University of Toronto
Faculty of Applied Science and Engineering
APS111 & ASP112
Conceptual Design Specification (CDS)

Team#	Team0160	Date	12/04/2022

Project Title	Conceptual Design Specification
Client	University of Toronto
Client Contact Person	[redacted]
Tutorial Section	0127
Teaching Assistant	[redacted]
Communication Instructor	[redacted]
Engineering Manager (ASP112 only)	[redacted]
Prepared By (Names and Student #s of Team Members)	[redacted] Siaa Gor [redacted]

Please check off which components you are submitting for your assignment.

__ CDS submitted as a PDF to Quercus with the following components:

- __X Cover Page
- __X Executive Summary
- __ XIntroduction
- __X Problem Statement
- __X Service Environment
- __X Stakeholders
- __ X Detailed Requirements (FOCs)
- __X Generation, Selection and Description of Alternative Designs
- __X Proposed Conceptual Design Specification
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Executive Summary
Based on a client statement submitted requesting a redesign of the Sidney Smith Front Entrance [1], it was determined that the front entrance lacks an equitable and safe system that allows people to access the building. There is a need for a safe system that "adheres to the accessibility standards" [1]. The primary function of the design is to transport individuals from the base of the stairs to the platform of the entrance. The secondary functions are to change the user's elevation, to clearly inform how to use the design and to indicate clearly where the entrance and exit of the design are. The primary function was determined based on the functional basis (Appendix B), while the secondary functions were determined using the Black-box method (Appendix B, Table 3).
Important characteristics of the service environment were the wide range of temperature and the high precipitation levels during certain parts of the year.
The objectives of the design is that it should be safe to use, effective, and durable with low environmental impact. The material of the design should be stable, slip-resistant, and support the user's weight. In accordance with National Floor Safety Institute's 101-A standard, the high traction wet static coefficient of friction should reduce slip-and-fall scenarios. Additionally, the design should limit the user's input energy: no more than a certain amount of kcal is expended and maximize the solution's life to aim for at least 21 years. The design should be wear-resistant to sun and water.

Constraints are imposed by the client, stakeholders such as Ontario Nature and Ontario Wildlife Foundation, and codes. The design shall contain accessibility signs as required. Situated outdoors, the design must have at least a minimum amount of lighting at all times when the design is in use.

The idea generation phase started with brief rounds of unstructured brainstorming. Once the team had exhausted this method, structured idea generation tools were employed. The team used the SCAMPER method, analogy tools, and a morphology chart. Most of the structured idea generation was completed in in-person meetings, allowing for members to collaborate and build on each other's ideas. A feasibility check eliminated ideas which did not fulfill the constraints and functions defined in the detailed requirements. This left the group with a consolidated list of 82 feasible ideas. Using multivoting, the design space was narrowed down to 10 ideas, which were graphed based on safety and ease of use. From the graph the top three ideas were chosen as the alternative designs. The proposed design and the alternative design would be consulted with the client before proceeding.

From the Pugh chart, graphical analysis, and secondary research on how each design alternative fulfills each objective resulted in one of the top three design ideas that scored the highest in the Pugh chart to be proposed. As a future recommendation, the prototype of the design would be tested using the standards of measuring each objective; due to the scope, time and resources of the project, the coefficient of friction on the escalator would be tested. Moreover, the proposed design is an escalator with a glass covering and the design encompasses accessibility signs, textured surface at the end of the escalator, lights on the sides throughout the design, railings for support, and width accounting for movement space. Hence, the final design accounts for accessibility through universal design principles prioritizing safety, accessibility, flexibility, ease of use, tolerance to error, and low physical effort.

1.0 Introduction

The architecture of the Sidney Smith building reflects on the importance of equity and inclusion of the Faculty of Arts and Science; the purpose of the re-design is to be accessible to all users. Sidney Smith building, situated on St.George Street, encompasses various facilities and houses several Arts and Science classes. Christine Burke, representative of the University of Toronto, elucidates “the value that it places on access, equity, inclusion, and intellectual exploration” [1]. This reports investigates the service environment and its stakeholders, through methods including a how-why tree, primary observations, the black box method, and secondary research, this report determines the objectives, functions, and constraints of the design.Various sub-sections of the report detail the problem (accessibility) to be solved, depict the project requirements, idea generation stages using various methods, idea selection, proposed alternative design through a multi-modal approach, and measures of success.

