Lightweight Enterprises 

February 15, 2016

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

RE: ENSC 440W Functional Specifications for **Bartini Drink Dispensing System**

Dear Dr. Rawicz,

The attached document, *Functional Specifications for Bartini Drink Dispensing System*, provides an overview of the functional aspects of our capstone project. The goal is to design a software controlled drink dispensing system using electronic control, mechanical design, and software design techniques.

The functional specifications will outline what the project will accomplish and describe the functionality of the various subsystems that compose our design. Our team of hardworking engineers will use this document as an outline when designing the automated drink dispensing system.

Lightweight Enterprises consists of 3 talented senior design students: Noel Barron, Luke Mulder, and Ben Hieltjes. If you have any concerns or inquiries related to our functional specifications, please do not hesitate to contact our Head of Communications, Noel Barron, by email at nbarron@sfu.ca.

Sincerely,

Luke Mulder
CEO
Lightweight Enterprises

Enclosure: Functional Specifications for Bartini Drink Dispensing System

Bartini Drink Dispensing System

by

Lightweight Enterprises

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Submitted to: Dr. Andrew Rawicz - ENSC 440W
Mr. Steve Whitmore - ENSC 305W
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Executive Summary

According to IBISWorld's market research report, Canada's bar and nightclub industry has an annual revenue of three billion dollars. IBISWorld also estimates that for every $1.00 the industry spends on wages, $0.09 is required for capital equipment, including the use and replacement of buildings and fittings [1]. With our product *Bartini*, any business can redistribute these funds and greatly increase their net profits. Bartending is well suited to automation because of its variable levels of complexity and high mark-up.

Here in Lightweight Enterprises we design our product *Bartini* to deliver delicious, enjoyable cocktails tailored to the needs of the consumer. The *Bartini* is a fully autonomous machine which can perform the majority of a bartender's duties. Given a user-friendly interface, making the perfect, precise drink has never been easier. The graphic user interface (GUI) will be run on a Raspberry Pi and will be brought to life using Python. With a press of a button, the user can choose and customize a drink from a pre-set menu. Once selected, *Bartini* will then dispense the necessary ingredients into a mixing mechanism visible to the consumer. Base liquids will be taken from a cooled enclosure and brought through a series of tubes, while the spirits are displayed in the front in a carousel and dispensed directly into the mixing chamber. The transfer of liquids would be accomplished primarily through gravity flow and will be regulated by servo-controlled valves. All this combines to create a unique experience and a consistent and professionally made cocktail.

The *Bartini* is targeted towards various venues such as bars, clubs, restaurants, hotels, and even homes. Currently, there are similar products in production and in the market but they tend to be large, obtrusive, and more importantly expensive machines. We differentiate ourselves from the competition with our relatively inexpensive, modular, and scalable design. In addition to selling units to these markets there is possibility for renting them out to events that need to serve a large number of people for short periods of time such as temporary sporting events, conventions and conferences. In this document, we will discuss the functional specifications of our drink dispensing system.

Lightweight Enterprises consists of three fourth year Simon Fraser University engineering students whose mission is to a deliver reliable, low cost and innovative bartending machine with the *Bartini*. Every member possesses a varying set of skills necessary for the production of our prototype, including circuit design and analysis, software programming, and mechanical design. This automated bartender seeks to provide a consistent, entertaining experience to its end users while reducing operating costs and increasing efficiency for its clients.

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Glossary

AC	Alternating current.
APEG	Association of professional engineers and geoscientists.
CPU	Central processing unit.
DC	Direct current.
FDA	Food and drug administration.
GPIO	General purpose input and output. Refers to configurable general use ports used to send or receive electrical signals.
GUI	Graphical user interface. A means of interaction with electronic devices through graphical icons and other visual indicators.
IEEE	Institute of electrical and electronics engineers.
Raspberry Pi	A small computer containing a low-power microprocessor, various inputs/output devices, expandable memory, and capabilities of running an operating system.
PCB	Printed circuit board.
Servo	A miniature rotary actuator consisting of a motor driving a train of reduction gears.
Solenoid Valve	A mechanical value used to control fluid flow. Operated by electrical signals.

