

# Table of Content

List of Figures .....	2
List of Tables .....	2
Abstract .....	3
1. Introduction .....	4
1.1 Background .....	4
1.2 Scope .....	5
1.3 Intended Audience .....	5
1.4 Classification .....	5
2. System Overview .....	6
2.1 Product Design .....	6
2.1.1 .....	Website
2.1.2 Parcel Locker .....	7
3. System Requirements .....	8
3.1 General Requirements .....	8
3.2 Electrical Requirements .....	8
3.3 Physical Requirements .....	9
3.4 Hardware Requirements .....	10
3.4.1 Hardware Overview .....	10
3.4.2 Display Interface Requirement .....	11
3.4.3 Micro-controller Requirements .....	11
3.4.3.1 The Master Controller Requirement .....	11
3.4.3.2 The Slave Controller Requirement .....	12
3.4.4 Camera Module .....	12
3.4.5 Electronic Cabinet Lock .....	13
3.5 Software Requirements .....	14
3.5.1 Software Overview .....	14
3.5.2 Database Requirement .....	14
3.5.3 Server Requirement .....	14
3.5.4 Web-Application Requirement .....	15
3.5.5 Central Control Unit Software Requirement .....	16
4. Engineering Standards .....	17
5. Safety and Sustainability .....	18
5.1 Safety.....	18
5.2 .....	
Sustainability.....	19
6. Conclusion .....	20
Glossary .....	21
References .....	22
Appendix A: Acceptance Test Plan (for PoC) .....	24
Hardware Testing .....	24
Software Testing .....	25

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## List of Figures

<i>Figure 1:</i>	Overview of system interactions	6
<i>Figure 2:</i>	Proposed DPL station for final product	9
<i>Figure 3:</i>	Hardware layer interaction diagram	10
<i>Figure 4:</i>	Electronic Cabinet diagram	13

## List of Tables

<i>Table 1:</i>	Engineering Standards	18
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## Abstract

This document describes the functional specifications and outlines the requirements of DPL. It contains a detailed look at each specific engineering standard and a complete analysis of the problems it targets to solve. The goal is to give the reader an explanation of the product without excessive design details.

The DPL consists of 2 components at its highest level: a website and a parcel locker aimed at improving security and efficiency of online shopping. The website will display UI and the frontend; however, the website will be controlled by the underlying server which will have its own components. Other than filling backend needs, the server will control the DBMS, DPL management, and a connection to the courier server for information retrieval. The parcel locker will consist of its own intuitive software controls along with an easy to use UI. The website and the parcel locker will seamlessly integrate with the firmware and hardware, resulting in a product that creates the most efficient and secure online shopping experience.

Overall, there are four main sections in this document:

- Requirement Specifications aimed at providing the reader with requirements of the system. This includes the general, electrical, software, safety and mechanical requirements of the system along with justification for design decisions.
- Engineering Standards aimed at outlining the standards that apply to the system with references from outside sources
- Carefully analyzed sustainability and safety issues related to device
- Proposed test plan for Proof-of-concept prototype

This document includes figures and graphs to represent specs as well as extensively detailed constraints considered for a marketed product. As well as providing the reader with a more comprehensive system overview of DPL. Furthermore, Sustainability and Safety of the project have been integral parts of the design phase, and they will continue to play a large role at every phase moving forward. The document will conclude by discussing the deliverables up until the end of August 2020.

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# 1. Introduction

When you combine efficiency, security, and accessibility, you get DPL by Parcel Solutions Inc. A delivery parcel locker that allows online shoppers to access their packages efficiently and securely every time. DPL will produce a secure passcode for an online shopper and the courier company. Parcel Solutions will then check its database and search for an available DPL and match it with the expected delivery date of the package. The delivery courier will have to verify themselves through scanning a QR code or inputting their passcode. Upon verification, the courier will place the package inside the appropriate locker. The customer will then use an access code provided by DPL to pick up their package from the locker.

## 1.1 Background

A common issue many online shoppers have is efficiency and accessibility to one's package. At the moment, couriers around North America are instructed to leave a note on apartment buildings if the customer is not available to receive their package. The customer is then expected to take the note left at the door by the courier and go pick up their package from the nearest postal service office. This solution is extremely inefficient and inconvenient for many customers. With DPL, online shoppers will no longer need to go to a postal service office to pick up their package. Parcel Solutions will provide online shoppers with a secure and remote method for customers to have their packages delivered.

A major issue that has surfaced across North America in the past several years with the fast rise of online shopping is package theft. Online shoppers around North America have packages delivered to their homes and apartments all the time, however, occasionally they come home from work to pick up their package from their doorsteps just to realize that their package has been stolen. A major issue we Parcel Solutions is targeting is security. DPL by Parcel Solutions will improve package security all around North America and ensure that customers will never have to worry about package theft again.

Currently, there is no product like this on the market, only Amazon offers something with a similar functionality. However, the lockers that Amazon offers aren't widely accessible across North America and are only available to online shoppers that directly order through Amazon. This is where we differentiate ourselves from the competition.

