October 14, 2014

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

Re: ENSC 305W/440W Functional Specification for the Plantmosphere, an automated greenhouse system

Dear Dr. Rawicz,

The following functional specification document outlines the various requirements of our product. The Plantmosphere automated greenhouse system controls key elements for plant growth to institute food production in virtually any environment. Our gardening solution requires no prior knowledge or technical experience to operate and has been designed to work in the harsh sub-Saharan Africa climate.

The enclosed functional specification provides the complete set of high-level requirements for a prototype and also establishes future goals for the final production model. This document will serve as reference material throughout our product's development phases.

Plantmosphere Technologies is a team of six diverse and highly qualified engineers: Faisal Emami, Terry Hannon, Jane Horton, Alex Naylor, Jeffrey Shum, and Mike Thiem. Please feel free to contact me via email at jhorton@sfu.ca with any questions or concerns regarding our functional specification.

Sincerely,

Jane Ashley Horton
Design Engineer
Plantmosphere Technologies

Plantmosphere

Functional Specifications Document

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Figure 1: The Greenhouse Structure [1]

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Glossary

Arduino	Open-source microcontroller enabling more control over the physical world
ATX	**A**dvanced **T**echnology e**X**tended motherboard form factor specification
BS	**B**ritish **S**tandards
CO2	**C**arbon Di**O**xide
CSA	**C**anadian **S**tandards **A**ssociation
IEC	**I**nternational **E**lectrotechnical **C**ommission
NFPA	**N**ational **F**ire **P**rotection **A**ssociation
Opto-isolator	An electronic component that transfers electricity to between two circuits by using light
RH	**R**elative **H**umidity
RoHS	**R**estriction **o**f **H**azardous **S**ubstances directive
Venturi Effect	The tendency of high-speed gas flow to entrain adjacent, lower velocity gas

Executive Summary

Despite Sub-Saharan Africa's ample agricultural resources, more than one quarter of its 856 million residents are undernourished [2]. Malnutrition plagues the region, resulting in stunted growth in children and lowered productivity in adults [2]. Insufficient education leaves inhabitants unable to effectively use farming technologies, while those living in poverty are unable to afford the expensive imported foods [2]. Plantmosphere Technologies aims to rectify these rampant issues by providing a cheap, sustainable solution.

The Plantmosphere is a user-friendly, automated greenhouse system designed to manage a plant's environment for the duration of its growth cycle, with minimal user input. Our product's durability and focus on water recycling makes it an attractive option for the unpredictable Sub-Saharan Africa climate. The Plantmosphere's modular system design allows users to purchase optional modules that provide additional functionality, enhancing the gardening experience.

The development cycle of this project has been divided into two main phases:

Phase 1:
- Assemble the greenhouse
- Design, build, and test the essential automation systems
- Power the systems with mains electricity

Phase 2:
- Design, build, and test the non-essential automation systems
- Migrate the system from mains electricity to self-sustainable power sources

The completion of the first phase will result in the product prototype to be demonstrated at the close of the term. The latter phase focuses heavily on self-sustainability and modularity to augment the Plantmosphere's versatility. An alternative power source will be incorporated to eliminate the need for reliance on mains electricity, and support for extra sensors will add control over more environmental factors. Both development phases will prioritize safety and standard compliance to ensure the well-being of our customers and modular compatibility of our product.

The following document provides detailed functional specifications for each subsystem, general requirements for the system as a whole, and a test plan outline.

1 Introduction

The Plantmosphere is a greenhouse system that will maintain the appropriate environment needed to effectively grow vegetables. Our product will be easy to set up and operate such that even non-gardeners can grow plants.

1.1 Scope

This document describes the functional requirements for the Plantmosphere. The requirements are divided into sections based on function and are classified based on need and development phase.

1.2 Intended Audience

The intended audience for the document includes product designers, product developers, project managers, business stakeholders, quality assurance, change management, and investors. The document needs to be detailed but also non-technical because the intended audience includes non-technical personnel.

1.3 Development Constraints

Currently, Plantmosphere Technologies lacks the capital necessary to engage in mass production resources that would aid in making the Plantmosphere an economically viable venture. Moreover, we lack the expertise to effectively market the product without consulting with professionals in that field.

The prototype system will incorporate scavenged parts to reduce development costs. Additionally, the system will use pre-existing standalone products as components in order to cut down on design labour and to meet development milestones on-schedule.

The final version of the product would not include any scavenged parts unless a reliable and consistent source of recycled materials could be located. Incorporating existing products into the Plantmosphere would require appropriate licensing and permissions to be granted, which we do not currently have.

