DGMasters Inc.

October 09, 2015

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

Re:ENSC 440 Functional Specification for a Medicine Dispensing System Capstone Project

Dear Dr. Rawicz,

The document attached *Functional Specification for a Medicine Dispensing System* briefly describes our product functional requirements. The goal of our company is to make the medication system in nursing homes more efficient with high reliability by tackling the errors at dispensing and administration stages. We are designing a medicine dispenser that will reduce the stress for health workers distributing pills on daily basis, remind users to take the pill on time, split the pill as needed for swallowing ease and dosage controlling purposes.

This document outlines the high level functional requirements of our product at three different levels: system, hardware, and software. Our product will be mainly focused on fixing the errors such as wrong dosage, time, method, and order of the medication. Moreover, this document also discusses our product is designed with sustainability and safety as the top priorities where the engineering standards are strictly followed.

Our company, DGMasters Inc., is composed of six engineers: Jasmine Liu, Tony Lu, Chris Xiao, Daniel Lan, Ritchie Kieu and Jose Mendoza. This is an enthusiastic and diverse team with background in several fields of engineering including electronics, computer, systems and biomedical engineering. If you have any questions or concerns, please contact me by email at zyl2@sfu.ca.

Sincerely,

Jasmine Liu
CEO
DGMasters

Enclosure: *Functional Specification for a Medicine Dispensing System*

DGMasters Inc.

Functional Specification

The PillMaster

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DGMasters Inc.

Executive Summary

If the stage has been reached where a person has reached an age where they cannot take care of themselves reliably, then they are usually admitted into a nursing home. These people have trained staff at their disposal to cater to their needs. There are approximately 400000 people older than 65 in Canada that live in a nursing home[1].

One of the most important aspect of the nursing home system is their medication system, designed to deliver medications to seniorsat the nursing home. This system has to be fast, reliable and safe to ensure that the elderly have a high standard of living.

Unfortunately, the reality is that this system is slow, not reliable and full of mistakes that can be fatal. All of the stages are handled by the staff manually, with limited technology used to aid them in the maintenance of the medication system[2]. Errors in the system are done in every stage of the system. Elderly that are exposed to any error in the medication have a chance of death increased up to 80%[3].

DGmasters Incorporated deems this situation unacceptable and has taken upon them to make the medication system more efficient and reliable. Specifically, the company is going to tackle the administration and dispensing stages. These stages are currently executed by staff members directly distributing the medication to seniors, room by room. The most notable errors are dispensing the wrong dosage and providing the medicine at the wrong time. We want to correct these errors with the development of The PillMaster. This product is essentially a programmable and automatic pill dispenser.

In this document, the functions that will be provided by The PillMaster will be described as well as justified. First, the functions at the system level will be listed. These are the ones that the user will be aware of. In order for The PillMaster system to follow the system requirements, it needs support from the mechanical, software and electrical systems. The second requirements listed belong to the mechanical system which comprises all the motors and structure that will dictate the speed and length of the pill path. The next set of requirements listed belong to The software system consists of the user interface and control structures that dictate the motor activities. The third set correspond to the electrical system which governs all the power distribution to the mechanical and software system. Finally, this document will discuss the safety requirements for that this product will conform to.

This document will serve as a guide for the engineers to refer when they design modules of The PillMaster.

DGMasters Inc.

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Glossary

DC	Direct Current
kg	Kilograms
cm	Centimeters
V	Volts
mA	Milliamps
A	Amps
s	Seconds
ms	Milliseconds
Hz	Hertz
dB	decibels
LCD	Liquid Crystal Display
IEEE	Institute of Electrical and Electronics Engineers
CSA	Canadian Standards Association
RoHS	Restriction of Hazardous Substances

DGMasters Inc.