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## 1.2 Scope

This report clarifies the functional specifications and requirements of DPL, which must be met by Parcel Solution Inc. This document will give a thorough description of the proof of concept model and all the different requirements necessary for production. Additionally, it seeks to clarify the high-level functionality of the product, how it would work and how it would be utilized.

## 1.3 Intended Audience

This document is intended to be used by the members of Parcel Solutions Inc. for development of DPL as well as the teacher assistants' marking this document, and senior engineers who are keen on this project. It can be used throughout the research and product development stages as a reference to provide the overall view of the product. Furthermore, future revisions of DPL will draw from the framework outlined and detailed in this document.

## 1.4 Classification

In order to make it easier to reference and prioritize the requirements, the following convention will be used throughout this document:

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

Req is an abbreviation for requirements. The letters **A**, **B**, **C** and **D** correspond to integers values that symbolize the hierarchical order of the requirement. The letter **A** will reference the root section, **B** represents the subsection of **A**, **C** corresponds to the subsection of **B** and finally **D** corresponds to the subsection of **C**. The **XX** specifies the priority of the requirement.

There are three priority levels:

**PC** – The requirement refers to a proof-of-concept (Alpha phase)

**PT** – The requirement refers to a prototype (Beta Phase)

**FP** – The requirement refers to a final product (Production)

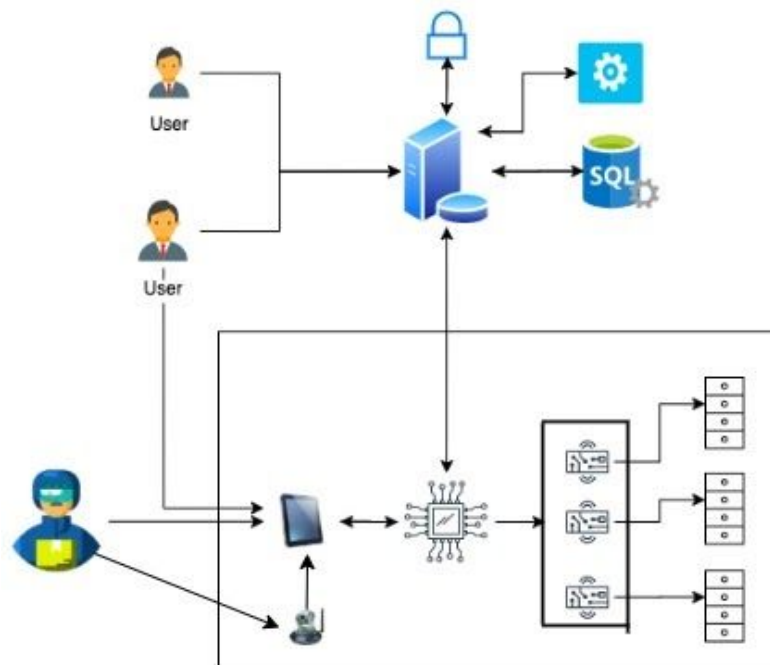
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## 2. System overview

### 2.1 Product Design

DPL is a modern parcel locker that consists of a backend/frontend website and a locker to improve the online shopping experience. The website will display UI and the frontend; however, the website will be controlled by the underlying server which will have its own components. Other than filling backend needs, the server will control the DBMS, DPL management, and a connection to the courier server for information retrieval. The interactions between the server, DBMS, DPL management and website can be seen in Figure 1.

The parcel locker will consist of its own intuitive software controls along with an easy to use UI. The UI will be presented to the customer and courier in the form of a digital screen. The courier and customer interaction with the parcel locker UI is shown in Figure 1.



**Figure 1:** Overview interaction system diagram

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### **2.1.1 Website and Server**

The website component of DPL will consist of a backend server and a DBMS that will coordinate the customer and DPL interactions. The customer will be required to log in onto our website and make a DPL delivery request. DPL will generate a set of instructions for the courier company to access the DPL lockers. Once the customer receives their tracking number, they will be required to input the tracking number into the DPL website. This allows DPL to check the database and match the delivery date of the package with an empty locker. Once the package tracking number has been put into the database, DPL will generate an access code for the customer to access the parcel locker. The tracking number and customer information will be stored in the database for future reference.

### **2.1.2 Parcel Locker**

The parcel locker will consist of its own intuitive software controls and a digital touch screen to present the UI. The courier and the customer will interact with the DPL lockers through the digital touch screen. The courier company will have specific instructions given to them by DPL to access the parcel lockers and place the customer package inside. The customer will use an access code provided by DPL to pick up their package from the parcel locker. Once the customer has picked up their package, DPL will update their database and the locker availability.

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## 3. System Requirements

### 3.1 General Requirements

[Req 3.1.1 - FP] The system will be intended for indoor and outdoor usage.

[Req 3.1.2 - FP] DPL owner and customers should be able to cancel any expected deliveries.

[Req 3.1.3 - FP] The embedded system along with its needed hardware must cost less than \$500. (not including the cost for the skeleton body of the mailboxes).

[Req 3.1.4 - FP] The device shall be easy to assemble and disassemble.

[Req 3.1.5 - FP] Strong documentation practices and software version control management systems will be implemented.

[Req 3.1.6 - FP] Physical user manual should be printed and shipped with the product.

