.

[R3.1-3 P1] The device shall be easy to configure.

3.2 HARDWARE REQUIREMENTS

3.2.1 Electrical Requirements

[R3.2.1-1 P1] The GSM module shall be powered by its required voltage.

[R3.2.1-2 P1] The microcontroller shall be powered by its required voltage.

[R3.2.1-3 P1] The display shall be powered by its required voltage.

[R3.2.1-4 P1] The GSM module, microcontroller and display shall be powered by a shared battery pack.

[R3.2.1-5 P2] The system battery shall be charged by a solar panel.

[R3.2.1-6 P2] The solar panel shall provide accurate voltage for the battery pack.

[R3.2.1-7 P2] The solar real time transit display system shall have sufficient battery life to run for two days without an external power source.

[R3.2.1-8 P2] All switches shall be marked to indicate ON/OFF position.

3.2.2 Charging Requirements

[R3.2.2-1 P1] The charging module shall limit the current and voltage within the maximum ratings of the battery pack.

[R3.2.2-2 P1] The charger shall be intended for lithium ion batteries.

[R3.2.2-3 P2]The charger shall use a solar panel as its source of power

[R3.2.2-4 P1] The charger shall be able to detect battery levels to prevent overcharging

[R3.2.2-5 P1] The charger shall be able to operate from -40°C to 50°C.

ensc440-sunlink@sfu.ca
778-235-4757
Simon Fraser University,
8888 University Dr.
Burnaby, BC

3.2.3 Sensor Requirements

[R3.2.3-1 P1] Light and proximity sensor shall be controlled by the microcontroller.

[R3.2.3-2 P1] The proximity sensor shall be able to detect nearby users.

[R3.2.3-3 P2] The light sensor shall accurately measure the brightness from outdoors and switch on the backlight for the screen.

[R3.2.3-4 P2] The sensors shall be enclosed within a housing to be protected from outdoor weather conditions.

[R3.2.3-5 P2] The proximity sensor shall run in continuous mode.

[R3.2.3-6 P2] The light sensor shall sample at a certain interval.

3.2.4 GSM Module Requirements

[R3.2.4-1 P1] The GSM module shall support GSM850, EGSM900, DCS1800 and PCS1900 frequency bands.

[R3.2.4-2 P1] The GSM module shall able to send and receive GPRS data.

[R3.2.4-3 P1] The GSM module shall support at least a standard 2G SIM card.

[R3.2.4-4 P1] The GSM module shall support AT commands for GPRS communication.

3.2.5 Cellular Antenna Requirements

[R3.2.5-1 P1] The cellular antenna shall support GSM850, EGSM900, DCS1800 and PCS1900 frequency band.

[R3.2.5-2 P1] The cellular antenna shall have a sufficient length to function within the enclosure.

[R3.2.5-3 P1] The cellular antenna shall be compatible with the GSM module.

3.2.6 Microcontroller Requirements

[R3.2.6-1 P1] The microcontroller shall have enough programmable I/O pins to support all peripheral devices.

[R3.2.6-2 P1] The microcontroller shall implement all available low power features.

[R3.2.6-3 P1] The microcontroller shall support C/C++ programming.

ensc440-sunlink@sfu.ca
778-235-4757
Simon Fraser University,
8888 University Dr.
Burnaby, BC

3.2.7 Display Screen Requirements

[R3.2.7-1 P1] The display screen text shall be visible during the daytime and nighttime.

[R3.2.7-2 P1] The display screen shall be an e-paper display.

[R3.2.7-3 P1] The display screen shall have a low power consumption.

3.2.8 Wiring Requirements

[R3.2.8-1 P1] All electrical wiring shall be well insulated.

[R3.2.8-2 P1] All wiring shall be within the housing.

[R3.2.8-3 P2]All components within the enclosure shall be contained on a PCB board.