While we are designing the Plantmosphere for use in sub-Saharan Africa, the only biome in which we will perform testing is that of Vancouver's temperate rainforest, which differs significantly from the demographic geography. The final version of the product would need to be more thoroughly tested in a variety of climates to ensure environmental compatibility.

The development team is made up of driven, motivated, engineering students. However, we lack any horticultural experience. To ensure that the Plantmosphere addresses all the needs of the various plants that could be grown in it, it would be beneficial to involve such experts in the design process. While we will be seeking the advice of such professionals, we do not have the funding to contract these resources.

1.4 Classification

This document uses the following classification method: [C.S.R-P]

- C - Category: The category the requirement belongs to (i.e. Hardware).
- S - Subcategory: The subcategory the requirement belongs to (i.e. Arduino).
- R - Requirement: The requirement number within the subcategory.
- P - Priority: The priority of the requirement:
    - A - Showstopper[1]; prototype development phase
    - B - Must Have[2]; prototype development phase
    - C - Nice to Have; final production phase
    - D - Optional; future product revisions

2 System Requirements

2.1 System Overview

Once the Plantmosphere is set up and the plants, seedlings, or seeds are planted – the user only needs to enter a few pieces of information into the user interface to start the process.

2.1.1 User Interface

The user will enter the following information:

- Plant Type
- Growth Stage

In order to maintain the appropriate environment the Plantmosphere needs to know what plant the user will grow. Using this information, various target parameters will be established by the Plantmosphere, including soil saturation, air temperature range, daily light flux, and air humidity. Additionally, plants have different needs depending on what stage of growth they are in. The Plantmosphere will predict how long the plants will be in each stage.

2.1.2 Irrigation System

The Plantmosphere will turn on the irrigation system when soil saturation levels are below a minimum value and will keep it on until the moisture content reaches a desired threshold value.

[1] A "Showstopper" priority requirement is one that, without fulfillment, halts the development process entirely. (i.e. without a greenhouse enclosure, there would be no environment to control.)
[2] A "Must Have" priority requirement defines the systems required for the basic functionality of our product. (i.e. without an irrigation system, the plants would not survive.)

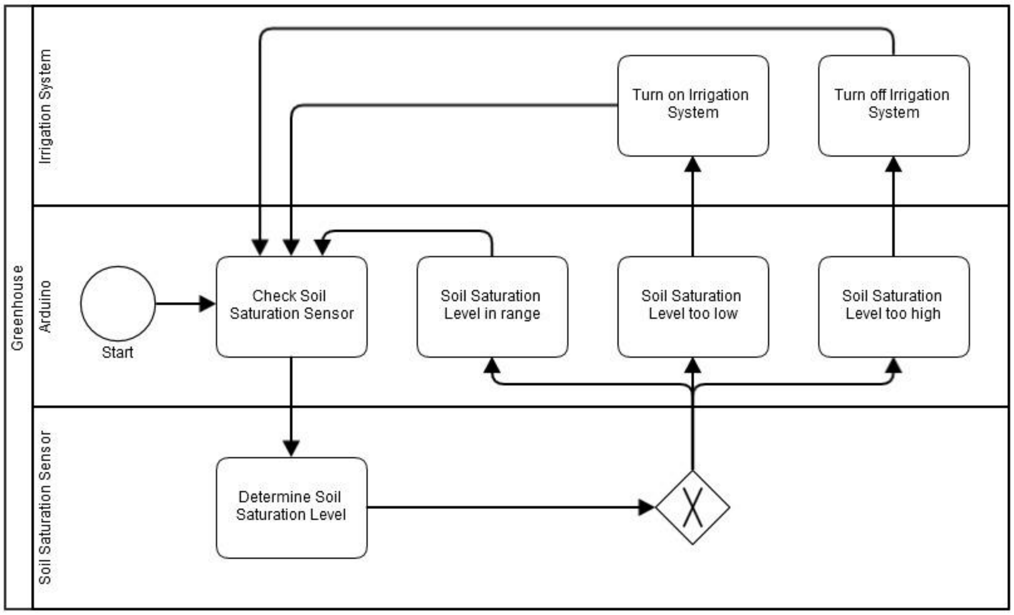

Figure 2: Irrigation Process Flow Diagram

A reservoir designed to store the water needed for irrigation and humidification will keep the Plantmosphere as water efficient as possible. Two main methods of water capture will be included:

- Rainwater capture through eaves
- Water run off through eaves under the planters

2.1.3 Ventilation System

The Plantmosphere will control vents in the upper and lower sections of the greenhouse to maintain temperature and humidity. Fans will also be used to circulate air and ensure sections of the Plantmosphere's interior do not stagnate. Fans will also be turned on occasionally to ensure plant leaf movement in order to improve the diffusion of carbon dioxide into the plant.

