510 INNOVATIONS

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February 8, 2010

Andrew Rawicz
Simon Fraser University
Burnaby, British Columbia
V5A 1S6

RE: ENSC 440 Functional Specifications for the Enhanced Recycling Bin System

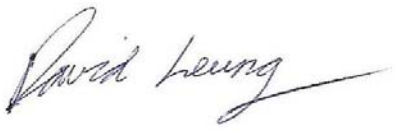
Dear Dr. Rawicz,

Enclosed in this document is the functional specification for our ENSC 440/305 Project. Our objective is to design an "Enhanced Recycling Bin" System that automatically detects and separates recyclables that are disposed into the bin.

The high level functional requirements for our device are specified in our functional specification. The specification for each individual development phase as well as the final product will be featured. Each component is categorized and scheduled in accordance to importance and priority. And the set development timeline will be used by the members of 510 Innovations to direct the research, design and testing efforts of our project.

510 Innovations is comprised of five innovative and dedicated engineers – Scott Hsieh, Michael Kume, Fritz Lapastora, Jeremy Lau and David Leung. If you have any questions or concerns regarding the attached document, please feel free to contact David at 604-767-6108 or DBL1@sfu.ca.

Sincerely,



David Leung
Chief Executive Officer
510 Innovations

Enclosure: Functional Specification for the Enhanced Recycling Bin System

510 INNOVATIONS

SEE green. THINK green. DO green.

February 8, 2010
Revision 1.8

Functional Specifications for an
Enhanced Recycling Bin System

Project Team:

CEO – David Leung
CME – Jeremy Lau
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Submitted to:

ENSC 440 – Dr. Andrew Rawicz
ENSC 305 – Steve Whitmore
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ENSC 440/305

Executive Summary

510 Innovations is looking to provide the world with real solutions on environmental issues. Through innovation and new technologies, our engineers are constantly thinking of ways to achieve a more sustainable lifestyle.

The number of landfills is increasing and although awareness on a greener perspective is spreading, recyclables are still making their way into these landfills. 510 Innovations is proposing the Green Bin, a system that will ensure a significant decrease of recyclables diverted into landfills. We strongly believe the technology and the know-how to accomplish this exists today; there is a growing potential with RFID technology which will be paramount in the development of the Green Bin.

The development of the Green Bin will be designed under two models; the conceptual model and the production model.

The conceptual model will meet minimum requirements and only achieve the essential functions of the system. The conceptual model is not intended for public testing. For the purpose of ENSC 440, it is important that this model be completed by April 2010. The full development of the conceptual model will fall well within the proposed schedule and the devoted funding towards the project. Some functions to be developed under this model include:

- **sensing and sorting**
- **power and self-sustaining options**
- **user interface**

The production model will meet designed requirements and achieve all functions of the system. The production model will be intended for public use. The full development of the production model will be followed according proposed schedule and devoted funding. Further functions to be developed under this model include:

- **cell compartments**
- **designed exterior casing**
- **display options**
- **safety requirements and standards**

Further details into the model requirements, their respective functions, the system test plan, and proposed concept designs can be reviewed within the rest of the documentation.

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Glossary

Bin	Refers to the 'Green Bin' product.
Cell	The storage compartment for the recyclables and garbage.
Chamber	The section of the Green Bin that houses the identification sensors and sorting mechanism.
Garbage	Objects that may be found within a garbage can that are not recyclable. An object that is not a glass container, plastic container, or aluminum container. This includes garbage that is misplaced in recycling bins.
Object	Refers to any expected recyclable or common garbage placed in the bin.
Orifice	Refers to the mouth of the bin where object will be placed.
Refuse	Mixture of recyclables and garbage; any inputs of the Green Bin.
Typical User	People with a minimum height of 80 centimetres, aged 4 and above.

