CleanLift

February 15th, 2016

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

Re: ENSC 305W/ENSC 440W Functional Specifications for CleanLift

Dear Dr. Rawicz,

Attached is the functional specifications for CleanLift, a touchless elevator panel system. CleanLift is the inaugural product developed by our company, Porcupine Solutions, and aims to reduce disease and germ transmission between elevator users in disease-sensitive environments such as hospitals and cruise ships.

The functionality of the CleanLift system will be outlined, as well as the requirements for each subsection of our system. The requirements for each stage of the development from proof-of-concept to production version will be defined in terms of technical specifications, external standards, safety, and sustainability. The functionality requirements in this document shall be used to guide system design. Functional specifications presented in this document aim to create a competitive, safe, sustainable and intuitive product so that users can benefit from touchless technology.

The Porcupine Solutions team is comprised of four engineering students: Ryan Goldan, Elizabeth Durward, Lauren Jackson, and Simon Huang. We thank you for your consideration of the CleanLift functional specifications. If you have any questions, feel free to contact our Chief Communications Officer, Lauren Jackson, by email at lljackso@sfu.ca.

Sincerely

Ryan Goldan
CEO, Porcupine Solutions

Enclosed: Functional Specification for CleanLift: Touchless Elevator Panel

Porcupine Solutions

CleanLift

Touchless Elevator Panel

Porcupine Solutions

Functional Specifications

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Primary Contact: Lauren Jackson - lljackso@sfu.ca

Submitted By:

Ryan Goldan
Lauren Jackson
Elizabeth Durward
Simon Huang

Abstract

As world population density increases, the task of keeping surfaces clean of harmful bacteria becomes harder to accomplish without simultaneous increases in technology. Disease transmission through contaminated common surfaces is a growing concern in high-risk environments such as hospitals, and elevators have been identified as a major culprit for harboring significant amounts of bacteria [1]. By introducing CleanLift touchless elevator panels, bacteria growth and transmission between elevator users can be significantly reduced and even minimized. Touchless panels will provide significant benefits for any user, but will be of greatest importance in disease-sensitive locations such as hospitals, where patients, doctors, staff, and visitors use elevators constantly.

For a touchless system, as for any for new technology, to be adopted by institutions it should satisfy three major requirements: have comparable reliability and functionality as current systems, be economically viable, and, most importantly, be intuitive to users. The functionality for the CleanLift system will be outlined in this document. Current elevator panels are reliable, easy to use and have minimal safety hazards, and to ensure CleanLift is competitive in the elevator market it shall be comparable to standard elevator panels in these categories. The sustainability of CleanLift shall improve upon current panels by focusing on Cradle to Cradle design throughout the development process from the proof-of-concept to the final production design. Technical consideration such as power consumption and control requirements shall also be considered along with the functionality required to meet all current applicable standards. CleanLift shall also decrease the cost of maintenance and upkeep for units by decreasing sanitization costs and having a robust construction.

CleanLift will provide significant health benefits for users by employing a touchless panel instead of a conventional mechanical button panel, and still needs be competitive in the current market for institutions to adopt this new and beneficial technology. The requirements to ensure a competitive, safe and sustainable product shall be thoroughly analyzed in this document.

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Glossary

Term	Description
BCSA	BC Safety Authority
DSPDD	Division for Social Policy and Development Disability, United Nations
IEC	International Electrotechnical Commission
I/O	Input/Output
IR	Infrared Light: 700 nm – 1 mm wavelength
ISO	International Standards Organization
LEDs	Light Emitting Diodes
ODM	Original Design Manufacturer: a company that designs and manufactures a product to be specified and branded by another firm for sale
RH	Relative Humidity
SFU	Simon Fraser University
UN	United Nations
USB	Universal Serial Bus

1 Introduction

CleanLift is a revolutionary solution aimed at reducing disease and bacteria transmission via elevator button surfaces. We have designed a simple, yet effective, touchless button panel system to greatly reduce bacterial spread in high-risk places such as hospitals, cruise ships, and residential buildings.

The CleanLift system is comprised of three main subsections, the physical panel, an optical sensing grid, and the control system. The physical panel will have indents instead of mechanical buttons as shown in Figure 1 below, and the design shall be intuitive so that new users will use it correctly without touch. The optical sensing grid is comprised of optical beams and optical sensors both horizontally and vertically, and the intersection points will create a touchless button in each of the indents. The control system will process input from the optical sensing grid and then activate visual and auditory feedback. Additionally, the control system will also have diagnostics that can monitor and detect faults in the sensing grid.