Languages used in the manual will be appropriate for their destination.

[Req 3.1.7 - FP] The device can be operated and initialized by a single person without a need for prior technical knowledge

### 3.2 Electrical Requirements

[Req 3.2.1 - PC] The system is powered using wall plug

[Req 3.2.2 - PC] DPL shall draw electrical power using a NEMA 5 electrical plug.

[Req 3.2.3 - FP] For outdoor usage DPL will require hard-wired electrical lines

[Req 3.2.4 - FP] All voltage level for all components should be in the range 3 - 12 V

[Req 3.2.5 - FP] Lose the power suddenly will not lose information and breakdown the function of locking the boxes

[Req 3.2.6 - FP] The internal circuit shall have short circuit protection for unexpected excessive voltage frequency run in the circuit.



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### 3.3 Physical Requirements

[Req 3.3.1 - FP] DPL's exterior body must be made out of heavy duty aluminum to be impact resistant.

[Req 3.3.2 - FP] DPL's exterior must be water-proof.

[Req 3.3.3 - FP] The controller's box must allow for air to transfer out, this will be used along with fans for cooling mechanism.

[Req 3.3.4 - FP] The height of DPL must not exceed 160 cm.

[Req 3.3.5 - FP] All the lockers and main console box must be attached together.

[Req 3.3.6 - FP] Each locker must be with the following dimensions, (L:W:H), 20x20x40 cm - 50x50x90 cm.

[Req 3.3.7 - FP] All inputs, outputs, and controls must be clearly labeled

[Req 3.3.8 - FP] The Display monitor must be within 60-80 cm from the ground, which is in compliance with the average adult waist measurement of 70 cm in North-America.

[Req 3.3.9 - FP] DPL will require a minimum of 180 cm of flat base and 80 cm of clearance space.

[Req 3.3.10 - FP] DPL must allow for circulation of fresh air in the main controller locker.



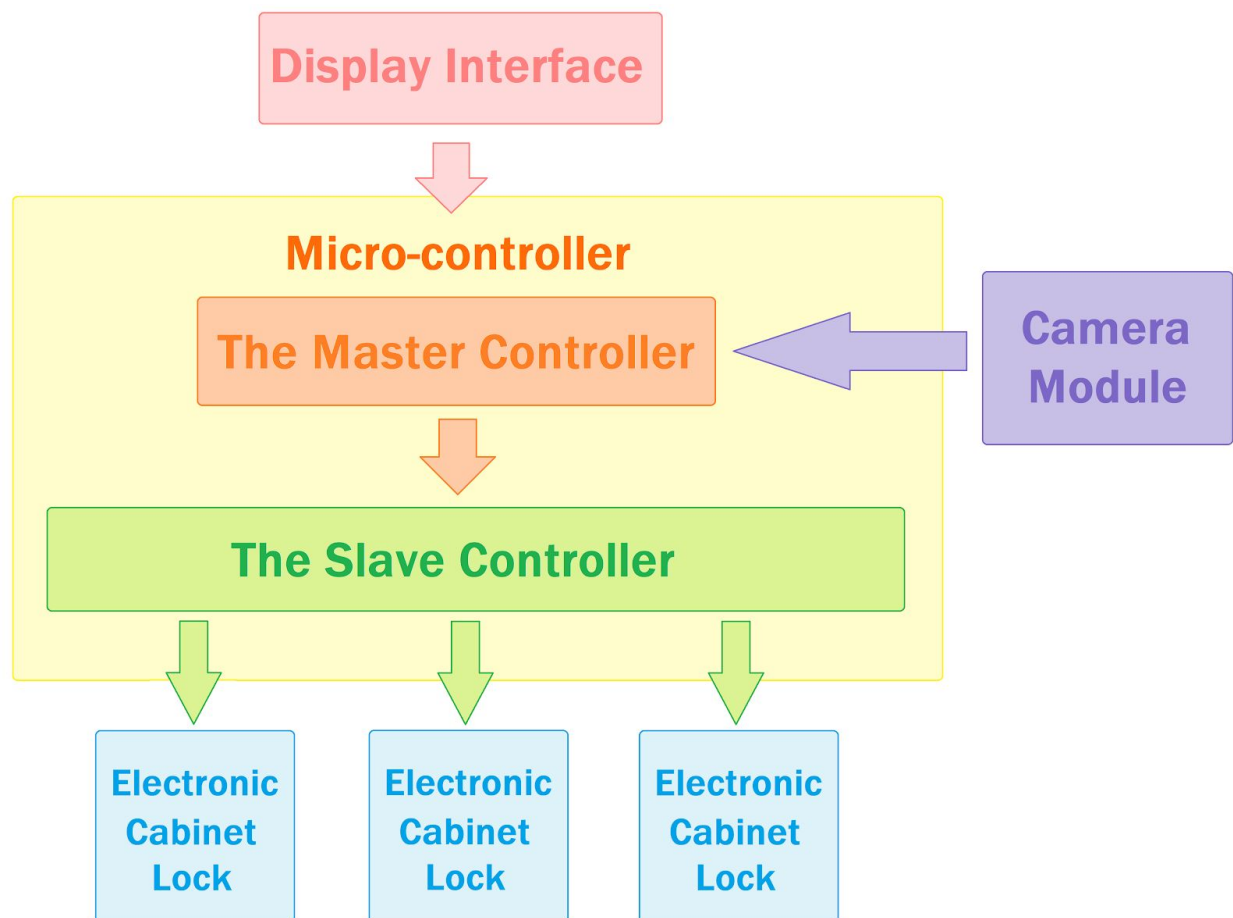
**Figure 2:** Proposed DPL station for final product.