1 Introduction

The PillMaster is a product that releases prescribed medication at specified times. As the aging population increases, more and more elderly people need daily medical and nutritional treatment. Our product is designed to dispense pills with limited interaction from nurses and caregivers. We plan to integrate customized shafts, microcontrollers, sensors, and a pill splitter to complete these functions. These functions include:

- **Dispenser**: the PillMaster will use a customized shafting mechanism to dispense one pill at a time so that it is able to dispense the exact amount of pills from the container
- **Splitter**: the user can choose the split option to split pills for easy consumption and lower dosage
- **Clock Reminder**: the PillMaster will remind users to take the pills at specific times and it is able to detect whether the pills have been taken from the dispenser

Our product can provide convenience in many care facilities, as well as avoiding human error.

1.1 Scope

This document will cover the list of functional requirements of The PillMaster automated medical dispenser. These specifications will act as a guideline for future project design modifications and implementations.

1.2 Intended Audience

This Functional Specification document is created by and intended for use by DGMasters Incorporated. Members of DGMasters Inc. will refer to this document to complete the necessary specified requirements for the development of the prototype. This document contains functions that are planned to be implemented by The PillMaster.

1.3 Classification

This document will be separated into the following sections: System Requirements, Mechanical Requirements, Electrical Requirements and Software Requirements. This document will use the following format: **X.#** , where **#** will denote the functional requirement number, and **X** will have the following convention: **M** to denote the mechanical system, **E** to denote the electrical system, **S** to denote the software system, **F** to denote safety requirements and **R** for reliability requirements. Each requirement will be justified and referenced to the appropriate standards.

2 Engineering Standards

The PillMaster follows engineering and government regulation. This ensures the dispenser conforms to safety and quality regulation for the users. Users in this context refers to the nurses, caregivers, and patients. The PillMaster conforms to the following standards:

1. The IEEE standard for Sensor Performance Parameter Definition [4]
2. The CSA standards under the Medical, Laboratory and Health Care Section [5]
3. The IEEE Standard for Medical Device and Communications [6]
4. The CSA Electrical standards [7]

3 System Requirements

The System Requirements comprise all of the functions that will be seen by The PillMaster users. Table 1 below contains a list for these requirements and their justification. Consequently, there are no standards that apply to this section.

Name	Requirement	Justification
U.1	The PillMaster will dispense pills automatically.	This is the main function of the product. This will allow the
U.2	The PillMaster will dispense one pill at a time.	This function will allow the system to control the position of the pill more reliably.
U.3	The PillMaster will dispense the pill at the time specified by the user with a maximum delay of 2 minutes.	This function ensures that there will be no errors on the time delivery of the pill.
U.4	The PillMaster will cut pills as specified by the user.	This is the function that will separate this product from the ones in the market. This also allows for the user to have control over the dosage.
U.5	The PillMaster will dispense the exact amount of pills as specified by the user.	This function allows the user to have control of the medication dosage.
U.6	The PillMaster will dispense any size of pills.	This function ensures that the product is robust enough to attract users to utilize it.

Table 1: The PillMaster System Requirements List

DGMasters Incorporated has divided the PillMaster System into three major systems: Mechanical, Software, and Electrical Systems. How these systems interact with each other, and how these systems will interface with users is shown in Figure 1.