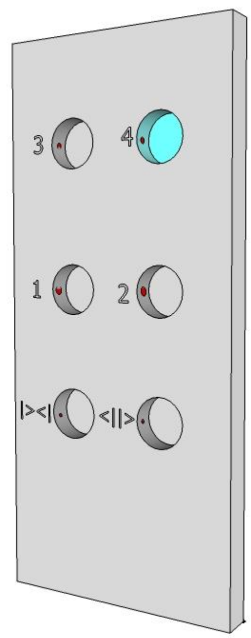

Figure 1: Outer panel of a 3x2 touchless panel

1.1 Background

Several studies have shown that elevator buttons are subject to more bacteria colonization than any other surface in hospitals and other public spaces [1] [2]. Currently, there are only two implemented approaches to address this issue: encourage personal hygiene for users [3] (washing hands, hand sanitizer, etc.), and regularly cleaning and disinfecting elevator surfaces. These approaches are dependent on the thoroughness of hospital administration and staff, thus leading to an inconsistent effect in reducing the spread of infectious disease.

Over the past two decades, touchless technology has been effectively implemented in nearly all modern buildings. Toilets, faucets, and door handles have been replaced with touchless mechanisms in hopes of reducing the presence of bacteria and improving sanitation on common surfaces. Unfortunately, this trend has yet to transfer over into the realm of elevators. CleanLift is a new technology presented by Porcupine Solutions that aims to introduce touchless technology to modern elevator panels. By implementing a system that consists of a sensing grid composed of optical beams oriented both vertically and horizontally across the physical panel, a touchless button is created at each intersection. In this manner, CleanLift eliminates the need for current elevators' potentially infectious physical buttons.

1.2 Scope

This document is intended to provide the functional specifications of the physical panel, sensing grid, and control system of CleanLift. These sections describe the mechanical, hardware, and software aspects of CleanLift, respectively. The document will also address the standards with which the system will comply, as well as the safety and environmental factors that will be considered throughout design, prototyping, and production phases.

1.3 Intended Audience

The functional specifications in this document are intended for - but not limited to - the engineering staff of Porcupine Solutions and any external elevator companies associated with the development and manufacturing of CleanLift. In particular, this document should be referenced by both design engineers and quality assurance engineers, to ensure that the design of the system as well as the manufactured product are concurrent with the functionalities outlined. Upper management, sales, and marketing staff should also be familiar with this document, as it provides important information about CleanLift, which will assist in the promotion of the product. Knowing all of the functions that have been considered in the design process will give more points on which to market the system.

1.4 Classification

The following convention will be used to denote individual specifications and the tier of development they pertain to:

[ST - ## - TD]

ST: Section Title
##: Specification Number
TD: Tier of Development

The development process for CleanLift has been split up into three tiers (TD), each with increasing functionality, and ending with a final production version. Requirements for a given version apply to that version and all subsequent versions unless otherwise specified. They will be labeled as follows:

I	Tier 1 - Proof of concept, basic functionality
II	Tier 2 - Prototype, some added features
III	Tier 3 - Prototype, all features implemented
P	Production Version

2 General System Requirements

The distinguishing feature of CleanLift is the touchless panel, aimed at reducing the spread of disease. This differentiates CleanLift from conventional elevator panels in function, however the appearance of the panel will be based off existing standards and conventions to uphold familiarity for users. CleanLift shall use optical sensing to implement touchless buttons, while feedback will be given to users to ensure they do not physically touch the panel. The main components of the system are the physical panel, the point of contact between CleanLift and users, the optical sensing grid, used to implement touchless buttons, and the control system, responsible for processing the inputs from the sensing grid and triggering feedback. Figure 2 below illustrates how the CleanLift subsystems interact and combine to form a cohesive system.