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## 3.4 Hardware Requirements

### 3.4.1 Hardware Overview

The Hardware segment of DPL is the bridge that allows couriers and users to physically interact with DPL. DPL will supply an empty box for a courier to store the parcel. The courier will verify themselves and the master controller will receive the signal from the touch interface then give the commands to the slave controller to open the door automatically. After the courier stores the parcel and closes the door, the locked Electronic Cabinet Lock sends the message to the master controller that this box is employed. Upon the delivery, the main controller will be responsible for communicating with the web servers to alert the customer. The data flow relation between different hardware components are displayed in figure 3.



**Figure 3:** Hardware layer interaction diagram

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### 3.4.2 Display Interface Requirement

Display interface is the main port of communication between the DPL and clients. The display interface provides display information in pictorial form. Via the touchscreen, customers are met with intuitive package delivery and retrieval steps, while the couriers are met with a quick drop off process.

[Req 3.4.2.1 - PC] The display Interface must be a touch interface.

[Req 3.4.2.2 - PC] The power supply of display interface shall provide at least 500mA.

[Req 3.4.2.3 - PC] The display screen must be 7 inches diagonally.

[Req 3.4.2.4 - PC] The display interface shall have a minimum brightness of  $900 \text{ Cd/m}^2$  to be visible even on bright days.

[Req 3.4.2.5 - PC] The display interface shall have a minimum pixel resolution 800x480 pixels.

[Req 3.4.2.6 - PC] The display interface shall be connected to the master controller through a 40 pin interface capable to buffer and refresh the display interface panel at 60 Hz.

[Req 3.4.2.7 - PC] The display interface shall have general-purpose input/output (GPIO) and Display to the serial (DSI) ports to connect to the master controller.

### 3.4.3 Micro-controller Requirements

[Req 3.4.3.2 - PT] The main memory of the CCU controller must be at least 2 Gb.

[Req 3.4.3.3 - PC] The main controller must support Gigabit Ethernet connection.

[Req 3.4.3.4 - FP] The main controller must have support for the bluetooth module.

[Req 3.4.3.5 - PC] CCU controller must have a wifi module with capability of both LAN and wifi connectivity.

[Req 3.4.3.6 - PC] The master controller shall have general-purpose input/output (GPIO) and Display to the serial (DSI) ports to connect the display interface.

[Req 3.4.3.7 - PC] The master controller shall have USB ports to connect the slave controller.

[Req 3.4.3.8 - PC] The main controller must operate within 3.3 to 5 DC-Volts.

[Req 3.4.3.9 - FP] DPL must contain a 5-V DC cooling fan for when excessive heat builds up inside the controller.

[Req 3.4.3.10 - PT] The unexpected loss of electricity won't bring about loss of data.

#### 3.4.3.1 The Master Controller Requirement

The master controller shall generally connect with the slave controller, scanner and touch screen. It can supply adequate power for the slave controller working usually. The master controller will

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collect signals from the camera and touch screen, then analyze and furnish the feedback into the server and database.

[Req 3.4.3.1 - PC] The secondary storage of the CCU controller must be at least 8 Gb.**3.4.3.2**

### **The Slave Controller Requirement**

The slave controller shall contain multiple channels relay board that performs lock controlling in the electronic locker system. It acts as the interface between the master control and the electronic cabinet locks. The slave controller operates under control of the master controller and provides relay output to the locks, meanwhile provides report of the door status to the main.

[Req 3.4.3.1 - PC] The slave controller shall have standard pins as electric control lock connection.

[Req 3.4.3.2 - PC] The slave controller shall have USB ports or interface to connect to the master controller.

[Req 3.4.3.3 - PC] The slave controller shall connect to the electronic cabinet lock.

[Req 3.4.3.4 - PC] The slave controller shall have digital input for door status reporting.

[Req 3.4.3.5 - PC] The operation current of the slave controller shall not exceed 5A.

[Req 3.4.3.6 - PC] The slave controller shall have a short circuit protection function in particular.

[Req 3.4.3.7 - FP] The slave controller shall support up to 5 electronic cabinet locks.

### **3.4.4 Camera Module**

The camera is responsible to scan the QR code which is provided through the courier's and user's mobile device. The QR code will contain the information such as the recipient's recognizable token and tracking number that will be transferred to the master controller for further processing.

[Req 3.4.4.1 - PT] The camera shall be able to scan the QR code.

[Req 3.4.4.2 - PT] The camera shall have a Camera Serial Interface (CSI) port to connect the master controller.

[Req 3.4.4.3 - PT] The size of camera shall not be exceeded, (LxWxH) 40 x 40 x 20 mm.

[Req 3.4.4.4 - PT] The camera shall be capable of at least 3280 x 2464 pixel static images.