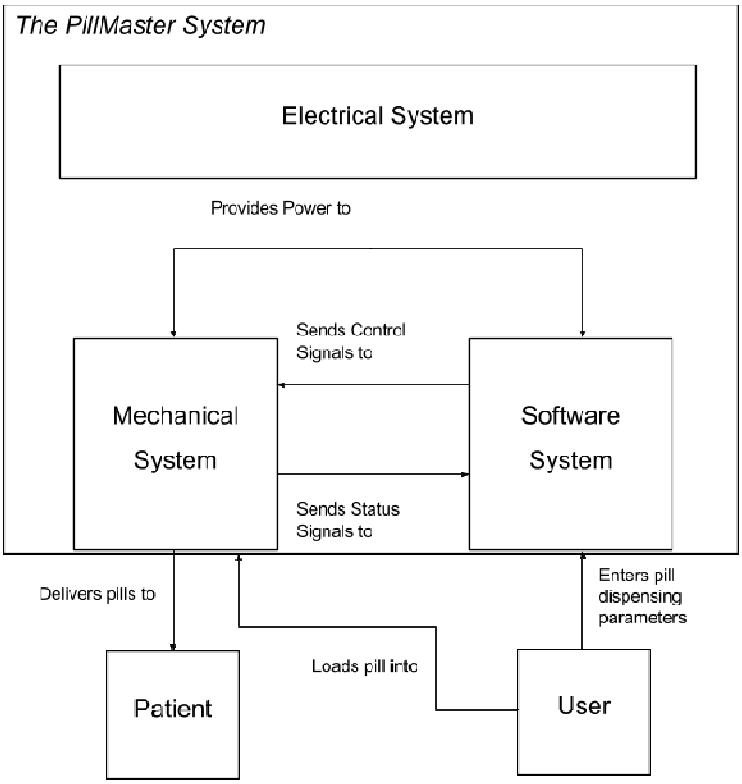

Figure 1: Block Diagram of The PillMaster System

3.1 Software System Requirements

The Software System serves as a bridge between the user and the Mechanical System that will dispense the pill. The Software System consists of four components: microcontroller, user interface, clock timer, and system management module. These requirements are not directly related to any engineering standards as the components of each module will be purchased and DGMasters Incorporated assumes that the vendors conform their products to the engineering standards in Section 2.

The following table refers to the electronic hardware on which the software will operate. It comprises the instruction memory, data memory and physical characteristics of the hardware. The requirements for this module are listed in Table 2.

Requirement Number	Requirement Description	Requirement Justification
S.1	The microcontroller will have instruction memory.	Memory is needed for a typical control program. [8]
S.2	The microcontroller will have data memory.	Memory is needed for a typical control program.[8]
S.3	The microcontroller will have digital inputs.	This function will allow the system to process information from each button of the keypad
S.4	The microcontroller will have digital outputs.	This is needed to manage an LCD [9].
S.5	The microcontroller will have analogue inputs.	This function will allow the system to receive information from pressure sensors.
S.6	The microcontroller will have analogue outputs.	This function will allow the system to drive servomotors into different positions via pulse width modulation [9]. It also needs to feed a signal into an audio system.
S.7	The microcontroller will have a 5V pin.	This function will allow power to be distributed to all components of the system.
S.8	The microcontroller will have a ground pin.	This function will allow ground to be distributed to all components of the system.

Table 2: Microcontroller Requirements List

The following table refers to the user interface that is in charge of relaying the input to the microcontroller from a keypad. In addition, it is also in charge of relaying information to the user through an LCD. An audio module has been planned to serve as an alert to the elderly that the pill has been dispensed. The requirements for this module are listed in Table 3.

Requirement Number	Requirement Description	Requirement Justification
S.10	The keypad will have digit buttons.	This function will allow the user to enter digits from 0 to 9 in order to specify time of pill dispensing.
S.11	The keypad will have a button for “Accept” and a button for “Cancel”.	This function will give the user more control over the information they enter.
S.12	The keypad will have a button to “reset” the system.	This will allow the user to reset anytime they have entered erroneous data or wants to update the data.
S.13	The LCD will have the ability to display characters.	The guide questions that the system will ask the user will have 20 characters on average.
S.14	The audio module will be able to produce an output with the magnitude of at least 30 dB.	The human ear on the elderly deteriorates. They lose about 25 dB on average [10].
S.15	The output of the audio will have a frequency of about 100Hz	A healthy person can hear sounds between 20Hz and 20kHz. As the person ages their hearing deteriorate and the person is less sensitive to the extremes [10].

Table 3: User Interface Requirements List

The following table refers to the software timer that times when the pill will be dispensed as specified by the user. In addition, the timer will keep track of the current time of the day. Its respective requirements are shown in the Table 4.

Requirement Number	Requirement Description	Requirement Justification
S.16	The timer will have a resolution of 1s or less	The user will select the pill to be dispensed hours after they have entered the data. This allows the system to have a resolution in the order of seconds. Anything with less resolution can be too inaccurate.
S.17	The timer will be in sync with the time zone of the place where the product is being operated.	This will allow the system to provide essential timing information to the user.
S.18	The timer will reset every 24 hours.	This will avoid the possibility of overflow.