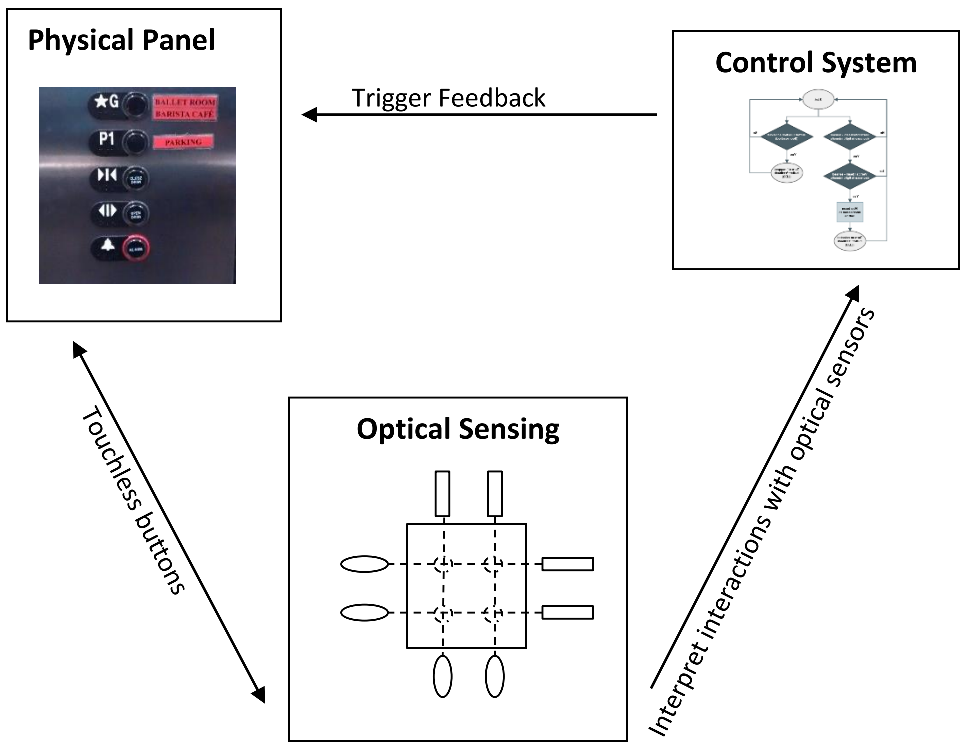

Figure 2: Subsystem Interactions Diagram

The requirements for the systems as a whole will be presented below, with specialised requirements for the physical panel, control system, and optical sensing described in later sections of this document.

2.1 User Interaction Requirements

[GS-2.1.1-I] Greater than 60% of new users shall use the system without touching it
[GS-2.1.2-I] Greater than 85% of experienced users shall use the system without touching it
[GS-2.1.3-II] Greater than 75% of new users shall use the system without touching it
[GS-2.1.4-II] Greater than 90% of experienced users shall use the system without touching it
[GS-2.1.5-P] Greater than 80% of new users shall use the system without touching it
[GS-2.1.6-P] Greater than 95% of experienced users shall use the system without touching it
[GS-2.1.7-P] The panel aesthetics and button placement shall match existing elevator standards

2.2 Cost and Availability Requirements

[GS-2.2.1-P] The system shall be available as both a retrofit option and as a standalone unit
[GS-2.2.2-P] The system shall be customizable for specific floor numbering schemes, such as numbers only or a mix of numbers and letters
[GS-2.2.3-P] Cost of production per unit shall be less than $5000
[GS-2.2.4-P] Units shall be sold for under $8000 to be competitive with mechanical elevator panels
[GS-2.2.5-P] System shall be sold to and installed by elevator companies

2.3 Build Consideration Requirements

[GS-2.3.1-I] For the initial prototype the optical sensing set-up shall be modular and versatile enough to make modifications as needed to improve user experience
[GS-2.3.2-I] The initial prototype shall be made with an easy to work material so that modifications to the panel structure can be made
[GS-2.3.3-I] The physical panel prototypes shall be easily constructed and inexpensive while being an accurate representation of the final design
[GS-2.3.4-P] The system shall conform to all relevant elevator standards and conventions - refer to Section 7 for standards
[GS-2.3.5-P] The system shall provide the same functionality as current elevator panels
[GS-2.3.6-P] The system shall weigh less than 20 lbs for easy installation

2.4 Reliability Requirements

[GS-2.4.1-P] The system shall have a lifetime of greater than 20 years
[GS-2.4.2-P] The system shall self-diagnose faults due malfunctioning optical beams and sensors in the optical sensing grid
[GS-2.4.3-P] The system shall be designed for the environmental conditions shown in Table 1

Table 1: Environmental variance in elevators

Environmental Condition	Minimum	Maximum
Temperature	0°C	40°C
Humidity	15% RH	80% RH
Ambient Light	50 lux [3]	1000 lux
Panel Size	0.4 m^2	1 m^2

2.5 Safety & Sustainability Requirements

[GS-0.1-I]	Optical Sensing method shall not present an eye safety hazard during installation or use
[GS-0.2-I]	Physical panel shall not present a safety hazard during installation or use
[GS-0.3-I]	All materials used in the system shall be non-toxic and RoHS compliant [4]
[GS-0.4-I]	Reusable, recyclable, repurposed, or biodegradable materials shall be used whenever possible
[GS-0.5-II]	System shall be designed so that individual components can be easily repaired

2.6 Accessibility Requirements

[GS-2.6.1-P]	The system shall have voice control implemented for visually impaired users
[GS-2.6.2-P]	The panel shall have braille for visually impaired users in case of voice control failure

3 Physical Panel

CleanLift's panel shall be based off current elevator panel designs, both in function and aesthetics. This creates an intuitive user experience, with the goal of providing seamless functionality for first time and frequent users. The panel shall also meet existing elevator standards on size, capability, and safety features, which will be discussed in Sections 6 and 7. Overall, CleanLift's panel shall be designed to reduce hygienic concerns inherent in current elevator panel designs by implementing a touchless interface, while also being convenient and comfortable for users. As shown in Figure 3 below, the exterior surface of the panel is visually identical to any generic elevator control panel, with exception of the mechanical buttons. These mechanical buttons have been replaced with user-sensing indents.