[Req 3.4.4.5 - FP] The weight of the camera shall not exceed 3g.

[Req 3.4.4.6 - PT] The camera shall support at least 640x480p video.

[Req 3.4.4.7 - PT] The camera shall have a native resolution of 8 megapixel.

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### 3.4.5 Electronic Cabinet Lock

The electronic cabinet lock is a high security access control solution for DPL. It will be constrained by a slave controller shall be compatible with the control system with simple push-to-close operations.

[Req 3.4.5.1 - FP] The lock shall be made by steel plate material.

[Req 3.4.5.2 - FP] The lock shall have surface mounting either vertically and horizontally offers easy and flexible installation.

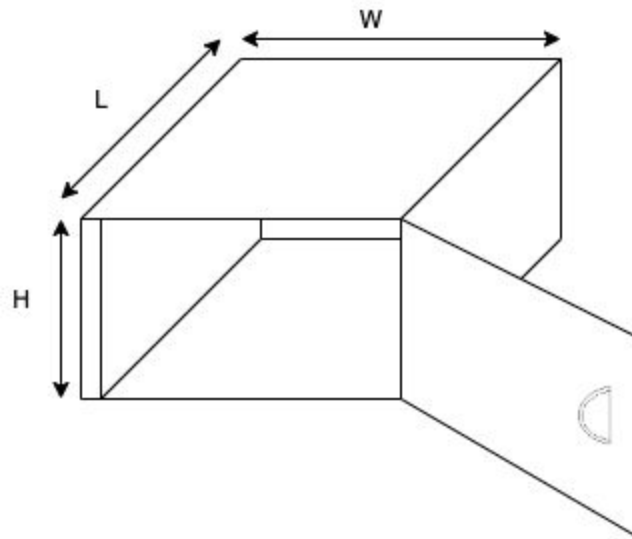
[Req 3.4.5.3 - PC] The lock shall have a minimum lifespan of 1 million clicks.

[Req 3.4.5.4 - FP] The lock shall have a dimension no larger than (LxWxH) 80x70x18mm.

[Req 3.4.5.5 - FP] The lock shall be applicable for 0.5-4 Kg weight doors.

[Req 3.4.5.6 - FP] The work environment of the lock shall be between -30 to 50 Celsius.

[Req 3.4.5.7 - PT] The cabinet lock shall not have a handle, upon opening the lock will be unlocked and the door will be pushed open.



**Figure 4:** Electronic Cabinet diagram

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## 3.5 Software Requirements

### 3.5.1 Software Overview

DPL software will mainly comprise of the web-application and the backend servers that will be the spine of dealing with the sum of interactions. DPL will gather sensitive data containing client information and data about the bundle. It is fundamental to forestall information spillage and keep hidden information secure. Also, the modules must be intended to represent future redesigns and extensions. Our web-application will be based upon a layer of framework so as to deal with functionalities in the most efficient and secure way.

### 3.5.2 Database Requirement

The entirety of our data will be put away utilizing a DBMS server. DPL is an information driven venture; in this way, there can not be any irregularities with the database. It is crucial for the DBMS to be able to handle as many as concurrent real-time queries. It is additionally significant for the information to be steady and not be changed in an unfortunate manner. DBSM must catch cutting-edge interleaving ways to deal with forestall abnormalities and interdependencies.

[Req 3.5.2.1 - PT] DBMS must follow ACID properties.

[Req 3.5.2.2 - PT] Database tables must be normalized to prevent interdependencies.

[Req 3.5.2.3 - PT] DBMS must be able to interleave transactions such that isolation and consistency protocols are followed.

[Req 3.5.2.4 - PT] DBMS must use conflict serializability or a higher level of concurrency control to prevent read-write conflicts.

[Req 3.5.2.5 - PT] DBMS must be relational as the data is carefully structured.

[Req 3.5.2.6 - FP] DBMS's connection pool must be optimized using spindle count.

[Req 3.5.2.7 - FP] DBMS engine must be able to store no less than 10Gb of data per each DPL machine existent.

### 3.5.3 Server Requirement

The server must have enough memory to guarantee the site doesn't crash.

So as to extend DPL over numerous urban areas and develop in huge scope, it must have a versatile framework. The server should deal with all the frontend and backend rationale. DPL CCU should speak with the servers to empower foreseeable features.

[Req 3.5.3.1 - PT] Client and host server will communicate using Client-server structure

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[Req 3.5.3.2 - FP] Down time after a failure shall not exceed 5 hours.

[Req 3.5.3.3 - FP] User's sensitive data must only be visible for internal modulus of the server and employees with valid permission.

[Req 3.5.3.4 - FP] In case of exception the server must take appropriate recovery steps.

[Req 3.5.3.5 - PT] Permission updates must be immediately communicated to the control system.

[Req 3.5.3.6 - PT] All the interaction with the system must be done in real time (less than 500 ms latency).

### **3.5.4 Web-Application Requirement**

The web-application goes about as a passage between the client and the CCU/servers. Client's solicitations, for example, conveyance demands are received through the web-application. The API's will utilize fundamental modulus to finish their solicitation.