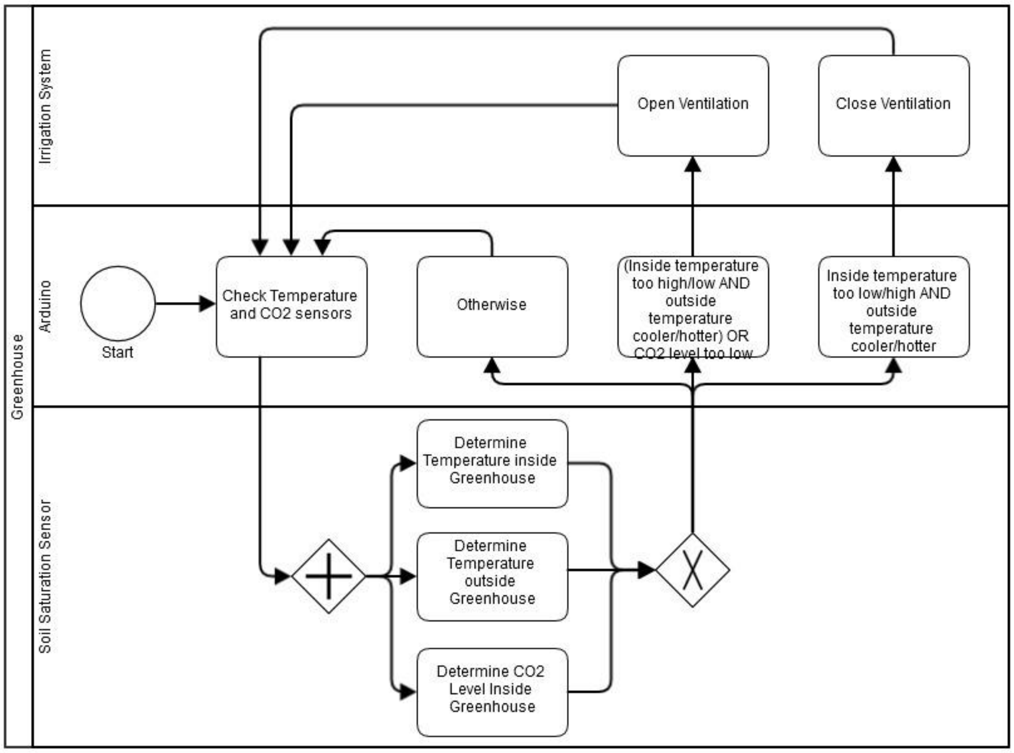

Figure 3: Ventilation Process Flow Diagram

2.1.4 Lighting System

The Plantmosphere will monitor the amount of light the plants are getting from sunlight and augment it through the use of artificial lighting. The system will measure the light incident upon the plants and turn on the artificial lighting system compensate if required.

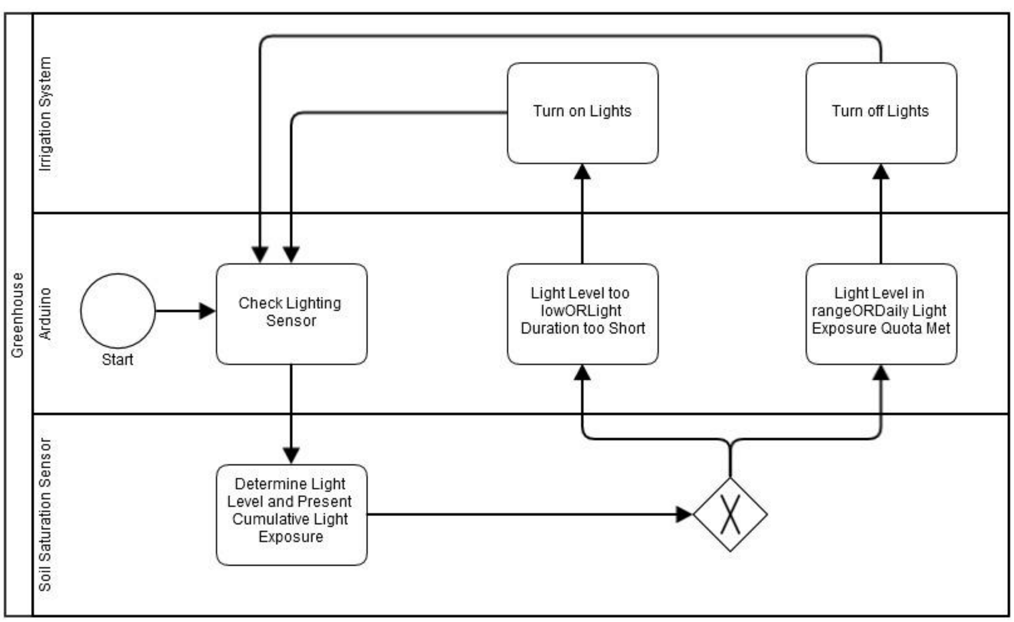

Figure 4: Lighting Process Flow Diagram

2.1.5 Soil Heating System

The Plantmosphere will ensure that the soil does not fall outside of a specified temperature range by employing a soil temperature sensor. When the soil becomes too cold, the heating system will turn on and remain active until the temperature of the soil has reached an acceptable value.