1.0 – Introduction

The *Bartini* automated drink dispensing system is an entertaining solution in the amenities industry that will automatically pour a mixed beverage based on input from a user. By use of a graphic user interface (GUI) a user can request any number of predefined drink recipes or create their own based upon the liquids available in the machine. Valves, motors, and the software-based GUI are controlled by a single embedded processor system and work together to produce the end product. The requirements for the *Bartini* system, as proposed by the creating company Lightweight Enterprises, are outlined in this functional specification document.

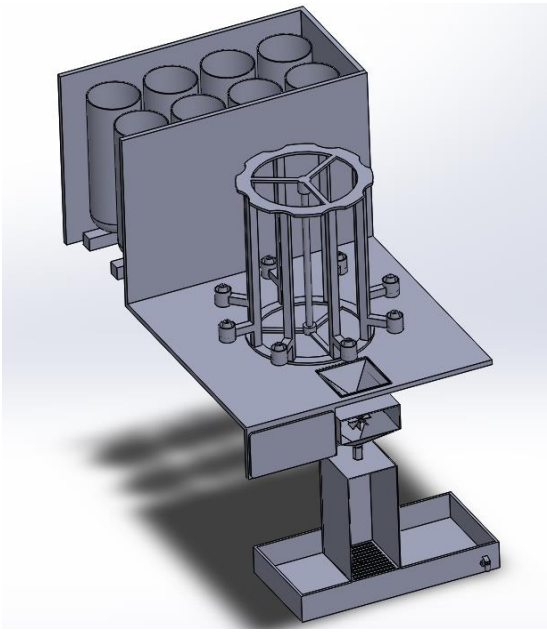

Figure 1: SolidWorks Concept Model - Bartini System

1.1 – Scope

This document describes the functional specifications of the *Bartini* automated drink dispensing system. The requirements of each subsystem are outlined to provide sufficient details pertaining to the engineering and design aspects. The final product must uphold strict standards, meeting both legal and sustainability requirements. This document will serve as a reference to be used extensively in the building and prototyping stages to ensure a fully functional product has been designed and tested in a proper manner.

1.2 – Intended Audience

This document will be used as a guide for all team members of Lightweight Enterprises during the design and testing phases of development. As the team works on the design of the project it will be used to set a quality standard and keep track of design goals and restrictions. During the testing phases it will be used to verify that our goals and sustainability targets have been met and that all restrictions have been followed.

1.3 – Classification

In order to make it easier to cross reference and prioritise the functional requirements, the following convention is applied throughout this document:

> **[Req A.B.C – XX]** A functional requirement.

Req is an abbreviation of requirement. Letters **A**, **B**, and **C** correspond to integer values and denote the functional requirement with A representing the root system, B representing a subsection of A, and C representing a subsection of B. **XX** indicates the priority of the requirement specified by three levels below:

> **PC** - The requirement applies to the proof-of-concept system.
> **PT** - The requirement applies to the prototype system.
> **FP** - The requirement applies to the final production system.

2.0 –System Overview

This device performs the most essential functions of a bartender. The interaction between the user and the device is intended to mimic the experience of ordering a cocktail. First the user will select from a list of possible drinks displayed on a GUI. The machine will then dispense the appropriate amount of each ingredient into a mixing chamber. The mixing chamber mixes the various liquids and cools the drink. The finished drink is then dispensed into a glass. Finally, the chamber is rinsed of the previous drinks remnants and the remaining ingredients are updated. An overview of the system operation is shown in figure 2. These main functions can be broken into processes: Selection, Pouring, Mixing and Cooling, Rinsing, Data Collection, and Entertaining. Figure 3 shows how these processes work together in the *Bartini* system.