[Req 3.5.4.1 - PT] The website must be compatible with the latest version of Google Chrome(version: 83.0.4103.97) , Safari (version: 12.1.2), Firefox (version: 77) and Edge (version: 81.0.416.77).

[Req 3.5.4.2 - PT] The website design must be intuitive and must not take more than 3 redirects to complete a request.

[Req 3.5.4.3 - FP] The system shall provide password protected access to web pages that are to be viewed only by employees.

[Req 3.5.4.4 - PT] Customers should be able to register themselves in order to use DPL services.

[Req 3.5.4.5 - PT] Customers should be able to update their information.

[Req 3.5.4.6 - PT] Web-Application must notify the customer, through email, about their status of package.

[Req 3.5.4.7 - PT] Web-Application must communicate with the appropriate mailbox upon a delivery request and return the feedback to the user.

[Req 3.5.4.8 - PT] DPL owner should be able to provoke permission of tenants.

[Req 3.5.4.9 - PT] Web-Application should not unethically access personal data.

### **3.5.5 Central Control Unit Software Requirement**

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Each mailbox has an embedded Central Control Unit, CCU, which is the control unit and the main source of communication with the mailbox. CCU is mainly responsible for locally managing electronic cabinet lockers, locker allocation, and communicating with the servers. DPL mailboxes will briefly store client data and conveyance subtleties. Any privately put away data will be encoded. This is all because of ensuring client information if there should be an occurrence of a burglary.

[Req 3.5.5.1 - FP] It must invalidate a user's request for the locker, if the package has not been delivered 2 days past the expected delivery date.

[Req 3.5.5.2 - PT] CSS must store information regarding the users and packages related to it, in a local database.

[Req 3.5.5.3- PT] DPL must use internet connection to update status of delivery and accept pending deliveries.

[Req 3.5.5.3 - FP] CSS must encrypt the local database stored on disk, in case of a theft.

[Req 3.5.5.4 - PC] CSS must send unlock signals to individual lockers.

[Req 3.5.5.5 - PC] CSS must be able to receive and interpret signals from individual lockers.

[Req 3.5.5.6 - PC] CCS must be able to verify and cross reference the input passcode with the expected packages.

[Req 3.5.5.7 - PT] CSS must immediately process and communicate to the servers the delivery of a package.

[Req 3.5.5.8 - PC] CSS must deny/approve a delivery request based on the expected availability of the lockers.

[Req 3.5.5.9 - PC] CSS must be able to accept packages, based on its local database, when operating without the internet.

[Req 3.5.5.10 - PT] CSS must send all its backlogged messages upon connecting to the internet.

[Req 3.5.5.11 - FP] The software/firmware upgrades must take place outside the local courier operation hours.

[Req 5.5.12 - PC] The CSS must recover from an idle state within 4 seconds.

[Req 5.5.13 - PC] The CSS's locker allocation management must use a dynamic priority scheduling algorithm to maximize the number of delivery requests.

[Req 5.5.14 - PC] Software, hardware, and I/O interrupts must be handled and not place the system under undefined behaviour.

## **4. Engineering Standards**



A very important aspect of creating a durable and maintainable product is to be sure to abide by proper standards for the design, as well as the integration process. The Canadian Standards Association and International Organization for Standardization is an acclaimed organization who's publications act as a guideline for the team at Parcel Solution Inc.

We use standards that are taken from CSA and ISO since their standards are widely used and recognizable. We aim to meet most of their standards by the end of our prototype stage, as well as all of their standards by our production model. The selected engineering standards are listed and described in table 1 below.

Standards	Description of standard
CSA-C22.2 NO. 61508-1:17	Functional safety of electrical/electronic/programmable electronic safety-related systems - Part 1: General requirements [1]
CSA-C22.2 NO. 0-10	General requirements - Canadian electrical code, part II [2]
CSA 60730-1	Class B certification in any STM32 application [3]
ISO 13850:2015	Safety of machinery -- Emergency stop function -- Principles for design [4]
ISO/IEC/IEEE 29148:2018	Systems and software engineering -- Software life cycle processes [5]
ISO/IEC 26551:2016	Software and systems engineering — Tools and methods for product line requirements engineering [6]
ISO/IEC 18004:2015	Information technology — Automatic identification and data capture techniques — QR Code bar code symbology specification [7]
ISO/IEC 26551:2016	Series 1 freight containers — Handling and securing [8]
ISO 14119:2013	Safety of machinery — Interlocking devices associated with guards — Principles for design and selection [9]
ISO 9241-9:2000	Ergonomic requirements for office work with visual display terminals (VDTs) — Part 9: Requirements for non-keyboard input devices [10]
ISO 14040:2006	Environmental management — Life cycle assessment — Principles and framework [11]

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**Table 1:** Engineering Standards

## 5. Safety and Sustainability

### 5.1 Safety

The main goal of DPL is to improve the safety and security for our customers. Safety and security is a fundamental feature for our company as we want to ensure a customer receives their package securely. Additionally, any potential hazards shall be prevented and listed in this document. We will require the final product to hide all circuitry to prevent users from coming into contact with the wiring, and the device to avoid any accidents. Additionally, we will eliminate the hard edges of the locker by making sure they are well sanded. The final product will be well designed in such a way to prevent users from hurting.