3.3 SOFTWARE REQUIREMENTS

Solarity has two independent software components. The first component, the device firmware resides on Solarity's microcontroller and controls the device's interaction with the display, the GSM module, the charging circuit, and the sensors. The second software component, the Solarity manager server will store the registered devices and their assigned stop numbers in a database. The server will also have an API which each device will query for its image data. The database will be managed by way of a web interface which an authenticated manager can log in to and add, modify, or delete devices and their assigned stops. Figure 2 shows the interaction between the software components.

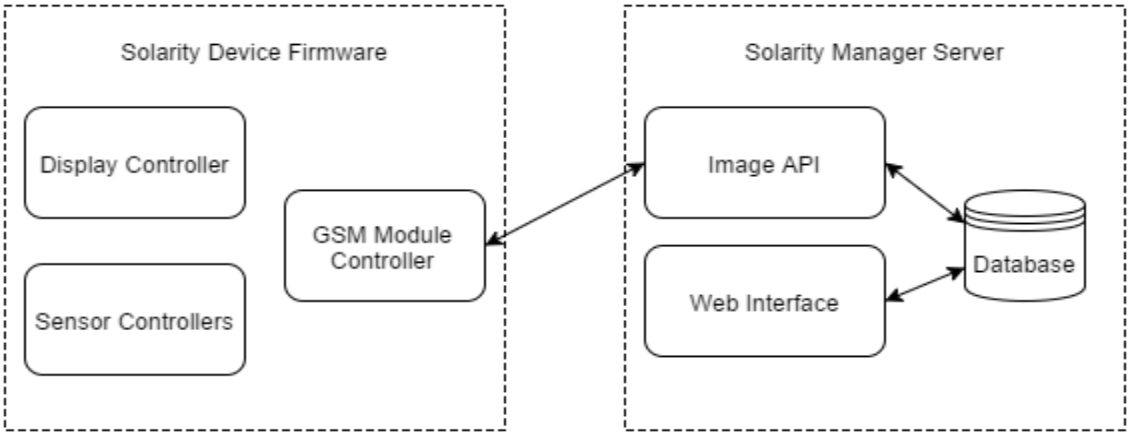

Figure 2: Solarity Software Interaction Diagram

ensc440-sunlink@sfu.ca
778-235-4757
Simon Fraser University,
8888 University Dr.
Burnaby, BC

3.3.1 Solarity Device (Client) Firmware Requirements

[R3.3.1-1 P1] The microcontroller shall interface with the GSM module to retrieve data over the HTTP protocol.

[R3.3.1-2 P1] The microcontroller shall interface with the display through an SPI protocol.

[R3.3.1-3 P1] Solarity shall display the next bus arrival times for all routes at the assigned stop.

[R3.3.1-4 P2] Solarity shall display transit alerts. These may include but are not limited to cancellations, system wide disruptions, and safety bulletins (e.g. amber alerts).

[R3.3.1-5 P1] Solarity shall retrieve the display image information from the Solarity manager server.

[R3.3.1-6 P1] Solarity shall update its display no less than once every five minutes while in active mode.

[R3.3.1-7 P2] Solarity shall enter sleep mode when no recent activity has been picked up by the proximity sensor. It will return to active mode once the proximity sensor detects a nearby object.

3.3.2 Solarity Manager (Server) Requirements

[R3.3.2-1 P1] The server software shall retain Solarity device IDs and the corresponding assigned transit stop numbers in a database.

[R3.3.2-2 P1] The server software shall generate and return image data when Solarity sends an HTTP request for this information.

[R3.3.2-3 P2] The server software shall be secured behind a login screen, a manager must log in with a preassigned username and password.

[R3.3.2-4 P1] The manager shall be able to add new devices and assign transit stop numbers.

[R3.3.2-5 P2] The manager shall be able to delete devices.

[R3.3.2-6 P2] The manager shall be able to modify stop numbers for existing devices.

ensc440-sunlink@sfu.ca
778-235-4757
Simon Fraser University,
8888 University Dr.
Burnaby, BC

3.4 MECHANICAL REQUIREMENTS

3.4.1 Enclosure Requirements

[R3.4.1-1 P1] The enclosure shall be designed for appropriate heat dissipation.