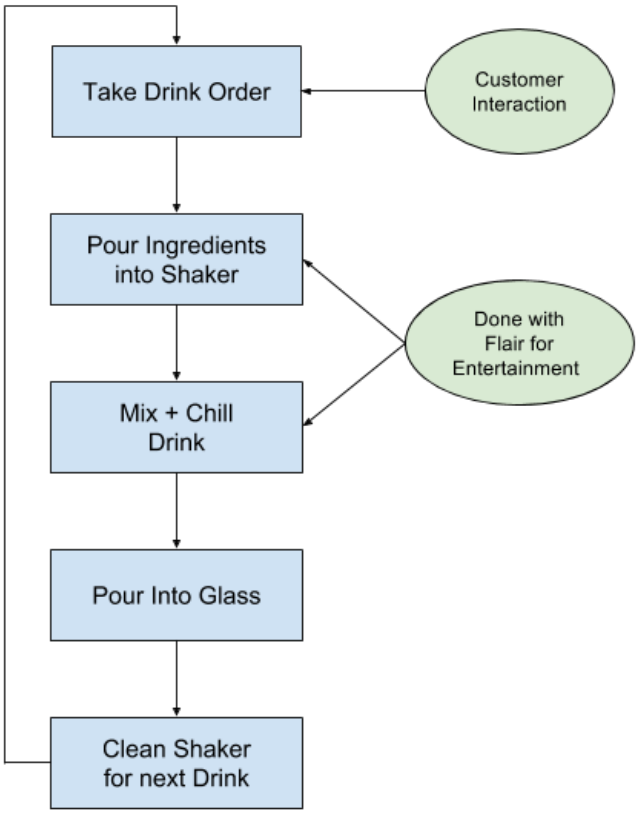

Figure 2: Bartini Operation

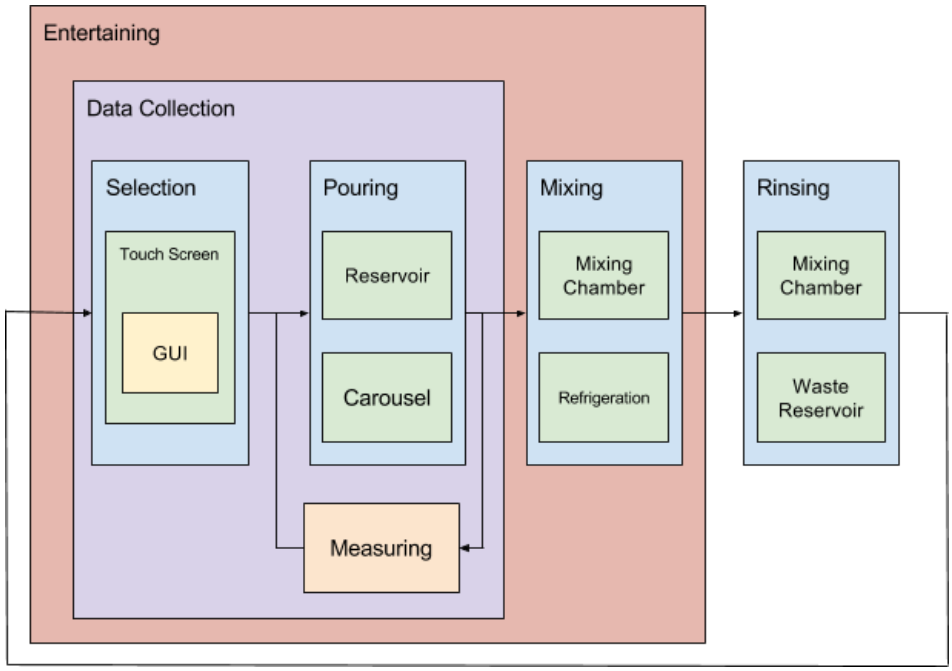

Figure 3: High Level Bartini Processes

Selection is done through a graphical user interface. A user can choose from a list of possible will be displayed. In addition, the user has the ability to make a custom drink based on the liquids in the machine. The user places their order and the price is displayed. Then the device will request for them to place the appropriate glass with a certain amount of ice into the dispensing chamber. When the glass has been detected pouring begins.

Pouring is performed in two different ways depending on whether a base liquid or an alcohol is needed. A base liquid is any liquid that does not typically have a brand attached to it such as water, tonic, lemon juice, lime juice. These are stored in reservoirs contained within the device (for the proof of concept model) and dispensed into the mixing chamber internally through valves and tubes. A production model may have faucet-type inputs for these base liquids instead of the reservoir-based model. Alcohols are mounted on the exterior of the device so it can be seen that it has been poured. A carousel will rotate a selection of alcohols so that the needed alcohol can be released by a valve directly into the mixing chamber from above. The amount of liquid poured by both methods is measured by sensing the height of the liquid contained in the mixing chamber.