[Req 5.1.1- FP] The mailbox body shall circumvent sharp corners and edges to avoid injuries.

[Req 5.1.2 - PT] DPL shall be grounded to avoid injury to the user and/or damage to the system

[Req 5.1.3 - FP] The skeleton material shall not be toxic and recyclable.

[Req 5.1.4 - PT] DPL should be non-flammable and non-explosive.

[Req 5.1.5 - FP] DPL must be securely screwed to wall or ground to not tip over.

[Req 5.1.6 - FP] The master controller shall be designed to improve the heat dissipation to prevent overheating.

[Req 5.1.7 - PT] The hardware parts shall tighten suitably in case lose components and hurt people

[Req 5.1.8 - PT] The electrical components pins shall properly connect with breadboard and wires shall orderly be aligned to avoid touching human parts.

[Req 5.1.9 - PT] DPL shall be physical and systematic stable during users using and prevent mistakenly operating from a breakdown

[Req 5.1.10 - FP] The boxes doors shall work adequately to prevent eject from hitting users

[Req 5.1.11 - FP] DPL shall ground the wire properly because of metal outline

[Req 5.1.12 - FP] DPL shall be stable on the ground and shall not dump during using the top of the boxes

### 5.2 Sustainability

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With the growing concern of sustainability, it is significant that doing our part of the environment when people have an enormous economic benefit from their distinguished achievement. In designing, we take a "cradle-to-cradle" as a core value. Meanwhile, DPL is designed with sustainable and environment-friendly materials and the substances are recycled at the end of the lifetime of the product. It will be prosecuted to the end that keeps the core value from the beginning of the product lifecycle to the end of merchandise lifetime. Parcel Solution Inc. will maintain the "cradle-to-cradle" design to encourage sustainability while producing an excellent quality product.

[Req 5.2.1 - PC] DPL in the development stage we shall re-use wires and composite wood

[Req 5.2.2 - FP] The master controller can be reused because it is a mainframe that is able to satisfy future projects

[Req 5.2.3 - FP] The camera and touch screen are applicable in other different equipment with compatible interface

[Req 5.2.4 - FP] The slave controller can be reused in a system which operates under the control of the main controller and provides relay output to the sub-components

[Req 5.2.5 - FP] DPL uses aluminum as its outline, which is a 100 percent recyclable and sustainable metal. [12]

## **6. Conclusion**

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This document is a reference to the architectural and structural design of DPL. These requirements will provide a brief introduction of hardware and software functionality that is necessary for DPL to perform its intended purpose. They are also considered in detail to ensure a specified product. These requirements uphold the system and machine's design and test. The physical requirements meet with the size and weight of DPL being designed and supply environmental security for the packages. DPL can operate fluently by the hardware requirements and afford demands for regular usages. The software requirements can provide efficiency for couriers and security for customers. A layer of an open-source framework will institute our website to handle functionalities in the most optimized manner and prevent data leakage. Combining with the server and DBMS, they can handle the concurrent real-time queries and store customers' information adequately.

The development of DPL contains two stages: Proof-of-Concept and Engineering Prototype. Both of them will meet safety standards and sustainability issues. This document will be used not only through the design and development cycles as a reference but also in showing how the device will be tested and demonstrated.

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## Glossary

1. **ACID**: ACID stands for atomicity, consistency, isolation and durability. These are main characteristics that need to be met in order to build a concurrent and large scale database management system.
2. **API**: API stands for an application programming interface. It is a computing interface which defines interactions between multiple software intermediaries.
3. **CCU**: CCU stands for Central Control Unit, which refers to the master microcontroller embedded within the DPL system.
4. **CSA**: CSA stands for the Canadian Securities Administrators.
5. **DBMS**: Database Management System.
6. **DPL**: Delivery Parcel Locker
7. **DSI**: DSI stands for Display Serial Interface. It is a specification by the Mobile Industry Processor Interface (MIPI) Alliance aimed at reducing the cost of display controllers in a mobile device.
8. **GPIO**: GPIO stands for a general-purpose input/output. It is a substantive digital signal pin on an integrated circuit.
9. **ISO**: ISO stands for the International Organization for Standardization.
10. **LAN**: LAN stands for a local area network. It is a computer network that interconnects computers within a limited area.
11. **MIPI**: MIPI Alliance is a global business alliance.
12. **NEMA**: NEMA stands for a Standard of the National Electrical Manufacturers Association.