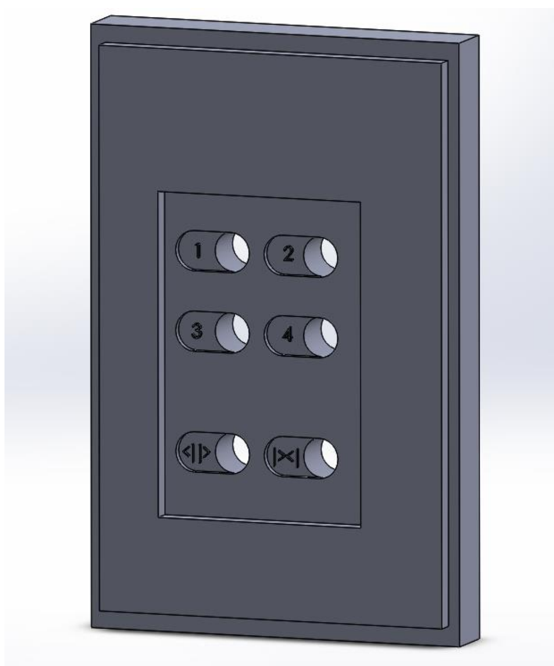

Figure 3: Prototype of 3x2 Tier 1 Panel (alarm buttons not shown)

3.1 Physical Appearance Requirements

[PP-3.1.1-I] Button locations shall be visually similar to existing elevator panel designs
[PP-3.1.2-P] Aesthetics shall be customizable to match common elevator décor

3.2 Feedback Requirements

[PP-3.2.1-I] Visual feedback shall be given to the user after button selection
[PP-3.2.2-I] Visual feedback shall be visible during ambient light conditions between 50-500 lux, as specified in Section 2 of this document
[PP-3.2.3-II] Simple audio feedback shall be given to the user after button selection
[PP-3.2.4-II] Audio Feedback shall be at 60 dB [5]
[PP-3.2.5-III] Simple haptic feedback shall be given to the user after button selection
[PP-3.2.6-III] Haptic feedback shall be noticeable but not painful to the average user

3.3 Maintenance & Cleaning Requirements

[PP-3.3.1-I] Panel surface shall be smooth to ensure easy to cleaning

[PP-3.3.2-I] A lockable maintenance panel, with access to control system, sensors, and optical beams, shall be included in the panel design

[PP-3.3.3-II] Optical beams and circuitry are clearly laid out and accessible within the interior of the panel for easy maintenance and replacement

[PP-3.3.4-P] Panel surface shall have antimicrobial coating to inhibit bacteria growth

3.4 Safety Requirements

[PP-3.4.1 -P] Panel sensing holes shall have smooth edges and surface to prevent harm to the user in case of contact

[PP-3.4.1-II] Optical beams shall be contained within the panel so that they are not accessible to users

[PP-3.4.2-III] Panel shall have mechanical buttons for alarm and emergency stop

[PP-3.4.3-III] Emergency stop and alarm mechanical buttons shall be a distinct colour to draw the user's attention

[PP-3.4.4-III] Emergency stop and alarm mechanical buttons shall be placed at least 5 cm under common used panel sensing holes, to ensure alarm buttons are not falsely triggered

[PP-3.4.5-III] Panel sensing hole size should not exceed 2.5 cm in diameter, to prevent anything other than a single or small grouping of fingers from being used

[PP-3.4.6-III] Panel shall be electrically isolated from all control circuits and grounded

[PP-3.4.7-P] Panel shall be non-magnetic to prevent objects from being attracted to the panel or interfering with personal objects

3.5 Durability and Sustainability Requirements

[PP-3.5.2 -P] Panel material shall be difficult to scratch or deface

[PP-3.5.3 -P] Panel material shall have a tensile strength greater than 430 MPa to ensure panel will be tamper resistant

[PP-3.5.4 -P] Panel shall be constructed out of a biodegradable, reusable, or recyclable material

3.6 Accessibility Requirements

[PP-3.6.1-I] Panel sensing hole size shall have a diameter greater than 20 mm

[PP-3.6.2-II] Panel sensing holes shall be illuminated

[PP-3.6.3-III] A braille legend shall be available for visually impaired users

[PP-3.6.4-P] Panel shall be mounted 0.9 m – 1.4 m from the floor [6]