Mixing and Cooling is done inside of the mixing chamber. Contained within the mixing chamber is a paddle-wheel driven by a DC motor. The DC motor is outside of the mixing chamber to prevent electrical problems and connected to the paddle-wheel by an axle. To cool the drink a refrigeration unit will cool the chamber. To transfer the most heat away the mixing chamber will be made of thermally conductive and food safe metal.

Rinsing must be done after the drink has been dispensed so that there is no contamination between orders. After the drink has been poured when the removal of the glass has been detected the mixing chamber fills with clean water. The water is agitated briefly by the mixing mechanism and then dispensed through the glass chamber by way of a cut out grill into the waste chamber.

Data Collection is the process of taking and storing the ingredient and recipe usage. This is done to keep vital statistics for serving and long term sales tracking. When an order is placed the statistics are updated for number of orders placed and for which recipes. In addition, as the ingredients are poured into the mixing chamber the statistics for how many millilitres of each liquid has been consumed by the drink making process.

2.1 – System Specifications

The *Bartini's* functionality is accomplished by a series of parts including microcontrollers, sensors, a line scanner camera, servos, motors, and an LCD display. For a high level perspective, the *Bartini* can be broken up into multiple subsystems, namely, the hardware-based controls, firmware, and software application.

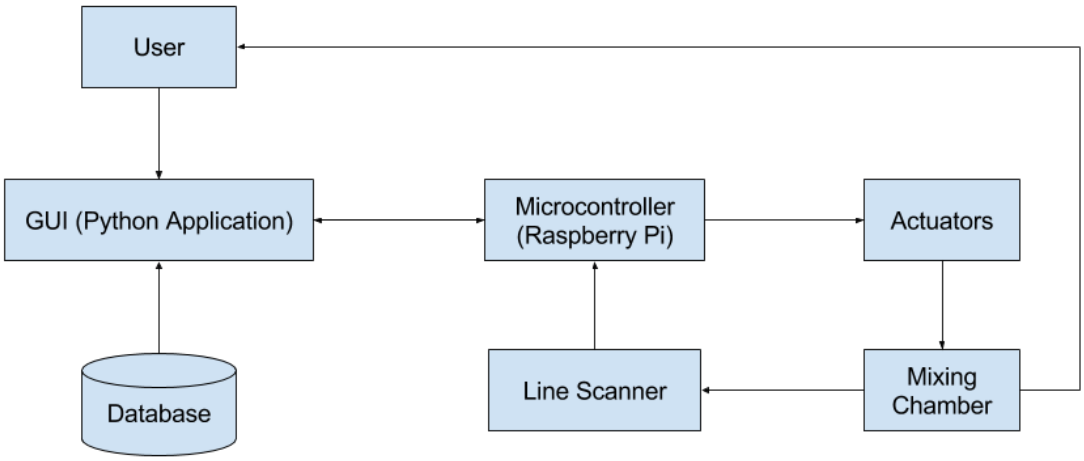

Figure 4: High Level Bartini Subsystem Interactions

The hardware system consists of various components including the line scan camera to measure liquid depth, servos and motors to mechanically move the system, mixing chamber, and enclosure. This is the physical entity of the system.

The firmware of the system resides in the Raspberry Pi. The firmware is the heart of the control system, regulating the timing and movement of the hardware components mentioned above. Firmware will allow for precise operation of valves, motors, and other physical components.

The software application is the 3rd vital component of the *Bartini* system. Its purpose is to bridge the gap between the user and the device in a natural and intuitive way. At the highest level of abstraction in the context of the project, the software application will use the firmware that in turn will work with the hardware to create a fully-functional system.

The interaction between the various electrical, software, mechanical, and control-based components is outlined in figure 5 below.