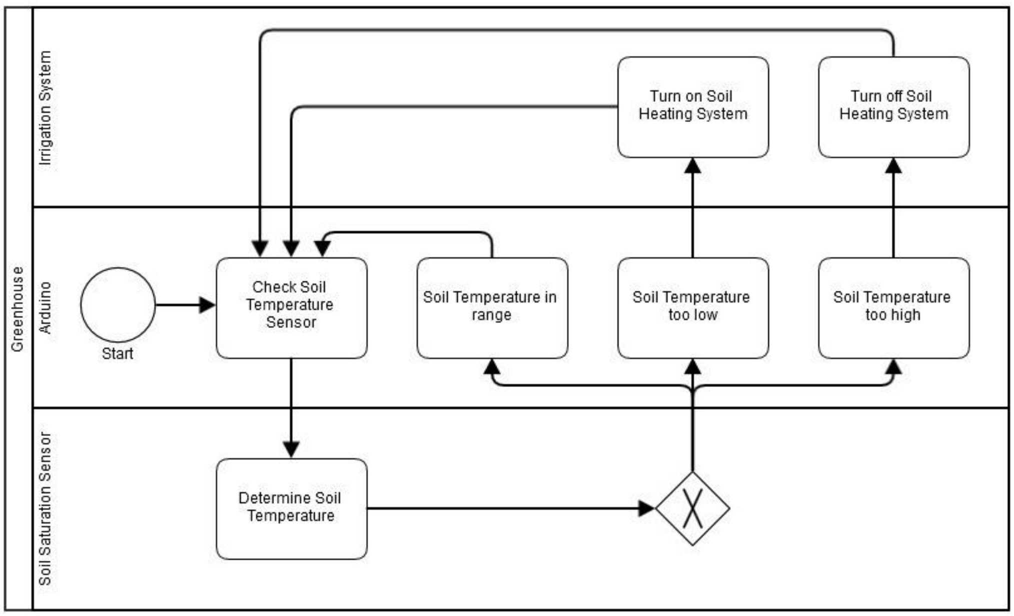

Figure 5: Soil Heating Process Flow Diagram

2.1.6 Humidification System

The Plantmosphere will ensure that the humidity in the greenhouse is optimal through the use of a humidity sensor and a humidifier. The humidification system will raise the RH when the air becomes too dry and then stay on until it reaches an ideal condition.

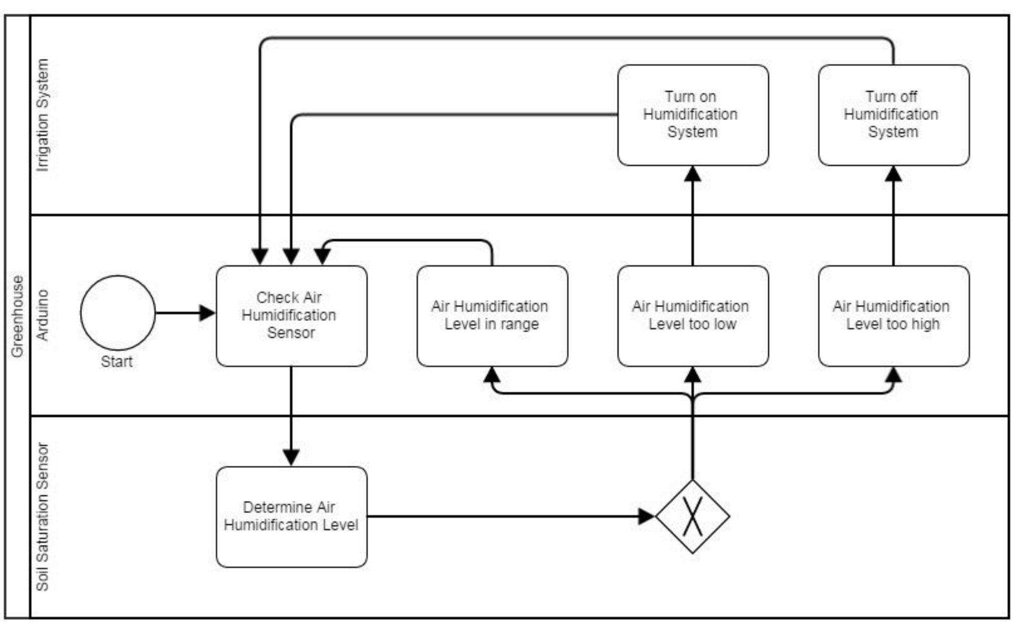

Figure 6: Humidification Process Flow Diagram

2.2 Performance Requirements

R2.2.1-A The system will promote healthy plant growth.