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1. Introduction

Residing in Vancouver, one of the greenest cities in the world, 510 Innovations is currently developing an enhanced recycling bin system, the Green Bin. The proposed design will automatically sort and separate recyclable bottles/cans composed of glass, plastic and aluminum from everyday garbage. It will be designed for use by the typical consumer within office buildings, malls, and other high traffic locations. As the condition of the refuse is unknown, a series of sensors will be employed to determine its composition.

Not only will it be an effective replacement for recycle bins, but it is expected to sufficiently capture its target audience: consumers who do not recycle. Motivating users to recycle and become more interested in sustainable technologies, the Green Bin will be an essential component of any society implementing initiatives to become more environmentally-friendly.

1.1 Scope. The functional specifications outline the requirements, capabilities, and quality of various working models of the enhanced recycling bin, the Green Bin. For the purpose of this course, a prototype, proof-of-concept model will be created with full functionality. However, a finalized production model will also be detailed, giving the reader an idea of the quality of construction that can be expected from a Green Bin deployed in the public. The functional requirements specific to each model and the requirements common to both will be presented. Effectively, this list will act as a standard or benchmark which our engineers will strive to achieve.

1.2 Intended Audience. The functional specifications are written for both the members of 510 Innovations and our clients. They also serve as a set of expectations that Dr. Andrew Rawicz, Steve Whitmore, and the teaching assistants may refer to when evaluating our progress and development. The engineering team will refer to this as a checklist to determine the completion of the Green Bin. It will also be used to market the Green Bin to potential clients during the prototyping phase, detailing the capabilities and quality that they can expect from the finished production model.

1. Introduction

***1.3 Requirement Classification Convention*.** The following convention will be used throughout the document to denote the significance of each functional requirement.

[R#, M] Functional requirement description.

Where # represents the functional requirement number and ***M*** represents the models which will require that particular function:

C	**Concept Model:** All of these requirements will only exist in the original proof-of-concept model, and will be obsolete or replaced before the final production model.
B	**Both Models:** These requirements will exist in both proof-of-concept and production models, as they are essential to the system.
P	**Production Models:** These requirements will only exist in the finalized product, as they are needed for the market, but not essential to the proof-of-concept model

2. General System Requirements

2.1 General System Overview. These are general requirements that pertain to the construction, appearance, placement, safety and standards of the Green Bin. In depth information of the inner workings of the Green Bin system will be covered in the subsequent sections

Potential production model designs have been provided in figure 1 and figure 2.

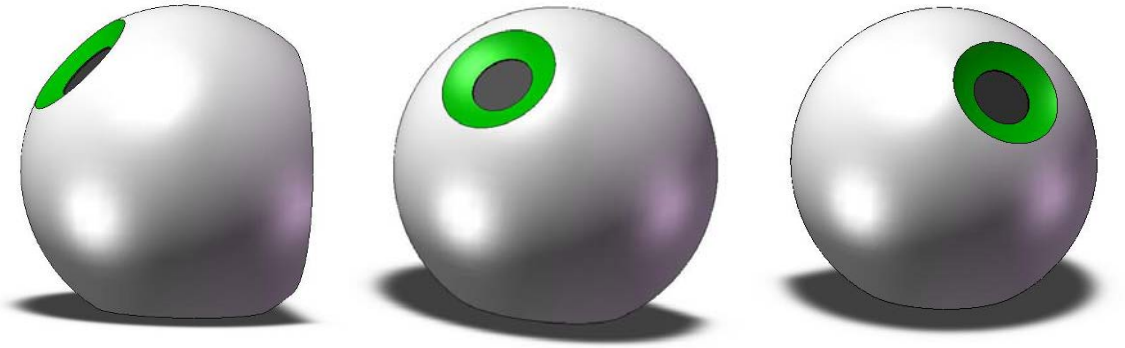

Figure 1 – Futuristic sphere-based design.

Figure 2 – Conventional recycling bin based design.