2.0 Problem Statement

2.1 Gap and Need

The front entrance of the Sydney Smith building lacks an equitable system that allows people to access it at all times. The client has requested “equitable access to all of the building’s facilities by the whole campus community” [1],which is the client want. They intend for the whole campus to be users of the design but the main focus of accessibility is people with disabilities. According to the client statement, “An increasing number of students are registered with Accessibility Services and require a range of accommodations to ensure that they can effectively pursue their studies”, and the actual stairs do not comply with the accessibility requirements [1].
In order to fulfill this gap, there is a need for a safe system that “adheres to the accessibility standards” as mentioned in the client statement [1]. The design should then be inclusive and take into consideration accommodations for individuals with disabilities as all individuals should have an ease of access to the entrance.

2.2 Scope

The design will be focusing on the East Façade of Sidney Smith building as shown in Figure 1. Since the project is about the accessibility of the building, the scope area is limited to the stairs and platform (Figure 1).

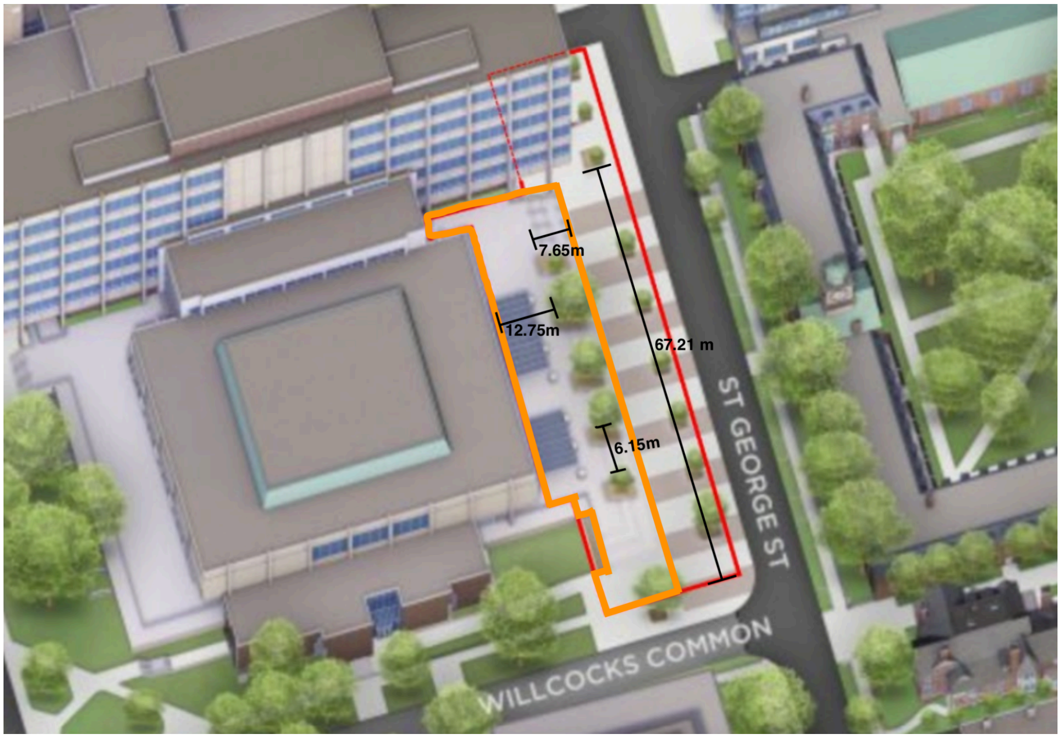

Figure 1. The scope is inside the orange boundaries.

Even though the platform does not affect the transition since there are not many obstacles, considering the safety of those approaching the door in this area is vital for accessibility so the whole platform area must be included in the scope. The redesign will focus on accessibility and safety, as these are the basic requirements for people to be able to access the entrance. Likewise, social usability may not be a priority because if individuals can not access the platform which is the area for social programs, then social usability may not be the primary issue. The sidewalk is outside the scope, as to not interfere with pedestrians. Our time and resources are limited. Thus, addressing all the client's needs is not possible.