R2.2.2-B The system will automate control of the following parameters:

- Interior Air Temperature
- Soil Temperature
- Soil Moisture
- Interior RH
- Plant Light Exposure

R2.2.3-B The system will simultaneously accommodate multiple plants.

R2.2.4-D The system will simultaneously accommodate multiple plant types.

R2.2.5-C The Plantmosphere software will be open source.

- **Rationale:** Users should be able to modify the source code to include other features.

R2.2.6-C The Plantmosphere hardware will be modular and user-configurable.

- **Rationale:** Users should be able to customize the Plantmosphere to tailor to their specific needs.

R2.2.7-B The Plantmosphere system will be intuitive and easy to install for any user.

2.3 Structural Requirements

R2.3.1-D The greenhouse structure will be secured to the ground.

R2.3.2-B The greenhouse will have a lock to protect the interior contents.

R2.3.3-B The greenhouse structure will be installed in a location that is not subject to water pooling.

R2.3.4-B The installation site for the greenhouse structure will have adequate water drainage capabilities.

R2.3.5-B Rainwater will not penetrate the greenhouse structure by any means other than rainwater collection system.

R2.3.6-C The greenhouse structure will be sufficiently transparent to the wavelengths of light used for photosynthesis to support plant life.

R2.3.7-C The troughs or planters that contain the soil and plants will be situated at an accessible height.

R2.3.8-B The greenhouse interior will be sufficiently thermally insulated from the exterior.

- **Rationale:** This allows the greenhouse to retain heat in cold weather, reducing the need for active internal ambient heating.

R2.3.9-B The greenhouse's dimensions will be sufficiently large to accommodate at least one user.

2.4 Electrical Requirements

R2.4.1-A All electrical connections will comply with CSA C22.1-12 [3].

R2.4.2-C All electrical connections will comply with NFPA 70 [4], BS 7671 [5], and IEC 60364 [6] & 61558 [7].

- **Rationale:** Future product versions should be electrically compatible internationally.

R2.4.3-B The system will use mains electricity.

R2.4.4-C The system will use self-sustainable power sources.

R2.4.5-C All electronic components will minimize power usage.

R2.4.6-A All interconnects will be electrically insulated to prevent damage.

R2.4.7-A All electronics and interconnects will be isolated to prevent shorts and ground loops.

- **Rationale:** Circuit breakers and opto-isolators can be used to protect the electronics.

R2.4.8-A All electrical components will be properly grounded.

2.5 Safety Requirements

R2.5.1-A All electrical connections will comply with CSA C22.1 [3].

R2.5.2-C All electrical connections will comply with NFPA 70 [4], BS 7671 [5], and IEC 60364 [6] & 61558 [7].

- **Rationale:** Future product versions should be electrically compatible internationally.

R2.5.3-A All electronic components will be adequately insulated from detrimental conditions to reduce the risk of device damage and fire hazards.

R2.5.4-A All electronic components and wiring will be lead-free and RoHS compliant.

R2.5.5-A All solder will be lead-free and RoHS compliant.

R2.5.6-A All interconnects will be electrically insulated to prevent damage.

R2.5.7-A All electronic components will be sealed to minimize human interaction and improve safety, without interfering with the Plantmosphere’s configurability.

R2.5.8-A Openly accessible system components will be designed with rounded edges to minimize risk of injury.

R2.5.9-A Warnings will be posted in appropriate, high visibility locations to notify the user of hazards.

R2.5.10-A The water reservoir will be sealed to prevent contamination and human consumption.

R2.5.11-A The Plantmosphere’s build materials will not contaminate or pollute proximal water, or otherwise render the water unsafe for humans or plants.

R2.5.12-A Mountable components will be securely fastened to a stable structure.

3 Hardware Requirements

3.1 Arduino Requirements

R3.1.1-A The Arduino input voltage will be between 7-12 V [8].

- Less than 7 V causes the 5 V pin to supply less than 5 V, and the board becomes unstable.
- More than 12 V can cause the voltage regulator to overheat, leading to permanent damage.

R3.1.2-A The Arduino will be limited to 20 mA per output pin, without exceeding 200 mA total current consumption [8].

R3.1.3-A The Arduino will interface with all sensors and actuators.

R3.1.4-C Additional Arduinos will be incorporated into the system to improve reliability.