2. General System Requirements

2.2 Physical Requirements. This pertains to the shape/build of the Green Bin.

[R1, P] Shall have maximum height of 150 cm and width 100 cm.
[R2, P] Shall have maximum weight of 90 kg.
[R3, P] Shall have the option to be bolted down to the ground or concrete slab.
[R4, P] Shall stand upright without additional support.
[R5, P] Metallic pegs or landing rails will be placed on the bottom, to provide 5 cm of elevation from the ground. 5 cm is enough to allow a typical Caterpillar Lift Truck to insert its fork underneath and prevent damage to the cells while moving the Green Bin.

2.3 Environmental Requirements. To maximize its usage, the Green Bin will be strategically placed in high traffic areas. Indoor locations will include malls, coliseums, and universities. Green Bins will also be deployed in outdoor locations such as parks, fairs, and busy commercial streets. Target locations within Vancouver may include:

- Metropolis Shopping Centre
- General Motors Place
- Simon Fraser University
- Stanley Park
- Pacific National Exhibition (PNE)
- Robson Street

[R6, P] Shall be waterproof such that internal components will not be affected by rain or snow.
[R7, P] Shall contain a defroster to defrost solar panel.
[R8, B] Shall be able to operate in varying temperatures, -50°C to 50°C.
[R9, B] Bins shall typically be placed in direct vicinity of a light source.
[R10, B] Shall generate minimal noise pollution when operating in maximum load.
[R11, P] Outer casing shall be made of UV resistant material to prevent damage from long-termed exposure to the sun.

Figure 3 – Placement of the Green Bin in its typical environment.

2. General System Requirements

2.4 Material Composition Requirements.

[R12, P] Constructed from environmentally-friendly materials.

***2.5 Aesthetics Requirements*.** The Green Bin must be aesthetically pleasing, in order to motivate the public to use it.

[R13, P] Shall have urban modern design to attract public attention.
[R14, P] Simple logos can be painted on, such as the reuse-reduce-recycle triangle, or garbage can symbol as show in Figure 3:

Figure 4 – Symbols that may appear on the Green Bin

[R15, B] The 510 Innovations logo or slogan will exist on the product, in order to promote brand recognition.
[R16, P] Custom decals or designs can be printed on the Green Bin at the request of the client.

***2.6 Safety Requirements*.** Precautions taken to avoid harming the user.

[R17, P] All electronic and mechanical components, as well as power connections, shall be enclosed.
[R18, P] The system shall be able to detect mechanical and electrical failure. Upon failure, the status light will light turn on and the opening orifice shall remain closed at all times.

***2.7 Standards Requirements*.** Laws or regulations that must be followed in order to deploy the Green Bin in North America and other densely populated areas in the world.

[R19, P] Shall be in compliance to the guidelines set by the Restriction of Hazardous Substances in electrical and electronic equipment (RoHS).
[R20, P] Shall be in compliance with the guidelines set by ISO 9001.
[R21, P] Shall be in compliance with the guidelines set by IEC 62369−1.

3. Scanning Chamber Requirements

3.1 Scanning Chamber Overview. The scanning chamber will be the heart of the system. This section of the system will be responsible for identifying and sorting an object. Most sensors and actuators will be here as well as all computing.

3.2 General Requirements.

[R22, B] All object scanning shall be done in scanning chamber.
[R23, B] There shall be a minimum of 3 scanning methods to increase sorting accuracy.
[R24, B] Objects to be sorted are classified into four categories: glass containers, plastic containers, aluminum containers, and garbage.
[R25, B] Scanning chamber shall be sized to accept the largest possible common recyclable within the demographic.

3.3 Scanning Sensor Requirements. These requirements pertain to the electronic components that identify the composition of the refuse.

[R26, C] Object scanning shall be performed sequentially.
[R27, P] Object scanning shall be performed simultaneously.
[R28, B] Scanning sensor methods shall remain non-intrusive and passive.
[R29, B] Scanning methods shall not create any sound uncomfortable to user.
[R30, B] A sensor method shall be able to perform height and width profiling.
[R31, B] A sensor method shall be able to perform material induction testing.
[R32, B] A sensor method shall be able to perform radio frequency identification scanning. Between frequency range (125 kHz and 132.4 kHz).
[R33, B] All sensor methods shall operate at a maximum voltage of 9VDC.
[R34, B] All sensors shall have testing time less than 5 seconds combined.