Table 4: Timer Module Requirements List

The following table refers to the System Management Software that will manage all of the systems. This section consists of the functions that the software will perform as decided by DGMasters Incorporated. The requirements are listed in Table 5.

Requirement Number	Requirement Description	Requirement Justification
S.19	The software will ask the user the following guide question: “How many pills do you want to be dispensed from container X?”. X can have a value from 1 to 3.	This function will enable the user to control the dosage they want to be dispensed from any of the three pill containers.
S.20	The software will ask the user the following guide question: “At what time do you want the pill to be dispensed from container X?”. X can have a value from 1 to 3.	This function will enable the user to control the schedule that will dictate when the pill will be dispensed.
S.21	The software will ask the user the following guide question: “At what time do you want the pill to be from container X to be cut in half?”. X can have a value from 1 to 3.	This function will enable the user to have further control on the dosage that will be provided to the patient.
S.22	The software will display the timer’s value, when the system is idle.	This function will allow the user to have information about the time measured by the system.
S.23	The software will send control signals to drive the motors into different positions.	This function will allow the system to control the path of the pill.
S.24	The software will process status signals from the pressure sensors.	This function will allow the system to track the position of the pill on the path.
S.25	The software will process all of the data entered by the user.	This will allow the system to perform its functions according to those parameters.
S.27	The software will compare the timer to the value entered by the user to answer the question in requirement S.20.	This will allow the system to keep track of when the pill will be dispensed.

Table 5: System Management Software Requirements List.

The Software System is the brain of the whole system. The relationship between it components' functions can be seen in Figure 2.

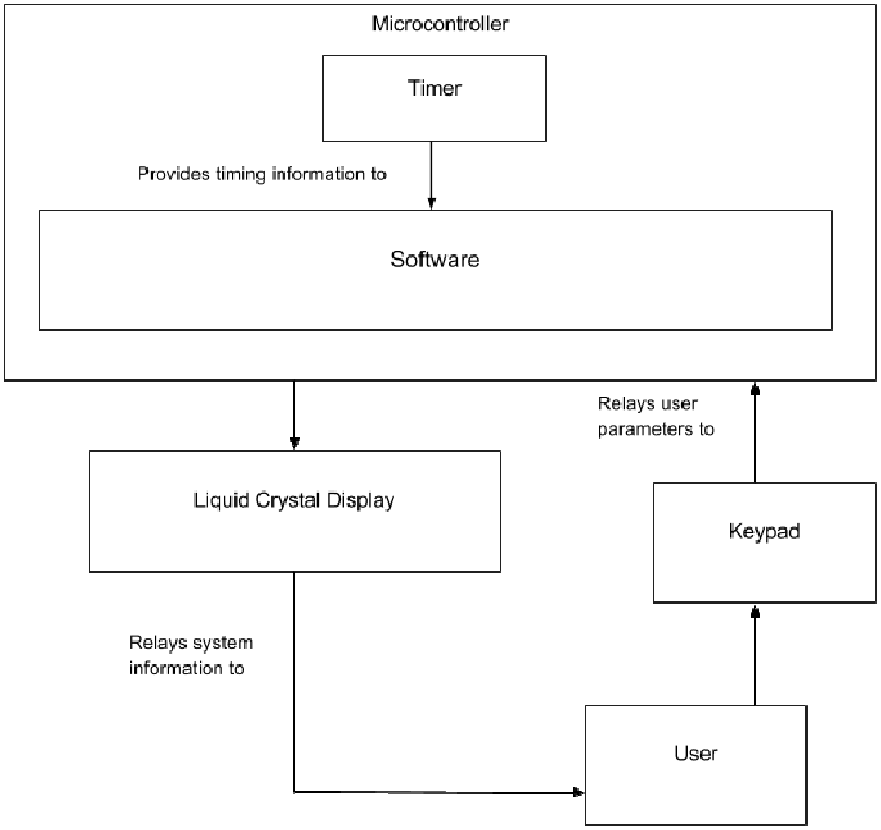

Figure 2: Relationship Between Software System Components

4 Electrical Requirements

The Electrical System provides power to the microcontroller, which further funnels power to the Mechanical System. It consists of an AC to DC converter, a backup battery system. These requirements are not directly related to any engineering standards as the components of each module will be purchased and DGMasters Incorporated assumes that the vendors conform their products to the engineering standards in Section 2. The requirements are listed in Table 6.