[R3.4.1-2 P1] The enclosure shall be large enough for all components to fit inside except the solar panel.

[R3.4.1-3 P3] The enclosure shall weigh under two pounds.

[R3.4.1-4 P2] The polarity of input and output leads shall be indicated.

[R3.4.1-5 P2] The enclosure shall be made of polymeric material which will not combust in air [2].

[R3.4.1-6 P3] Iron or steel components shall be protected against rusting [2].

[R3.4.1-7 P3] The enclosure shall be easily installable and removable on a circular pole.

[R3.4.1-8 P3] The enclosure shall be designated by the appropriate enclosure type number (See Table 1 in Appendix A). [3]

[R3.4.1-9 P3] The enclosure shall provide a degree of protection against varies environmental condition based on the enclosure type number (See Table 2 in Appendix A).

[R3.4.1-10 P3] The enclosure shall have a clear polymeric material to protect the display screen from damage.

[R3.4.1-11 P3] The enclosure shall not be shaped or decorated to resemble a toy [4].

[R3.4.1-12 P3] All electrical components inside the enclosure shall be secured so they cannot shift or move.

3.4.2 Solar Panel Placement Requirement

[R3.4.2-1 P3] The solar panel shall be easily mountable and removable on a circular pole.

[R3.4.2-2 P3] The solar panel shall be oriented to face south in the northern hemisphere and north in the southern hemisphere.

[R3.4.2-3 P3] The solar panel shall be mounted at a tilting angle of 15° with respect to the equator to maximize the solar panel array output. [5]

ensc440-sunlink@sfu.ca
778-235-4757
Simon Fraser University,
8888 University Dr.
Burnaby, BC

4 STANDARDS

[R4-1 P3] The device shall conform to CSA-C22.2 No. 1-15 Canadian Electrical Code Part I: Safety Standard for Electrical Installations [6]

[R4-2 P3] The device shall conform to CSA-C22.2 No. 0-10 Canadian Electrical Code Part II: General Requirements [4]

[R4-3 P3] The device shall conform to CSA-C22.2 No. 107.2.01- Battery Chargers [7]

[R4-4 P3] The device shall conform to CSA-C22.2 No. 94-M91 – Special Purpose Enclosures [3]

[R4-5 P3] The device shall conform to CSA-C22.2 No. 0.23-15 – General Requirements for Battery-Powered Appliances [2]

[R4-6 P3] The device shall conform to CSA-C22.2 No. 0.17-00 – Evaluation of Properties of Polymeric Materials [8]

[R4-7 P3] The device shall conform to RoHS [9]

ensc440-sunlink@sfu.ca
778-235-4757
Simon Fraser University,
8888 University Dr.
Burnaby, BC

5 SUSTAINABILITY & SAFETY

5.1 SUSTAINBILITY AND RELIABILITY

The reliability of Solarity is a critical aspect of the product. The device must be able to operate through months and years of servicing transit users.

The prototype device enclosure will be 3D printed with a strong, lightweight, and durable thermoplastic material. Individual parts of our product will be recyclable, lead-free, and toxic chemical free. Our system will be powered with environmentally friendly solar power.

The battery packs used by Solarity will be charged with solar power. The solar panels will provide enough energy throughout the year, even during days with limited sunlight.

The product will operate and remain reliable under a range of temperatures throughout the year and varying weather conditions.

5.2 SAFETY

Since Solarity will be installed in public areas, it will be subjected to many different environmental conditions as well as possible abuse from transit users. Solarity will be designed such that the risk of fire or electric shock as a result of abnormal operation, hazardous environment, and human factors are obviated as far as is practical. Solarity will meet the following safety requirements:

[R5.2-1 P1] The battery shall not be able to be installed in reverse polarity.