3. Scanning Chamber Requirements

***3.4 Mechanical Requirements*.** This refers to any mechanical components that will actuate during the insertion and sorting processes.

[R35, B] Opening orifice into scanning chamber shall be mechanical and actuated when activated by user.

[R36, C] Trap door holding disposed object during scanning process shall be mechanical and completed through use of high speed servo motors.

[R37, C] Sorting chute used to dispose object into proper bins shall be mechanical and completed through use of high speed servo motors.

[R38, B] The chute will be angled such that any empty recyclable will move purely by the influence of gravity.

[R39, B] All motors used as actuators in system shall operate at a maximum voltage of 9VDC.

[R40, B] All motors shall have a run time of less than 1 second each.

***3.5 Microcontroller Requirements*.** This refers to the processing unit that controls all inputs and outputs of the system.

[R41, C] Controller shall have a minimum of 8 inputs and 12 outputs.

[R42, C] Controller must support Serial Data transmit and receive.

[R43, C] Controller must have at least 2 of interrupt pins.

[R44, C] Controller must have at least 2 PWM output pins.

[R45, C] All controllers must have at least 4 of analog-to-digital converter inputs.

[R46, C] Controller shall operate at a maximum voltage of 9VDC.

[R47, C] Controller shall be programmable in assembly language or C programming language.

4. Cell Requirements

4.1 Cell Overview. The cells will make for most of the system's physical size as its sole purpose is to house and hold separated refuse.

4.2 General Requirements.

[R48, B] Each cell must be able to contain and handle liquids.
[R49, P] Each cell must be durable for typical use within expected lifetime.
[R50, P] Each cell must be composed of materials which surface is relatively capable of repelling stains or dirt.

4.3 Size Requirements. The size of each cell will vary based on its contents.

[R51, P] Each cell shall be sized to accommodate for the amount of objects of each category that is typically expected.
[R52, P] Volume of cell shall be based on likelihood of a particular object and its relative size.

4.4 Monitoring Requirements. This pertains to monitoring the vacancy and capacity of each cell.

[R53, B] All four cells shall be monitored for capacity. If a cell has reached maximum capacity, it shall indicate so.
[R54, B] Cell capacity indicators shall be displayed clearly to user.
[R55, B] Capacity sensor methods shall remain non-intrusive and passive.
[R56, P] A wireless signal will be sent to notify that the bin is full.

5. Maintenance Requirements

5.1 Maintenance Requirements Overview. The longevity of each Green Bin is vital to achieving its objectives and meeting the needs of our clients. The following requirements ensure that the bin will not only have a long lifespan, but can be easily assessed and repaired in the event of a failure.

5.2 Reliability Factors Requirements. This refers to the performance expectancy of components.

[R57, P] All electronic sensors, solar panels, and mechanical components shall have a minimum lifespan of 2 years, under proper use.

[R58, P] The batteries which store and supply power to the system shall last a minimum of 2 years under proper use.

5.3 Chamber & Cell Repair Requirements.

[R59, P] The bin must have an access panel to the sensor and mechanical chamber for technician service and repair.

[R60, P] The bin must have an access panel for cell removal.

[R61, P] An error signal will be wirelessly sent in the event of a failure.

6. Power Component Requirements

6.1 Power Component Overview. An important element of the Green Bin is its power source. While the Green Bin's objective is to help clean the environment, it must do so without directly or indirectly consuming natural resources or expelling any exhaust.

6.2 General Requirements.

[R62, B] Self-sustaining, does not require external power source.
[R63, B] Does not produce exhaust/pollution of any kind.