Requirement Number	Requirement Description	Requirement Justification
E.1	The system will be compatible with North America power outlets, that is to say withstand 120V, and 60Hz in frequency.	Our product will only be targeting North America market.
E.2	All electrical components will be soldered or properly connected	No lose connections to avoid unwanted short or open circuits.
E.3	The system will have internal short circuitry protection	So the system will shut down immediately to prevent any damages/hazards
E.4	The AC to DC converter will have a stable output between 5 and 12 V.	On average microcontrollers operate in the range between 5 to 12 V [9].
E.5	The system will have a battery with voltage in the range of 5 to 12 V.	The system will need a backup against power outages.

Table 6: Electrical System Requirements List

There is no relationship between electronic signal components. Both sources of electric energy must be independent in order to avoid damaging components.

5 Mechanical Requirements

The Mechanical System determines the path the pill will take starting from its respective container to the patient's cup, right when it exits the dispenser. The path can be divided into three main stages: container and dropping, pill routing, pill splitting. In addition, this section includes the physical requirements.

The following table refers to the containers in which the user will load the pills into. In addition, it includes rotating shafts plus its respective DC servo-motor which will drop the pill into the next path section. The requirements for this module are listed in the Table 7.

Requirement Number	Requirement description	Requirement Justification
M.1	The mechanical system will have 3 pill containers.	This function will allow for a more reliable monitoring of each pill path.
M.2	The rotating shaft will have a cylindrical shape and will have a circular slot.	The slots must fit the pills [11].
M.3	The DC servomotor needs to be able to operate with 5 V.	This function will allow the system to use low power consumption components.
M.4	The system will have 3 rotating shafts and each one will have a servomotor.	This function will allow for a more modular approach to the way the software can manage this section.
M.5	The containers will have a pressure sensor each.	This function will allow the system to know if there are still pills in the container.

Table 7: Container and Dropping Segment Requirements List

The pill routing consists of the receptacle that will catch the pill from the rotating shaft. This section also includes tubing that transports the pill from the receptacle to the exiting chamber. If the user has not requested the pill to be cut then it will be dropped via a trapdoor to the outside of the system. The chamber can be rotated in order for the trapdoor to face the tube that will transport the pill to the cutting segment. The requirements for the exiting section are listed in Table 8.

Requirement Number	Requirement description	Requirement Justification
M.6	The transporting tube will fit the pills.	The pills must fit the tubes.
M.7	The exiting chamber will have a pressure sensor.	This function will allow the microcontroller software to keep track of the pills position in the path.
M.8	The exiting chamber's pressure sensor will have an analogue output.	This will allow the software to sense if the pill is still in the chamber.
M.9	The exiting chamber's pressure sensor will be powered by 5 Volts.	This function will allow the system to use low power consumption components.
M.10	The exiting chamber's trapdoor will open by a 5 Volts DC servomotor.	This function will allow the trapdoor to be automatized and the redundancy will facilitate the management through the Software System
M.11	The exiting chamber's trapdoor servomotor will move through 2 positions: open and closed.	This function will allow the microcontroller to code the position of the trapdoor efficiently.

Table 8: Pill Routing Requirements List

The pill will be routed to be split only if the user specified that they wanted the pill to be cut. It consists of the splitter mechanism, the transportation tube from the exiting chamber and the ejection mechanism. The requirements are listed in Table 9.

Requirement Number	Requirement description	Requirement Justification
M.11	The splitter mechanism will have a metallic blade.	Necessary for quick and efficient pill splitting
M.12	The splitter mechanism will have a platform.	This mechanism needs a platform where the pill can rest,
M.13	The splitter's platform will have a mechanism that will hold the pill in place.	The pill need to be in place so it does not slide to other parts of the system.
M.15	The splitter platform and the knife will have a 6 Volts DC servomotors each to rotate them.	This function will allow the splitter mechanism to be automatized. Furthermore, the redundancy will facilitate the software control implementation.