[R5.2-2 P1] The solar panel shall not be able to be installed in reverse polarity.

[R5.2-3 P3] The enclosure shall contain all live parts except for input leads and output leads or terminals [2].

[R5.2-4 P3] The enclosure shall have no sharp edges or burrs to prevent any risks during transportation, installation, and handling [3].

[R5.2-5 P3] The device shall not readily accept general purpose batteries (either primary or rechargeable) as an energy source for their primary function [2].

[R5.2-6 P3] The following message label will be located near the battery: “CAUTION – DANGER OF EXPLOSION IF BATTERY IS INCORRECTLY REPLACED. REPLACE ONLY WITH THE SAME OR EQUIVALENT TYPE.” [4].

ensc440-sunlink@sfu.ca
778-235-4757
Simon Fraser University,
8888 University Dr.
Burnaby, BC

[R5.2-7 P3] The charge controller shall have over current and over voltage protection to prevent any possible hazards.

[R5.2-8 P3] A manual switch shall be installed between the solar panel and the charge controller to connect or disconnect during installation and maintenance.

[R5.2-9 P3] The device shall not be able to be opened without a special tool.

[R5.2-10 P3] The electronic components shall not cause interference with other devices.

[R5.2-11 P3] The live components between the solar panel and device shall be insulated to prevent electric shock

ensc440-sunlink@sfu.ca
778-235-4757
Simon Fraser University,
8888 University Dr.
Burnaby, BC

6 CONCLUSION

These functional specifications handle the requirements and capabilities of Sunlink's current design for Solarity.

The functional specifications were broken up into three major categories: Hardware, Software, and Mechanical, where each requirement has a specific priority. We are committed to completing critical requirements like easy configurability and basic power supply needs within our development phase, and if time permits, complete the lower priority requirements. Sustainability and safety is also a big concern to factor in for our product as reliability is key for success, and with the product in contact with the public 24/7, safety requirements must be followed closely.

The development of our proof-of-concept is well underway and we will be seeing a working prototype by December 2015.

ensc440-sunlink@sfu.ca
778-235-4757
Simon Fraser University,
8888 University Dr.
Burnaby, BC

7 REFERENCES

[1] K. S. Hāfez, "The Gift," Page 160, 1350. [Online]. Available: http://www.goodreads.com/author/show/859027._. [Accessed September 2015].

[2] CSA Group , "CSA C22.2 No. 0.23-15 : General requirement for battery-powered appliances," Toronto , 2015.

[3] CSA Group, "CSA C22.2 No.94-M91: Special Purpose Enclosures (reaffimed 2011)," Toronto, 1991.

[4] CSA Group, "CSA C22.2 No.0-10: General requirments - Canadian Electrial Code, Part 2 (reaffirmed 2015)," Toronto , 2010.

[5] IEEE, "IEEE 1562 - Guide for Array and Battery Sizing in Stand-Alone PV Systems," New York, 2007.

[6] CSA Group, "CSA C22.1-15: Canadian Electrial Code, Part 1: Safety Standard for Electrial Installations," Toronto, 2015.

[7] CSA Group , "CSA C22.2 No. 107.2-01 : Battery Chargers (reaffirmed 2011)," Toronto , 2008.

[8] CSA, "CSA-C22.2 No. 0.17-00 – Evaluation of Properties of Polymeric Materials (reaffirmed 2013)," Toronto, 2000.