4 Sensing Grid

The sensing grid is what makes CleanLift a touchless system, and is at the heart of the functionality of the product as a whole. It has two main functions:

- Set up a matrix of virtual buttons
- Detect when a user has selected a button

In order to achieve these functionalities, the sensing grid is composed of two main components:

- Optical beams
- Optical sensors

The grid is composed of an array of optical beams positioned vertically and horizontally, which project light onto optical sensors on the opposing side of the grid, as seen in Figure 4. A button is defined as the intersection of a vertical and horizontal beam. When a user crosses the plane of both a vertical and horizontal beam, they select the button defined by the intersection of those beams as shown in Figure 4 below

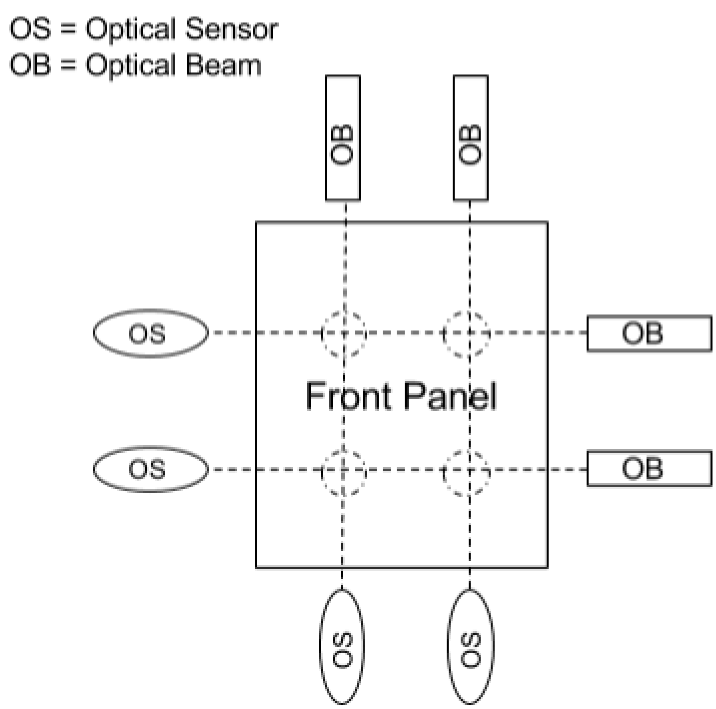

Figure 4: Sensing grid layout for a 2x2 touchless panel

4.1 Electronics Requirements

[SG-4.1.1-I]	Optical sensors shall detect changes in beam exposure
[SG-4.1.2-I]	Optical sensors shall be functional in varying ambient light conditions between 50-500 lux
[SG-4.1.3-I]	Individual components shall have signal propagation of less than 10 ms
[SG-4.1.4-I]	The power consumption of the sensing grid shall be less than 5 Watts
[SG-4.1.5-P]	Optical beams shall have a range of at least 0.5 m

4.2 Configuration & Scalability Requirements

[SG-4.2.1-P] Optical grid configuration shall be versatile enough to work with various panel sizes configurations as specified in Section 2.2
[SG-4.2.2-P] Optical grid shall be scalable up to 30 floors

4.3 Safety Requirements

[SG-4.3.1-I] Components shall be RoHS compliant [4]
[SG-4.3.2-I] Optical beams shall have no possible direct path to the eyes of users
[SG-4.3.3-III] Optical beams shall not cause thermal or photochemical damage to eyes for exposures for up to 5 seconds
[SG-4.3.4-III] Optical beam shall not cause skin damage for exposures up to 5 minutes
[SG-4.3.5-III] Emergency and call buttons shall be mechanical buttons
[SG-4.3.6-P] System shall have a backup power source for emergency situations
[SG-4.3.7-P] Components shall be grounded to the common elevator ground

4.4 Behavioral Requirements

[SG-4.4.1-I] Optical beams shall have consistent beam trajectories
[SG-4.4.2-I] Optical beams shall have uniform power of between 0.5 mW and 5 mW
[SG-4.4.3-I] Optical beams shall have uniform wavelength
[SG-4.4.4-I] Optical beams shall be precisely aligned with sensors
[SG-4.4.5-III] Optical beams shall not be visually distracting to users

4.5 Reliability Requirements

[SG-4.5.1-I] Optical beams and sensors shall have a mean time to failure of at least 20 years
[SG-4.5.2-I] Optical beams and sensors shall be accessible for easy maintenance
[SG-4.5.3-III] System shall include multiple beam and sensor pairings at each button for redundancy
[SG-4.5.4-P] Optical beams and sensors shall be fixed securely and maintain alignment during product lifetime
[SG-4.5.5-P] Optical beams and sensors shall be dampened against perturbations