Table 9: Cutting Segment Requirements List

This section comprises the physical characteristics of the body where the pill path will be contained. These requirements pertain to topics such as the materials of the body and tubes that make the pill path. These requirements are listed in Table 10.

Requirement Number	Requirement description	Requirement Justification
M.16	The body containing the mechanical system will be made of safe food plastic.	Ensures that no plastic contaminates the pill.
M.17	The tubes connecting the pill path segment will be made of safe food flexible plastic.	Ensures that the tubes are flexible to direct them to the correct positions.
M.18	The whole system will weight no more than 5 kg.	The system needs to be easy to carry around by the staff,

Table 10: Physical Requirements List

The relationship between parts of the mechanical system is one-directional. It follows the pills path from the user loading to the exit of the system.

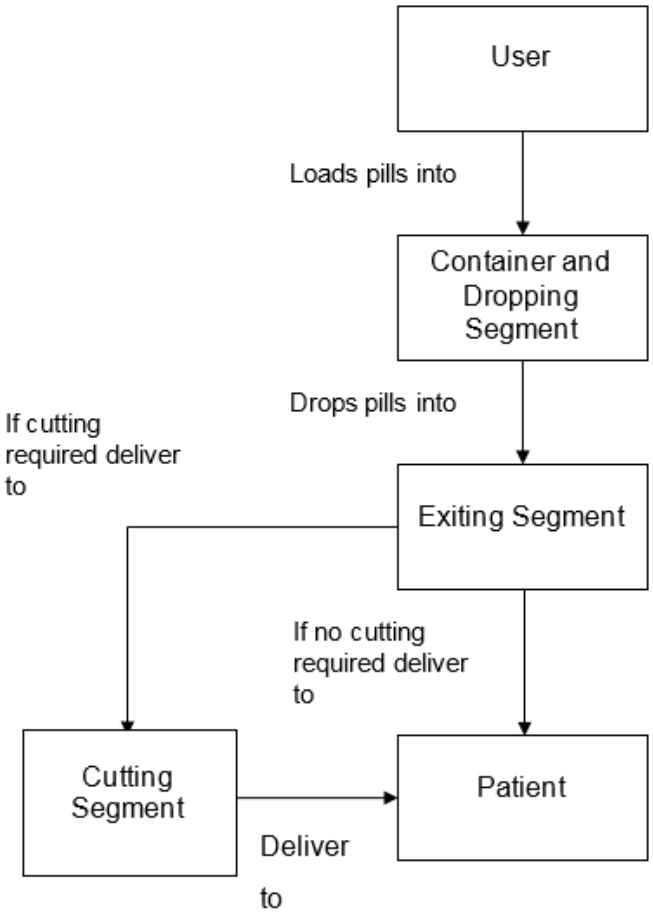

Figure 3: Mechanical System Component Relationship

6 Reliability and Durability

Reliability and durability refer to the long run performance of The PillMaster. This product is intended to have multiple uses without any major failure. DGMasters Incorporated have listed reliability requirements to project how long the system should operate without failure. In addition, the company has incorporated redundancy measures to increase reliability. The requirement list is in Table 7.

Requirement Number	Requirement Description	Requirement Justification
R.1	The system will last at least for 2 years without major failure to the main components under normal conditions.	Main components: integral circuitry, microcontroller Normal condition: room temperature 25 Celsius plus minus 10, no excessive pressure applied to product
R.2	The components inside the system's container will be bolted tightly.	The system cannot have hanging components falling from their place.
R.3	The system will have a microcontroller watchdog and back up.	The main microcontroller needs to be monitored. In case of a failure the backup microcontroller will take over.
R.4	The system will not lose the user's information in case of a power outage.	Patients cannot afford to miss a medication under any circumstances.
R.5	There will be a failure alert displayed to the user. It will tell the user to contact DGMasters Inc.	In case of a failure the system needs to tell the user what to do.