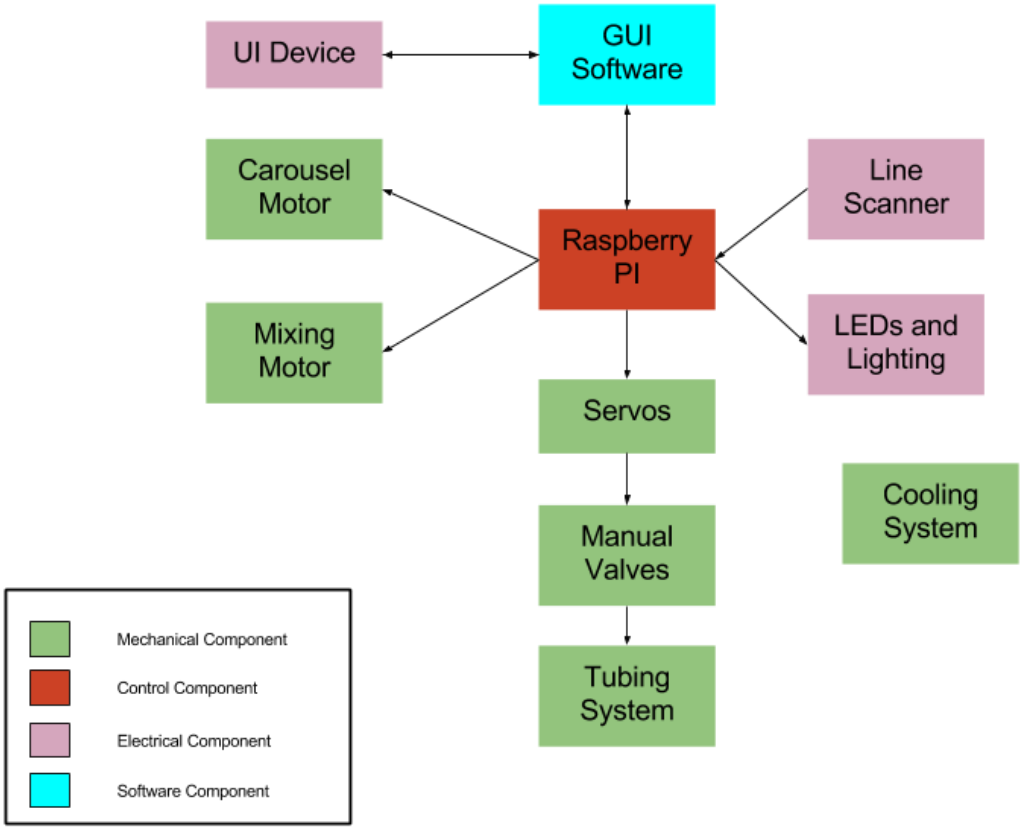

Figure 5: Bartini System Decomposition

3.0 –System Requirements

This section will detail the requirements of the drink dispensing system designed by Lightweight Enterprises. To further detail specifications of the *Bartini* system, requirements will be met at one of three possible levels. Each requirement will include one of the suffixes detailed in the classification section to indicate which concept level the requirement applies to.

3.1 – General Requirements

[Req 3.1.1 - FD]	Physical user manual will be printed and shipped with the product. Languages used in the manual will be appropriate for their destination.
[Req 3.1.2 - FD]	Control software will automatically initialize and launch when powered.
[Req 3.1.3 - FD]	Technical support will be provided to assist customers having troubles with the machine.
[Req 3.1.4 - PT]	Subsystems of the *Bartini* machine will be designed modular where possible for improved delivery and maintenance.
[Req 3.1.5 - FD]	All completed *Bartini* systems will be thoroughly and consistently tested according to established procedures prior to shipping.
[Req 3.1.6 - PC]	The device can be operated and initialized by a single person without a need for prior technical knowledge.
[Req 3.1.7 - PT]	Strong documentation practices and software version control management systems will be implemented.
[Req 3.1.8 - PT]	Energy usage information will be placed on the machine in compliance with Natural Resources Canada [2].
[Req 3.1.9 - PT]	All ingredients and nutritional information of a selected drink are available to the user at any time and accessible via the GUI in compliance the FDA or equivalent organization [3].
[Req 3.1.10 - PC]	Device will be able to support a minimum of 4 bottles in the rotating carousel and 4 mixer drinks.

3.2 – User Interface Requirements

[Req 3.2.1 - PC] A graphical user interface will interact with the *Bartini* system allowing control of predetermined drink options.

[Req 3.2.2 - PT] A 7” touch screen running the GUI will be mounted on the *Bartini* system.

[Req 3.2.3 - PT] Users will be able to create their own recipes based upon the liquids currently in the machine.

[Req 3.2.4 - FP] System will use open source platforms if available to lower costs and avoid legal issues.