3.2 Sensor Requirements

R3.2.1-A All sensors will be monitored by the Arduino.

R3.2.2-C All sensors will have redundancies to improve reliability.

R3.2.3-B All sensor voltage requirements will conform to the ATX form factor.

- **Rationale:** This allows sensors to be powered by commonly available power supplies.

R3.2.4-B All sensors will have minimal environmental interaction.

- **Rationale:** This is important as any readings the sensors take should not disturb its surroundings and falsify measurements.

R3.2.5-B Temperature sensors will be used to monitor both the internal and external temperature.

- **Rationale:** This is required to give feedback to the airflow system.

R3.2.6-B Humidity sensors will be used to monitor RH both inside and outside the greenhouse.

- **Rationale:** This is required to give feedback to the humidity control system.

R3.2.7-B Light sensors will be used to monitor the light incident upon each plant.

R3.2.8-C A carbon dioxide sensor will be used to monitor the carbon dioxide concentration inside the greenhouse.

- **Rationale:** This is required to give additional feedback to the airflow system.

R3.2.9-D A pH sensor will be used to monitor the pH levels of each plant's soil.

3.3 Lighting Requirements

R3.3.1-B The lighting will be encased inside a surface mountable box for easy installation.

R3.3.2-A The lights will be mounted such that they provide maximum lighting without blocking natural sunlight.

R3.3.3-A The emission spectrum of the lighting system will be optimized for the absorption spectrum of the plants.

R3.3.4-B The lights will be controlled by the Arduino microcontroller based on input from the light sensors and the lighting requirements of the plants.

3.4 Ventilation Requirements

R3.4.1-B The fan orientation will be manually adjustable.

R3.4.2-B The fan arrangement will ensure well-mixed interior air.

R3.4.3-B The fan arrangement will ensure sufficient leaf movement.

- **Rationale:** Plant leaf movement improves the diffusion of carbon dioxide into the plant.

R3.4.4-B The fans will be placed perpendicular to the lower intake vent.

- **Rationale:** This allows the fan to draw in exterior air using the Venturi effect, reducing the total number of necessary fans.

R3.4.5-B The maximum exhaust fan airflow rate will provide a sufficiently rapid air exchange.

- **Rationale:** This allows the temperature control system to maintain cool greenhouse temperatures in hot weather.

R3.4.6-B The fans will have a variable flow rate.

R3.4.7-B All vent position control will be motor driven.

R3.4.8-B In the closed position, all vents will be airtight.

- **Rationale:** This provides a necessary thermal and moisture barrier.

R3.4.9-B In the open position, all vents will provide adequate passive air circulation.

- **Rationale:** This reduces power consumption by removing the need for constant forced ventilation.

R3.4.10-B The lower intake vent will be installed near the bottom of the sidewalls.

- **Rationale:** This provides the largest height difference between the lower vent and roof vent, maximizing passive ventilation capabilities.

R3.4.11-A The lower vent will be installed sufficiently high up on the greenhouse wall to prevent floodwater ingress.

3.5 Humidification Requirements

R3.5.1-B The humidification system will maintain the interior air's RH at optimal levels, as determined by the plant type.

R3.5.2-B The humidification system will minimize the use of water.

R3.5.3-B The humidification system will disperse a mist of water from the reservoir to increase the RH of the interior air as required.

- **Rationale:** This ensures that the plants will remain in their optimal humidity range.
- **Additional Rationale:** Controlling RH gives the Plantmosphere an additional means of regulating internal temperature.

R3.5.4-B The humidification system will minimize losses of water from the reservoir due to evaporation and leakage.

R3.5.5-B The humidification and irrigation systems will be independently controlled.

- **Rationale:** This will prevent situations such as unintentionally over-watering the soil while trying to humidify the air.

3.6 Irrigation Requirements

R3.6.1-B The irrigation system will include a rainwater collection system, which will retain captured rainwater in a reservoir.

R3.6.2-B The irrigation system will monitor the moisture level of the soil in multiple locations.

R3.6.3-B The irrigation system will draw water from the reservoir and supply an appropriate amount of water to the soil.

R3.6.4-B The reservoir will be placed inside the greenhouse structure.

- **Rationale:** The large thermal mass of the water reservoir will help stabilize the air temperature of the greenhouse as the air temperature fluctuates.

R3.6.5-B The reservoir will be dark in colour to allow efficient absorption of heat energy from incident sunlight.

R3.6.6-C The reservoir will be able to release captured thermal energy back into the greenhouse's interior air when necessary.

R3.6.7-B The reservoir and its connections will not leak water.

R3.6.8-B The reservoir and its connections will minimize evaporative losses of water.