6.3 Operating Characteristic Requirements.

[R64, B] System shall consume power less than 50 watts.
[R65, B] All electronic and mechanical devices operate under 9VDC.
[R66, B] Sensors, motors shall be in standby mode until triggered by user.

6.4 Solar Panel Requirements.

[R67, B] Under direct sunlight the solar panel shall generate more power than consumed.
[R68, B] Under direct sunlight the solar panel shall generate minimum 9VDC.
[R69, P] Size of the panel must be smaller than the top of the bin.

6.5 Battery Requirements.

[R70, P] At full charge the battery life shall last a minimum of 12 hours under typical use.
[R71, B] Battery must provide sufficient power to power all devices in the system.
[R72, B] Battery shall support simultaneous charging and operating actions.

7. User Interface Requirements

7.1 User Interface Overview. While the Green Bin will be designed to be as intuitive as possible, there will be a learning curve for users to become accustomed to it. This learning curve will be made as moderate as possible through the user interface provided.

7.2 General Requirements.

[R73, P] Any interface shall remain minimal. Such an interface shall be designed for easy and intuitive use.

[R74, P] Sorting process and internal mechanics shall remain hidden and unknown to user.

[R75, B] Sorting process shall be automatic without any initiation from user other than disposal of object into orifice of the bin.

7.3 Display Requirements. This pertains to any text, symbols or LED indicators.

[R76, P] Any instructions or display shall be stated in all local languages pertaining to the expected demographic.

[R77, P] Any instructions or display shall be placed in clear view of user, preferably near orifice of the bin.

[R78, B] Status of capacity shall be clearly indicated.

7.4 Orifice Requirements. The only interactive part of the Green Bin: the opening.

[R79, P] The orifice of the Green Bin will be designed to resemble a camera shutter as shown in Figure 4:

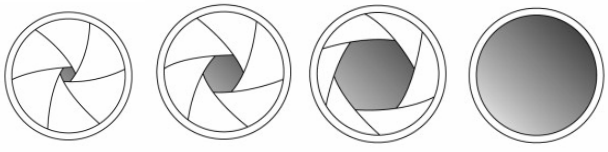

Figure 5 – Shutter design of the orifice.

[R80, P] Placed on an angle with a hood so that rain water may not enter.

[R81, B] Orifice shall be sized and shaped accordingly to limit objects to common garbage and expected containers.

[R82, B] Orifice shall only open when accepting objects.

[R83, B] Orifice shall remain closed while processing an object.

[R84, B] Orifice shall be opened by proximity sensor.

[R85, B] Orifice shall remain open if an obstruction is present.

[R86, P] Location and angle of orifice will prevent small animals from entering.

8. User Documentation

8.1 User Documentation Overview. The Green Bin is intended for use in high traffic public places, and as a result our product is expected to be used by a broad range of people. For our product to be used by the general public, the Green Bin must be designed and produced such that it can be easily used by almost everyone without the need of excessive work of reading user documentation papers.

For first time users that are not familiar with the use of the Green Bin, simple step-by-step instructions will be available on the system. Other forms of documentation for people interested in purchasing the Green Bin system as well as people responsible for the installation and maintenance of the system will also be developed.

8.2 General Requirements.

[R87, B] Documentation conveying information on functionality shall be written and provided to people interested in purchasing the Green Bin. In addition to functionality, the purpose and benefits of the system shall be explained.

[R88, B] Documentation explaining the proper installation and maintenance of the Green Bin system will be developed and provided for the technicians responsible for the care of the system.

[R89, P] All documentation shall be written in English along with other languages depending on the demographic.

[R90, P] All forms of documentation developed shall be available on the 510 Innovations company website.

8.3 Customer Requirements. Necessary to ensure that people can use the bin.

[R91, P] Simple step-by-step instructions shall be available for first time users and visible on Green Bin system. The instructions shall be written for an audience with minimal understanding of the proper disposal of recyclable materials.