5 Control System

The control system of CleanLift will provide functionality for three different categories:

- Ideal Usage
- Non-Ideal Usage
- Diagnostics

Ideal usage is defined as touchless, with the user only triggering one button at a time, under normal elevator operating conditions (non-emergency situations with full power and user capabilities). Non-ideal usage is anything that falls outside of that area, including situations where users accidentally trigger multiple buttons, trigger the same button multiple times in quick succession, place foreign objects into the sensing holes, attempt to tamper with the system, or keep buttons triggered for extended periods of time. During ideal usage, the control system will enable and disable feedback measures, such as visual and audio feedback, and will send floor selection information to the elevator's controller. The most basic form of what the control system's software will do is seen below in Figure 5. During incorrect usage, the control system shall deal with malfunctioning components, user error, and emergency situations. In Tier III and production models, it will also provide diagnostic reports for easier maintenance, debugging, and monitoring purposes.

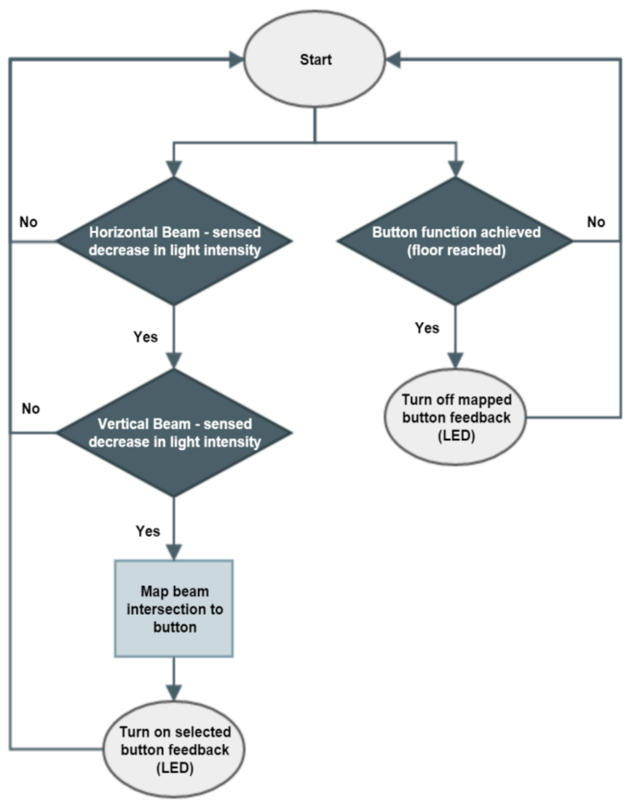

Figure 5: Control flowchart for button selection in basic use case

CleanLift's control system will be modular to allow for added features and redundancy, as well as easy maintenance and repair.

5.1 Behavioural Requirements

[CS-5.1.1-I] Feedback response time shall be less than 500 ms

[CS-5.1.2-I] All feedback systems shall be informative but unobtrusive to the user

[CS-5.1.3-I] The control system shall control the visual feedback for button selection

[CS-5.1.4-I] The control system shall control the audio feedback for button selection

[CS-5.1.5-III] The control system shall control the haptic feedback for button selection

[CS-5.1.6-III] The control system shall enable voice recognition module when triggered by user

[CS-5.1.7-P] Helpful audio feedback shall be given to the user if CleanLift is used incorrectly, as specified in the introduction of Section 5

[CS-5.1.8-P] The control system shall turn the optical sensing grid off to conserve energy if the elevator is empty for less than 10 minutes

5.2 Communication Requirements

[CS-5.2.1-III] The floor selection signal sent from the control system shall be compatible with existing elevator systems via serial communication

[CS-5.2.2-III] The control system shall communicate to the elevator control via serial communication

5.3 Signal Processing Requirements

[CS-5.3.1-I] Optical sensing grid signals shall be checked for behavior indicative of incorrect use, as specified in the introduction of Section 5

[CS-5.3.2-I] The control system shall ignore as accidental all signal changes that propagate for less than 200 ms

[CS-5.3.3-I] The control system shall register any signal changes that propagate for 200 ms or more

[CS-5.3.4-III] Sensing grid signals that are equipped with redundancy shall be triggered by a minimum of inputs

5.4 Safety Requirements

[CS-5.4.1-I] All components shall RoHS compliant [4]

[CS-5.4.2-III] Control system shall be physically and electrically isolated from the physical panel

[CS-5.4.3-P] Control system shall be contained in a waterproof housing to avoid water damage