R3.6.9-B In the event of reservoir water overflow water will be safely directed away from water-sensitive hardware, and towards drainage.

R3.6.10-C The irrigation system will measure the volume of water used during each watering cycle.

- **Rationale:** This allows the controller to estimate how long the remaining water in the reservoir will last if no additional water is added and offers redundancy.

R3.6.11-B The reservoir's water level will be directly measured.

R3.6.12-B The irrigation system will warn the user when the water reservoir is nearly empty.

R3.6.13-B In addition to the rainwater collector, the reservoir will have a conveniently accessible refill port.

- **Rationale:** This will allow the user to add additional water to the reservoir.

R3.6.14-C The irrigation system will recapture runoff water from the bottom of the plant troughs.

R3.6.15-C Runoff water captured from the plant troughs will be filtered sufficiently to make it safe for plant irrigation.

3.7 Soil Heating Requirements

R3.7.1-B The output of the soil heating system will be continuously monitored by temperature sensors.

R3.7.2-B The soil heating system will activate as necessary to maintain the soil temperature within an acceptable range.

- **Rationale:** This prevents the plants from freezing or overheating.

R3.7.3-B The soil heating system will provide evenly distributed heat throughout the soil.

- **Rationale:** Hot or cold patches of soil can hinder plant growth.

4 Software Requirements

4.1 General Requirements

R4.1.1-A The system software will be compatible with the Arduino platform.

R4.1.2-A The system software will continuously monitor sensor output.

R4.1.3-A The system software will control actuator output.

R4.1.4-B The software will be able to continuously acquire and store sensor signal data.

- **Rationale:** Sensor signal data is required for system testing and analysis.

R4.1.5-C The software will be open-source.

- **Rationale:** Open-source software allows for user-customizable system automation.

4.2 User Interface (UI) Requirements

R4.2.1-B The following inputs will be user-configurable via the user interface:

- Plant Type
- Power (On|Off)

R4.2.2-B The following information will be displayed to the user:

- System Health Status (OK|Error)

R4.2.3-C The following data will be visible to the user:

- Environment Target Parameters
- Soil Temperature
- Soil Moisture Level
- Internal and External Temperature
- Internal and External Humidity
- Remaining Required Light
- Water Reservoir Level
- Lighting System Status (On|Off)
- Humidification System Status (On|Off)
- Irrigation System Status (On|Off)
- Fan Status (On|Off)
- **Rationale:** The user requires access to system data in order to make sure the greenhouse is functioning desirably.

R4.2.4-B The user interface will be simple and intuitive.

- **Rationale:** The user should not require any previous knowledge of gardening to operate the Plantmosphere system.

5 Sustainability Requirements

R5.0.1-B The system will use Arduino microcontrollers, which can be repurposed after the product's lifespan has elapsed.

R5.0.2-B The irrigation system will collect rainwater and use it to irrigate the plants.

R5.0.3-B The irrigation system will recycle trough water and use it to irrigate the plants.

R5.0.4-B The Plantmosphere will be energy efficient.

R5.0.5-C The Plantmosphere will be powered by a self-sustaining energy source.

R5.0.6-B The Plantmosphere will sustainably promote plant growth.

- **Rationale:** The product itself is performing a sustainable process, as it produces food in a self-sustained and energy-efficient manner.

R5.0.7-C The prototype greenhouse will be made of recyclable materials.

6 System Test Plan

Testing of the Plantmosphere will be comprised of verification and validation of individual system components, and the system as a unit to ensure performance, reliability, and safety. Test suites will be executed on hardware and software components. Sensor signals will be obtained with a data acquisition system and exported to a storage device in order to monitor communication between software inputs and system outputs. Electrical equipment functionality and safety will be verified with a comprehensive testing procedure.

Table 1 lists the system components in terms of environmental parameters and their respective actuators to be tested as individual closed loop systems. Our team will test these subsystems in parallel prior to integration testing.

Table 1: Sensed Parameters and Their Corresponding Actuating Systems

Sensor Parameter	Actuating System
Light Intensity	Lighting
Ambient Temperature	Ventilation
Relative Humidity	Humidification
Soil Moisture	Irrigation
Soil Temperature	Soil Heating

6.1 Electrical Safety Testing

- Ensure the hermeticity of electrical insulation and enclosure subsections by individually exposing them to moisture and successively probing for failures.
- Verify the performance of our breaker circuit by employing a voltage tester.
- Verify that electrical component temperatures are not excessively high while under load.

6.2 Module Verification Testing

6.2.1 Arduino

- Test that the Arduino can read and handle all sensor signals without malfunctioning.
- Quantify latency between commands initiated by the Arduino and component response, and ensure that latency is within acceptable bounds.