[Req 3.2.5 - PT] GUI will display current state of machine and notify user of any problems or events.

[Req 3.2.6 - PT] GUI will include an instructional help section to educated unfamiliar users of the machine’s operation.

[Req 3.2.7 - PT] All predefined drink recipes will be associated with a picture of the completed drink and/or the ingredients.

[Req 3.2.8 - PT] Users must be able to update firmware versions and perform factory firmware reset using the GUI.

3.3 - Control Requirements

[Req 3.2.1 - FP] A lightweight computer will be designed and used in the system to eliminate cost of unnecessary peripherals in Raspberry Pi.

[Req 3.2.2 - PT] All input and output signals interfacing with the Raspberry Pi will be fixed in location and soldered to a PCB or similar device.

[Req 3.2.3 - PT] Minimum CPU requirement for operation at optimal levels is a quad-core architecture with a minimum clock frequency of 900Mhz.

[Req 3.2.4 - PT] Accuracy of dispensed liquids will be guaranteed within 10mL.

[Req 3.2.5 - PT] A drink will take no longer than 60 seconds to dispense from the time the sequence is initialized.

[Req 3.2.6 - PT] System requires 2GB of RAM and 100MB + 1MB per drink recipe of Storage to operate.

[Req 3.2.7 - PC] Software will be able to control the dispensing of each liquid independently from others.

[Req 3.2.8 - PC] All valves will be normally-closed to prevent leakage.

3.4 – Enclosure Requirements

[Req 3.4.1 - FP] Enclosure will contain dedicated sleeving for cable management and electronic routing.

[Req 3.4.2 - FP] Enclosure will hide / prevent unintentional access to all moving parts of the machine including motors, servos, gears and chains, valves, and the carousel of drinks.

[Req 3.4.3 - PT] Enclosure will have dedicated mounting point for processing unit and attached peripheral units (control board, motor board, etc.)

[Req 3.4.4 - PC] All parts of the enclosure that have potential to come into contact with the dispensed liquids are certified food safe materials as specified by the FDA, ISO standards, or equivalent [3].

[Req 3.4.5 - PC] All joints in contact with fluids will be tightly sealed to prevent leakage.

3.5 – Electrical Requirements

[Req 3.5.1 - FP] All circuitry excluding electronic lines leading to external peripherals mapped onto single chip.

[Req 3.5.2 - FP] A single integrated power supply will be used to power all motors, servos, solenoid valves, and the processing unit. This will allow for protection against unforeseen electrical irregularities in the network such as power surges and outages.

[Req 3.5.3 - PC] The power supply unit will be compatible with the destination country's electrical infrastructure accounting for differences in AC voltages and frequencies.

[Req 3.5.4 - FP] All electrical components contained within the unit will adhere to the ISO/CSA/ANSI standards [4] [5].

3.6 – Actuator Requirements

[Req 3.6.1 - PC] A DC motor used to mix the drink will operate using no more than 20 Watts.

[Req 3.6.2 - PC] A servo motor used to dispense liquid from the carousel will operate using no more than 100 Watts.

[Req 3.6.3 - PC] All moving parts will have proper lubrication to prevent grinding and other damages to equipment.

3.7 – Reliability and Sustainability Requirements

[Req 3.7.1 - FD] Water consumed during a rinse cycle will be no more than 400mL.

[Req 3.7.2 - FD] Construction materials including but not limited to woods, plastics, and metals will be sourced from recycled materials where possible.

[Req 3.7.3 - FD] System is free of any heavy metals including lead-based electronic components.

[Req 3.7.4 - PT] Device will operate in temperatures between -20 and 50 degrees centigrade.

[Req 3.7.5 - FD] Device will have a secondary memory partition containing the most recent successfully installed firmware version to allow for recovery if the current firmware partition becomes corrupted.

[Req 4.4.6 - FD] Software system will go to sleep with inactivity after a configurable period of time to save energy.

[Req 3.7.7 - FD] System will adhere to the energy efficiency standards and labelling practices outlined by Natural Resources Canada [2].

[Req 3.7.8 – FD] While in production device will undergo rigorous durability testing as specified by a comprehensive test plan to be outlined at a later date.