[9] RoHS, "RoHS Compliance," 13 October 2015. [Online]. Available: http://www.rohsguide.com/. [Accessed 15 October 2015].

ensc440-sunlink@sfu.ca
778-235-4757
Simon Fraser University,
8888 University Dr.
Burnaby, BC

APPENDIX A

Table 1: Enclosure Type Definitions [3]

Type	Description
Type 2	An enclosure for indoor use, constructed so as to provide a degree of protection against dripping and light splashing of noncorrosive liquids, and falling dirt.
Type 3	An enclosure for either indoor or outdoor use, constructed so as to provide a degree of protection against rain, snow, and windblown dust; undamaged by the external formation of ice on the enclosure.
Type 3R	An enclosure for either indoor or outdoor use, constructed so as to provide a degree of protection against rain, and snow, undamaged by the external formation of ice on the enclosure.
Type 3S	An enclosure for either indoor or outdoor use, constructed so as to provide a degree of protection against rain, snow, and windblown dust; the external mechanism(s) remain operable while ice covered.
Type 4	An enclosure for either indoor or outdoor use, constructed so as to provide a degree of protection against rain, snow, windblown dust, splashing and hose-directed water; undamaged by the external formation of ice on the enclosure.
Type 4X	An enclosure for either indoor or outdoor use, constructed so as to provide a degree of protection against rain, snow, windblown dust, splashing and hose-directed water; undamaged by the external formation of ice on the enclosure; resists corrosion.
Type 5	An enclosure for indoor use, constructed so as to provide a degree of protection against dripping and light splashing of noncorrosive liquids, and settling dust, lint, fibres, and flyings.
Type 6	An enclosure for either indoor or outdoor use, constructed so as to provide a degree of protection against the entry of water during temporary submersion at a limited depth; undamaged by the external formation of ice on the enclosure.
Type 6P	An enclosure for either indoor or outdoor use, constructed so as to provide a degree of protection against the entry of water during prolonged submersion at a limited depth; undamaged by the external formation of ice on the enclosure; resists extended corrosion.
Type 12	An enclosure for indoor use, constructed so as to provide a degree of protection against circulating dust, lint, fibres, and flyings; dripping and light splashing of noncorrosive liquids; not provided with knockouts.
Type 12K	An enclosure for indoor use, constructed so as to provide a degree of protection against circulating dust, lint, fibres, and flyings; dripping and light splashing of noncorrosive liquids; and provided with knockouts.
Type 13	An enclosure for indoor use, constructed so as to provide a degree of protection against circulating dust, lint, fibres, and flyings; seepage and spraying of noncorrosive liquids including oils and coolants.

ensc440-sunlink@sfu.ca
778-235-4757
Simon Fraser University,
8888 University Dr.
Burnaby, BC

Table 2: Comparison of Specific Application of Enclosures for Nonhazardous Locations [3]

Provides a degrees of protection against the following environmental conditions	Type of Enclosure											
	2	3	3R	3S	4	4X	5	6	6P	12	12K	13
Dripping and light splashing of noncorrosive liquids, falling dirt	x	x	x	x	x	x	x	x	x	x	x	x
Circulating dust, lint, fibres, and flyings	-	x	-	x	x	x	-	x	x	x	x	x
Setting dust,lint, fibres, and flyings		x		x	x	x	x	x	x	x	x	x
Hose down and splashing water	-	-	-	-	x	x	-	x	x	-	-	-
Corrosion	-	-	-	-	-	x	-	-	x	-	-	-
Occasional temporary submersion	-	-	-	-	-	-	-	x	x	-	-	-
Occasional prolonged submersion	-	-	-	-	-	-	-	-	x	-	-	-
Oil and coolant seepage, spraying and splashing	-	-	-	-	-	-	-	-	-	-	-	x
Rain, snow, and external formation of ice*	-	x	x	x	x	x	-	x	x	-	-	-
External formation of ice+	-	-	-	x	-	-	-	-	-	-	-	-
Wind-blown dust	-	x	-	x	x	x	-	x	x	-	-	-

*External operating mechanism(s) shall not be required to operate when the enclosure is ice covered.
+External operating mechanism(s) shall be operable when the enclosure is ice covered.
“X” indicates a degree of protection is provided.

ensc440-sunlink@sfu.ca
778-235-4757

Simon Fraser University,
8888 University Dr.
Burnaby, BC

SUNLINK
Simon Fraser University,
8888 University Dr.
Burnaby, BC Canada
Email: ensc440-sunlink@sfu.ca