[R92, P] For testing purposes, people of various ages and educational backgrounds will be gathered and asked to use the Green Bin system. Through various tests, the usability of the system shall be assessed.

8. User Documentation

***8.4 Patenting Requirements*.** Necessary steps to protect the Green Bin's patentability.

[R93, B] The files pertaining to this course shall remain confidential, and will not be published on the ENSC 305/440 course website or any public medium.

[R94, P] Provisional patent application process shall begin during the development of the system.

[R95, B] Engineering journals/records shall be kept by various team members as dated pieces of documentation when seeking a patent.

[R96, B] Team members shall decide on a description that can be used to inform clients and interested faculty members of the Green Bin's capabilities without disclosing information that may threaten its patentability.

[R97, B] Non-Disclosure Agreements shall be written up for faculty members that are given full privilege of viewing the product materials.

9. System Test Plan

9.1 Testing Methodology. During the development process of the Green Bin, the team will be divided into smaller sub-groups where multiple components can be built simultaneously. Therefore, the majority of the testing will be practiced by the individuals responsible for the module they are working on. Each sensor module will be tested throughout the development process to test for speed, accuracy and power consumption. The sensors must also pass all the performance constraints listed above before the milestone is considered complete. Once the milestone is completed, each sub-group will test each other's module before integration in order to understand the functionality of the component and to catch further bugs and possibilities for improvements.

When all the sensor types are tested and completed, the integrated scanning chamber dimensions will be determined by the size of individual sensors. The group will test the functionally for optimal placement and minimal interference between sensors together to ensure the best achievable performance. Once we have an integrated scanning chamber we will run numerous trials of common bottle shapes and material types to examine the accuracy, speed and power consumption of the overall systems to meet specification. Abnormally shaped bottles and common trash will be analyzed near the completion of the project to cover as much corner cases as possible.

The mechanical aspects will be tested during the development period to ensure that the moving components are built to withstand constant wear and tear. Also, the mechanical component has to be tested for speed and accuracy for how fast the sorting mechanism moves and the final position whenever the motor stops.

For our milestones, we have dedicated the final 3 to 4 weeks for the project cycle purely on final integration. At this stage of our project, we will assemble different components together to form a functional prototype and extensive studies will be carried out to gather data on the overall performance and accuracy of our system. Data will be collected based on bottles of different shapes and sizes and also plastic and glass bottles of different tints of color. Also, we will consider and tweak the system to be able to process as much corner cases to process as much oddities as we can, given the time constraints before finalizing the project.

9.2 Typical Usage Scenario. This section describes the user experience and the step requires when user is operating the Green Bin:

1. User stands in close proximity to the green bin.
2. Wait for orifice to open.
3. Insert object.
4. Wait for orifice to open again before inserting another object.

10. Conclusion

The functional specification document details the requirements needed to ensure the functionality of the overall product. This document also contains the general test plan and integration methodology for the project to warrant success and accuracy of the system. The requirements included within the document provide a complete set of guidelines and boundaries for the team to work within during the research and development stages. Likewise, it also consists of the features that will be implemented to make certain the device operates efficiently, safely and easy to operate for users. The specifications characterize the potential of the Green Bin for the proof-of-concept model to be completed within the course deadlines and also further improvements and add-ons for future production design.

11. References

2. General System Requirements

2.2 Physical Requirements

[1] Caterpillar Lift Trucks Specs
(http://www.cat-lift.com/tasks/render/file/index.cfm?fileID=8F3CC1F5-9433-F510-FD97C2047D9761B9)

2.7 Standards Requirements

[2] Restriction of hazardous substances in electrical and electronic equipment (RoHS)
(http://www.netregs.gov.uk/netregs/63025.aspx)

[4] IEEE ISO 9001
(http://www.computer.org/portal/web/readynotes/sample-standards-support-for-iso-9001-getting-your-organization-started)

[5] IEC 62369−1
(http://www.aimglobal.org/members/news/templates/template.aspx?articleid=3302&zoneid=42)