[CS-5.4.4-P] Control system shall be contained in a tamperproof housing

[CS-5.4.5-P] System shall have a backup power source for emergency situations

5.5 Diagnostics and Reliability Requirements

[CS-5.5.1-I] Control System shall have a mean time to failure of at least 20 years

[CS-5.5.2-I] Control System shall be accessible for easy maintenance

[CS-5.5.3-III] Diagnostic files will be created and will include buttons triggered, errors encountered, and incorrect usage attempts to aid in maintenance and debugging

[CS-5.5.4-III] The control system shall keep diagnostics files for at least 1 week and up to 4 weeks

[CS-5.5.5-P] Diagnostics files shall be easy to retrieve via the key-locked maintenance panel described in Section 3.3

[CS-5.5.6-P] Control System shall be dampened against perturbations

6 Sustainability & Safety

Environmental concerns and safety are paramount to Porcupine Solutions and the creation of CleanLift. We believe in creating a cleaner and more sustainable world, and CleanLift's clean-oriented design would not be complete without applying a Cradle to Cradle philosophy, as well as having safety as a top priority.

We aim to accomplish our sustainability goals by following two main policies:

- Minimize waste
- Use sustainable materials

The first policy will be implemented by optimizing our control and laser grid systems to avoid wasting power and materials, as well as creating a modular design. Ensuring that our design is modular will allow for re-use of components from prototype to prototype, as well as allowing the final production models to be easy to repair with minimal component replacement. The system shall also be designed to allow for retrofitting into existing elevator systems, allowing for potential installations to create less waste.

The second policy will be implemented on both the housing and components of the design. On the prototyping end of the design process, we will be relying on easily renewable resources, such as plywood and recyclable plastics. CleanLift will also use only RoHS compliant components. RoHS compliance ensures that our design will be free of the following hazardous and unethical materials: lead (Pb), mercury (Hg), cadmium (Cd), hexavalent chromium (CrVI), polybrominated biphenyls (PBB), polybrominated diphenyl ethers (PBDE), and four different phthalates (DEHP, BBP, BBP, DIBP) [4]. Lastly, as material recycling techniques and biodegradable plastics become more advanced, applications of ethical materials become more varied. As such, we will use recyclable, reusable, or biodegradable materials in our production models wherever possible, to minimize CleanLift's environmental impact at both creation and end of life of the product.

One of CleanLift's major applications is in hospitals, where safety of the patients, visitors, and staff must be maximized. To avoid any complications, we will ensure CleanLift has no toxicity, by implementing such measures as exclusively using RoHS compliant components, as described above. Magnetic fields and surfaces can also interfere with medical and personal devices, and so the physical panel shall be created from non-magnetic materials, such as aluminum. The panel shall also be fully grounded and insulated from internal circuits, to prevent any occurrence of electrical shocks or malfunctions. To avoid any physical harm to users, the production model of CleanLift's panel shall be designed to be smooth and have gradual indents, reducing sharp angles wherever possible.

The variety of optical beam used in CleanLift shall be heavily influenced by safety, as concentrated optical beams may be harmful if directed at an eye. Both visible light lasers and IR beams are being considered as the optical beam method, and safety will play an important role in the decision of what type, power and brand of optical beam selected. Figure 6 below shows the maximum permissible exposure power versus exposure time of various common optical beam wavelengths.

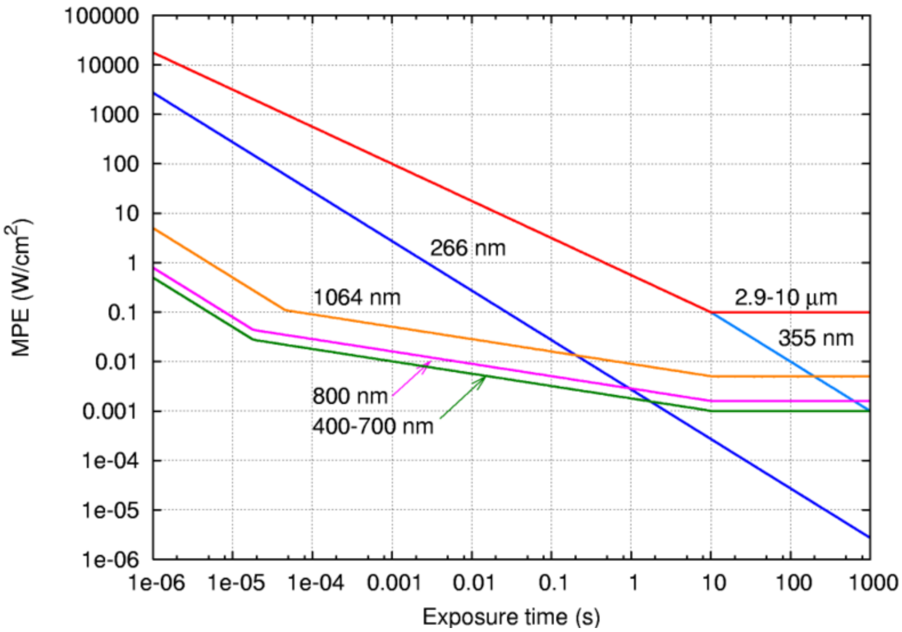

Figure 6: Maximum Permissible Exposure vs. Exposure time based on IEC 60825 MPE guidelines [7]