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## References

- [1] CSA, “CAN/CSA-C22.2 NO. 61508-1:17. - Functional safety of electrical/electronic/programmable electronic safety related systems — Part 1: General requirements” [Online] Available: <https://www.scc.ca/en/standardsdb/standards/28870> [Accessed at Jun 9, 2020]
- [2] CSA, “CAN/CSA-C22.2 NO. 0-10 (R2015) - General requirements - Canadian electrical code, part II” [Online] Available: [https://store.csagroup.org/ccrz\\_\\_ProductDetails?viewState=DetailView&cartID=&sku=CAN/CSA-C22.20NO.00-10&cclcl=zh\\_TW](https://store.csagroup.org/ccrz__ProductDetails?viewState=DetailView&cartID=&sku=CAN/CSA-C22.20NO.00-10&cclcl=zh_TW) [Accessed at Jun 8, 2020]
- [3] CSA, “UL/CSA/IEC 60730-1 - Class B certification in any STM32 application” [Online] Available: [https://www.st.com/resource/en/application\\_note/dm00105610-guidelines-for-obtaining-ulcsaiec-607301603351-class-b-certification-in-any-stm32-application-stmicroelectronics.pdf](https://www.st.com/resource/en/application_note/dm00105610-guidelines-for-obtaining-ulcsaiec-607301603351-class-b-certification-in-any-stm32-application-stmicroelectronics.pdf) [Accessed at Jun 7, 2020]
- [4] ISO, “ISO 13854:2017 - Safety of machinery -- Emergency stop function -- Principles for design” [Online] Available: <https://www.iso.org/standard/66459.html> [Accessed at Jun 7, 2020]
- [5] ISO, “ISO/IEC/IEEE 29148:2018 - Systems and software engineering -- Software life cycle processes” [Online] Available: <https://www.iso.org/obp/ui/#iso:std:72089:en> [Accessed at Jun 12, 2020]
- [6] ISO, “ISO/IEC 26551:2016 - Software and systems engineering — Tools and methods for product line requirements engineering” [Online] Available: <https://www.iso.org/standard/69530.html> [Accessed at Jun 8, 2020]
- [7] ISO, “ISO/IEC 18004:2015 - Information technology — Automatic identification and data capture techniques — QR Code bar code symbology specification” [Online] Available: <https://www.iso.org/standard/62021.html> [Accessed at Jun 10, 2020]
- [8] ISO, “ISO 3874:2017 - Series 1 freight containers — Handling and securing” [Online] Available: <https://www.iso.org/obp/ui/#iso:std:iso:3874:ed-6:v1:en> [Accessed at Jun 12, 2020]

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- [9] ISO, “ISO 14119:2013 - Safety of machinery — Interlocking devices associated with guards — Principles for design and selection” [Online] Available: <https://www.iso.org/obp/ui/#iso:std:iso:14119:ed-2:v1:en> [Accessed at Jun 11, 2020]
- [10] ISO, “ISO 9241-9:2000 - Ergonomic requirements for office work with visual display terminals (VDTs) — Part 9: Requirements for non-keyboard input devices” [Online] Available: <https://www.iso.org/obp/ui/#iso:std:iso:9241:-9:en> [Accessed at Jun 7, 2020]
- [11] ISO, “14040:2006 - Standard for environmental management -- Life cycle assessment -- Principles and framework” [Online] Available: <https://www.iso.org/standard/37456.html> [Accessed at Jun 8, 2020]
- [12] The Aluminum Association, *Aluminum Sustainability* [Online] Available: <https://www.aluminum.org/aluminum-sustainability> [Accessed at Jun 12, 2020]

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## Appendix A: Acceptance Test Plan (for PoC)

To ensure the quality of DPL, Parcel Solution Inc has developed a series of testing approaches to verify functionalities. Our goal is to detect and fix any arisen bugs during the development and fix them prior to demo.

In this appendix, we would mainly focus on how to test the functionalities about the proof of concept (PoC) of DPL. A comprehensive test plan is required to ensure that all aspects of DPL are covered and tested. It contains details of the testing scope, items and features to be tested. During our development process, the following specifications will be prioritized in order to ensure DPL can operate under the basic functionalities.

### Hardware Testing

The motivation behind hardware testing is to guarantee various modules are arranged accurately and play out their predetermined tasks as planned. This will occur in 2 phases. To start with, we will perform unit testing on all the modules independently. This is to guarantee all equipment segments are proceeding true to form. At last, we will perform integration testing to guarantee that DPL plays out its assignment true to form once all the modules are connected together.

Testing Number	Description	Pass/Fail	Comments
Test 1	The “lock-unlock” signals of lockers are able to transmit to the CCU.		
Test 2	The camera of DPL is able to scan the QR code from the courier.		
Test 3	The slave controller is able to receive the control signals from the master controller.		
Test 4	The slave controller is able to provide a report of the door status to the CCU.		
Test 5	Each electronic lock is controlled separately by the slave controller.		



Test 6	The electronic locks are compatible with simple push-to-close operation.		
Test 7	The microcontrollers have safety protection measures.		

## Software Testing

Our focus is primarily on the hardware portion for the implementation of the prototype. Our goal is to have most of our servers and web-application completed, anyway, this won't be the focal point of the PoC stage. Nevertheless, there are some software(firmware) components within the need for further testing.

Testing Number	Description	Pass/Fail	Comments
Test 1	The hardware components must have a protocol for any related interrupts.		Interrupts will include external, internal and software interrupts.
Test 2	A series of write-read queries will be dispatched to attempt to invalidate the data.		Additionally, we will be also looking for dirty-read anomalies.
Test 3	The touch display must be able to correctly register the numbers entered by the user.		
Test 4	Performing in an offline environment, without internet connectivity.		DPL must not completely rely on internet connection and needs to be able to perform based upon its locally stored data.