Table 11: Electrical Systems Requirements List

7 Sustainability/Safety

Our product follows the cradle-to-cradle product life cycle, meaning that our product is both sustainable and safe for users. As shown in Figure 4, at each stage of the product life, our product is designed to minimize its environmental impact. However, due to the usage of electronic components of our product, we cannot completely eliminate the environmental hazards at the end of the product life cycle. Regardless, we will do our best to design our product in a way that it can be disassembled for recycling, and thus reduce the environmental impact as much as feasibly possible.

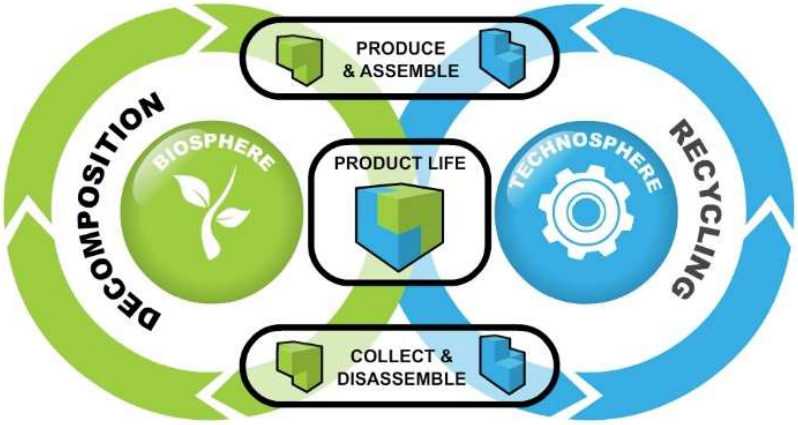

Figure 4: Cradle to Cradle Product Life Cycle [12]

The PillMaster's components belong to one of two categories - Biological and Technological. The Technological portions of the device will be made from materials that can be taken apart, repaired or reformed for use. The Biological components will follow the “waste is food” theory, resulting in minimum landfill contribution. Our product will consist of plastic casing, plastic pill containers and shafts, reusable motors, microcontroller boards and components, an LCD, switches, pressure sensors, and a steel blade. At the assembling stage, DGMasters Inc. will use as much as recyclable material as possible, such as our steel blade and plastic casing. The electronic components must be RoHS compliant and recyclable. Because the user takes the pill directly from our product, we will ensure that all plastic that makes contact with the pill is food safe when we selecting construction materials.

In regards to safety, the product must draw AC power from the wall outlet. This poses potential hazards in the case of malfunctioning components, and thus proper safe design is one of our top priorities. We understand that users may try to use the product outside of its intentional use and therefore, we will design our product such that important systems are secure from unintended access. For a more detailed list of safety specifications, refer to Table 12.

Requirement Number	Requirement Description	Requirement Justification
F.1	The system must not pose shock hazards to users under normal conditions	Normal conditions: room temperature 25 Celsius plus or minus 10, no excessive pressure applied to product, no force opening
F.2	The system must have automatic shutdown system in case of power or circuitry failure	
F.3	All hazardous electrical parts will be clearly labeled with warning markers	To prevent people to tabulate with the product other than professionals
F.4	The electrical and mechanical parts of the system must be compartmented	To prevent people to tabulate with the product other than professionals
F.5	There must be heat sink or fan installed to cool down the machine in case of overheating	Motors heats up fast
F.6	The system must be designed in a way the regular user will only have access to the pill container in case of refilling/change	To prevent people to tabulate with the product other than professionals

Table 12: Safety Requirements List

8 Non-priority Requirements

U.6, S.14, S.15, E.5, M.16 and M.17 are non-priority because they are regarded as extra features that do not jeopardize the main functionalities of the pill master concept, which is the automation and programming of pill dispensing. R.1 to R.5 are non-priority because we are not doing long term testing or development. F.1, F.3, F.5, F.6 are non-priority because we are not using high voltage or destructive testing. The rest of the requirements are essential for The PillMaster's functionality.

9 Conclusion

This Functional Specification document of The PillMaster is a descriptive document that lists requirements of systems and their components. The document provides a guideline for developers to meet components' safety, physical, electronic, and mechanical standards. Although all features and requirements are listed in this document, some features have different priorities. Top priority features will be developed first in order to build a safe and functional project. Other features will be completed if time allows.

10 References

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