The final panel design will be analyzed for safety, and any unforeseen risks discovered during testing will prompt a redesign. CleanLift will also be subject to the expansive existing standards (see Section 7 for details), which include the implementation and design of certain safety features, such as emergency alarms and stop buttons.

We are committed to creating a clean, easy to use CleanLift system that is also sustainable and safe, from design and prototyping to eventual production models.

7 Standards

As CleanLift is an advancement of existing elevator systems, there are current safety codes and standards that our panel must meet. The following associations and government bodies have developed standards for elevator controls:

1. Canadian Standards Association (CSA)
2. International Standards Organization (ISO)
3. International Electrotechnical Commission (IEC)
4. Health Canada
5. Division for Social Policy and Development Disability, UN (DSPDD)
6. BC Safety Authority (BCSA)
7. Elevating Devices Safety Regulation of the BC Safety Standards Act

Some of the design safety regulations and standards applicable to CleanLift are listed below:

- **ASME A17.1-2013/CSA B44-13** Safety code for elevators and escalators (Bi-national standard, with ASME A17.1) [8]
- **ISO/TC 178** Lifts, escalators and moving walks [9]
- **ISO 4190-5:2006** Lift (Elevator) installation -- Part 5: Control devices, signals and additional fittings [10]
- **ISO 8383:1985** Lifts on ships -- Specific requirements [11]
- **ISO 22201:2009/Cor 1:2011** Lifts (elevators) -- Design and development of programmable electronic systems in safety-related applications for lifts (PESSRAL) [12]
- **IEC 60825:2014** Safety of laser products [13]
- **Health Canada SOR/86-304 Part IV** Canada Occupational Health and Safety Regulations [14]
- **DSPDD 3.2-3** For ease of reach, the control panel should be mounted 0.90 m to 1.20 m from the floor [6]
- **DSPDD 3.3-3** Control buttons should be in an accessible location and illuminated. Their diameter should be no smaller than 20 mm [6]
- **DSPDD 3.3-4** The numerals on the floor selector buttons should be embossed so as to be easily identifiable by touch [6]
- **DSPDD 3.4-2** Tactile numerals should be placed on both sides of the door jambs at an approximate height of 1.50 m to help a lone sightless passenger to identify the floor reached [6]
- **DSPDD 3.8-1** The elevator should signal arrival at each floor by means of a bell and a light to alert sightless and hearing-impaired passengers simultaneously [6]
- **BCSA DIRECTIVE NO: D-L4 100311 2** Mandatory Requirements for Elevator Updating or Modernization of Motion and Operation Control [15]
- **BCSA DIRECTIVE NO: D-L4 070222 2** Requirements for Emergency Communication Systems for New Elevators [16]

8 Conclusion

Elevators are extensively used in the majority of public spaces, and are a breeding ground for bacteria [2]. Since harmful bacteria can be transmitted from user to user by touching the elevator buttons, having a touchless elevator panel, such as CleanLift, will greatly reduce disease transmission. Outlined in this document is the functionality required to ensure the CleanLift system is competitive in the elevator market, provides excellent user experience, and integrates with current elevator design, all while ensuring safety and sustainability.

CleanLift shall be designed in such a way that it can be used correctly and quickly by most users new to the system and nearly all experienced users. It shall integrate with existing elevators, while also ensuring relevant standards are met. Also high on the list of priorities while designing and producing CleanLift is that it shall be safe during use or maintenance and shall be based on the sustainable Cradle to Cradle philosophy. The system shall also be accessible for differently abled users, such as those who are visually impaired, or wheelchair users.

Since optical sensing grid is what makes CleanLift possible it shall be designed to be reliable and robust. The physical design of the grid shall be such that it does not present any safety hazards to users or provide opportunities for eye damage due to design fault or incorrect use.

The control system of CleanLift interprets input from the sensing grid. It shall have the functionality of being able to determine when a button area is activated and shall initiate appropriate feedback as quickly as possible. The system shall also recognize use patterns that signify a frustrated user and be able to diagnose optical sensors that are not working.

With the functionality outlined in the above document, CleanLift will provide significant health benefits to users with a competitive, easy to integrate, reliable and safe, intuitive, and sustainable product.

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