6.2.2 Lighting System

- Test whether the lighting system delivers evenly distributed light by placing light sensors throughout the plant trough and comparing their output values.
- Verify that the lighting system can supply sufficient light to plants to eliminate their sunlight dependency.
- Ensure that software commands from the Arduino to control light intensity are executed correctly.

6.2.3 Ventilation System

- Distribute multiple temperature sensors within the greenhouse structure. Compare sensed values to test whether the ventilation system can maintain isothermal internal air temperature.
- Verify that software commands from the Arduino to control the fans are executed correctly.

- Verify that software commands from the Arduino to control the vent positions are executed correctly.

6.2.4 Humidification System

- Ensure that the air humidification system can control humidity within the enclosure by quantifying system output versus sensed humidity.
- Test that software commands from the Arduino to the humidification system are executed correctly.

6.2.5 Irrigation System

- Verify that the output values of the soil moisture sensors are reasonable by comparing sensor output in dry soil with water-saturated soil.
- Test that the irrigation system evenly distributes a controlled volume of water by monitoring reservoir volume displacement, water pressure delivered by the pump, and soil moisture levels.
- Ensure that software commands sent from the Arduino to the irrigation system are executed correctly.

6.2.6 Soil Heating System

- Verify the soil temperature read from the temperature sensor against a soil thermometer to ensure accuracy.
- Distribute multiple soil temperature sensors across the soil in order to verify even thermal distribution delivered by the soil heating system.
- Verify that software commands from the Arduino to turn the heating system on and off are executed correctly.

6.3 Integration Testing

- Run all modules simultaneously from the Arduino and verify that all environmental parameters reach and remain stable at the configured inputs. Acquire continuous data of all obtainable signals and verify that the outputs are consistent with the expected values.
- Run various worst-case-scenario tests to map the operational boundaries of the integrated system.

6.4 System Validation Testing

- The testing team will plant an experimental group of plants in the Plantmosphere, and a control group of the same plants in an outside environment. The conditions of the control plants will be subjected to weather and nature, with the exception of any necessary additional watering provided by the test team. By comparing figures of merit between the two groups of plants, we can quantify the benefits of the Plantmosphere system.
- Harvest the control and case plants and compare their size, shape, and shade of colour in order to assess their relative health.

7 Sustainability and Safety

Plantmosphere Technologies is committed to developing a high quality product that adheres to established safety standards, while promoting sustainability at an affordable price.

Our vision for the production version of the Plantmosphere is to power the system with a renewable energy source that will eliminate the need for externally supplied electricity. The risks of electrical shock, fire hazards, and component damage will be eliminated by properly insulating all electronics and interconnects, in accordance with local electrical codes. Also, all delicate or hazardous electronics will be housed in a sealed enclosure outside the greenhouse structure in order to protect both users and fragile hardware.

Sustainability is an integral aspect of our product. The system's primary objective is to perform an inherently sustainable process: the growth of vegetation in an energy and resource efficient manner. The artificial lighting system will be comprised of long-lasting, energy efficient components. The irrigation system has been designed to collect and safely re-use rain water. These design considerations ensure that the greenhouse can operate in harsh, drought-prone regions for extended periods of time. Additionally, the Arduino microcontroller has been selected because it is cheap, readily available, and user-reconfigurable.

The majority of the Plantmosphere's components inherently lend themselves to a cradle-to-cradle (C2C) design. Unused vegetation grown within the Plantmosphere can be composted and reused as fertilizer for future gardening, satisfying a biological lifecycle design. The materials used for constructing the greenhouse system, such as aluminium and polycarbonate, are recyclable and do not fall under the C2C banned substances list [9]. The user can repurpose the sensors, actuators and the Arduino microcontroller for other applications long after the product's life span has elapsed.

Ensuring our product is safe, sustainable, and C2C certified are paramount considerations at the production level. Other concerns include designing our product such that it will continuously generate revenue in order to sustain Plantmosphere Technologies' growth. Disposables such as Plantmosphere Technologies brand fertilizer, seeds, nutrient packets, and replacement parts cover the economical aspect of C2C design. Furthermore, our product will be manufactured via ethical means. Workers will not be subjected to unsafe environments, and the Plantmosphere will be distributed in a manner that promotes fair trade.

8 Conclusion

This functional specification defines the requirements and functionality of the Plantmosphere. Our prototype will focus on the control and optimization of air temperature, soil temperature, water level, and light intensity. Additionally, the fully developed system will automate carbon dioxide concentration and soil pH. The final product will also utilize an energy efficient, self-sustainable power source. The Plantmosphere prototype and final product will comply with their respective requirements as per this document, and is scheduled to be completed December 3rd, 2014. Our team is confident that we can deliver a high quality, functional prototype by the listed date.

9 Works Cited

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