[Req 3.7.9 – FD] All electrical components shall be RoHS compliant where applicable [6].

3.8 – Safety Requirements

[Req 3.8.1 - PT] Device will not have sharp edges

[Req 3.8.2 - PT] Device will not collect substantial amounts of static charge that could be damaging to internal electronics or harmful to humans.

[Req 3.8.3 - PC] There will be no residual voltage or current present in the electrical components of the system when the system is not powered excluding an internal clock that may be present in the microcontroller unit.

[Req 3.8.4 - PC] Enclosure will be such that electrical components and liquids will not come into contact under expected usage.

[Req 3.8.5 - FD] Device will feature mounting points on either the bottom and/or back of the device to allow fastening to walls and/or floors.

[Req 3.8.6 - PC] A water-based rinse cycle will be applied between drink orders to prevent cross-contamination.

[Req 3.8.7 - FD] Any valves in the system will adhere to applicable ISO valve standards including those outlined in ICS 23.060.01 [3].

4.0 – Sustainability and Safety

Sustainability, both during the lifecycle of the device and after, is an important aspect of our design. We have an obligation to create sustainable products that uphold environmental standards. The team at Lightweight Enterprises has also acknowledged that a highly sustainable product has a favourable appeal to the public and thus sustainable design can be used to drive sales.

A focus on the manufacturing methods and materials of a production-quality model will have the largest effect on the *Bartini* system. Sourcing the base materials (wood, lightweight metals) from verified sustainable sources will help our product meet environmental standards. Recycled materials are also valid options in almost all aspects of the system design and decrease the environmental impact of the project. Any applicable plastics present in the final design will be composed of a thermoplastic polymer so the plastic can be melted and reused after the lifetime of the *Bartini* system. The engineering team will design the dispensing chamber rinsing mechanism to use a minimal amount of water to reduce wastage. The rinse water is also collected in a reservoir so it can be repurposed and/or reused if desired.

The Raspberry Pi computer was chosen as it is just sufficient for our design. Its microprocessor and the attached control electronics operate using a minimal amount of energy while still achieving the desired functionalities. Lead-free electronic components help reduce the environmental impact of the project. All motors and servos included in the *Bartini* system were chosen to accomplish the desired tasks while consuming the smallest amount of power that the engineering design called for. In addition to the environmental benefits, minimal power usage reduces strain on the electric infrastructure it is connected to while saving the customer money on their utilities bill.

Public safety is of utmost importance to the engineering team at Lightweight Enterprises. Because of the mechanical aspects of the *Bartini* automated drink dispensing system, an emphasis was placed on user interface in an attempt to understand how and where a user could interact with the project. Gears and motors will be hidden within the structural body of the *Bartini* in an attempt to minimize moving parts exposed to the user. Insulation and isolation of electrical subsystems is especially important as the project contains electrolytic liquids, electronic signals, processing, and interfaces. Similar to all products servicing the entertainment and alcohol industries, it is imperative to both the customers and producing company that a warning about the dangers of alcohol and its consumption are displayed prominently on the machine so all users are aware of the associated risks.

5.0 – Conclusion

This document highlights the functional requirements of the *Bartini* automated drink dispensing machine at various levels of the product's development. The *Bartini* is a complex system that interacts with users through a software interface to take drink orders, mechanically dispenses and mixes the drink ingredients, and presents a completed drink to the user. This document will allow the various development streams to maintain coherency and meet quality goals by designing to fit the functional requirements.

Lightweight Enterprises acknowledges the need for detailed specifications in all aspects of the product including electromechanical systems, software-based systems, safety, reliability, and sustainability. The modularity of the requirement sets allows for unit testing and development without need for integration in many cases. Many of these areas are regulated by organizations such as APEG and IEEE and as such, the engineering team has a responsibility to uphold the specifications presented in this document.

The *Bartini* system will be developed in the coming weeks to meet the various standards outlined in this specification and deliver a functional system for the project demonstration in April 2016.

References

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[3] Iso.org, "ISO - ISO Standards - ICS 23.060.01: Valves", 2016. [Online]. Available: http://www.iso.org/iso/home/store/catalogue_ics/catalogue_ics_browse.htm?ICS1=23&ICS2=60&ICS3=1. [Accessed: 12- Feb- 2016]

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