3.0 Service environment

Important features of the service environment were identified from site visits and research. The features documents helped determine the detailed requirements of the design and the stakeholders.

3.1 Physical Environment

Indents along the edge of the stairs allow for water to flow down from the platform to the sidewalk without collecting on the steps. The steps are made of large slabs of concrete, with a uniform texture and color (Figure 2).

Figure 2. The stairs are made of 11 uniform steps. As well, indented channels line the edges of the steps.

The highest monthly average of rainfall in Toronto is 51 millimeters during September [2]. The temperature ranges from an average monthly low of 25℃ to an average monthly low of -8℃ (Appendix A, Figure 4).Leaves, acorns, and litter tend to accumulate on the steps near the trees, obstructing the steps (Figure 3).

Figure 3. During the fall season leaves accumulate along the steps, where pigeons tend to peck at.

During sunny weather, the sun shines directly onto the steps and platform. The trees and Sidney Smith building provide little shade. The hours of sunlight per day range from 15 hours and 27 minutes to 8 hours and 56 minutes (Appendix A, Figure 5).

3.2 Living things

Dozens of pigeons flock in the area, looking for scraps and pecking at the concrete, indicative of Toronto's growing pigeon population [4]. Oak trees are planted along the steps with various plants in each plot.

3.4 Virtual Environment

Students and faculty have access to Eduroam and the UofT wifi in the area. As well, cellular service is available.

4.0 Stakeholders

The following stakeholders were identified based on the scope and service environment.

Table 1. Stakeholders and their interests and/or impact upon the entrance are listed.

Stakeholders	**Interest/Impact**
Food Companies	Increased accessibility leading to the entrance should positively impact other stakeholders such as the food companies in making it more inclusive for employees and potential customers[29].
Ontario Wildlife Foundation and Ontario Nature	The environmental organizations may be impacted by the design; their interests would be to protect animals or plants. Thus, the design should not harm any species (Section 3.2)[18] [19].
Government of Ontario, City of Toronto Urban Forest Management	Referring to the service environment, if the design affects the oak trees planted in the area, tree-cutting policies need to be followed [5].

5.0 Detailed Requirements

5.1 Functions

The functions are the ultimate goals of the design

Primary function: Transport individuals from the base of the stairs to the elevated platform of the entrance

Secondary functions:

- Change the user's elevation
- Clearly inform how the design should be used

5.2 Objectives

The objectives were generated from the how-why tree (Appendix C.3, Figure 6) and ordered as a priority from the pairwise comparison. These objectives were chosen because they are acceptable to the client's needs and are measurable.

Table 2. The objective, metric, objective goal, and reason for the objective are detailed in the chart.

Objective	**Metric**	**Objective Goal**	**Justification of Objective**
Safe to Use	How much weight the design can withstand.	Withstand more than 399.6 pounds per user [13]	The design must support the users' weight exerted by the user by more than 399.6 pounds per user[13]. This accounts for the average weight of 8 people being on the design at the same time, refer to appendix.
	The amount of friction required to reduce slip-and-fall incidents.	According to the National Floor Safety Institute's 101-A standard, the wet static coefficient of friction value should be greater than 0.6 to reduce slip-and-fall scenarios between 50 to 90 percent. [7]	When accounting for excessive rain or snow, the design should match the coefficient of friction of the concrete so there is less chance of users slipping.
Ease of Use and Efficiency	Energy required from the user to use the design.	1.21 kcal	Walking up the current steps of the Sidney Smith burns approximately 1.21 kcal (Appendix C.1).
Environment and Durability of the Design	How long the design will last without wearing down from direct sunlight, rain, temperature changes, and pigeons pecking on the design as discussed in Section 3.1.	21 years	Typically, Sidney Smith Hall is renovated every 21 years (Appendix C.2). If the design needs to be maintained or re-designed frequently, it may disrupt the regular activities. Regular maintenance ensures the design is safe and available to use.

5.3 Constraints

The constraints are imposed by clients, stakeholders, and regulations that place limits on the design.

Constraint Type/ Constraint Source	**Metric and Justification of Constraint**
Users and Safety	The maximum falling force body can withstand is 1800 lb of force on body [14].
In consideration of the potential stakeholders such as Ontario Nature and Ontario Wildlife Foundation, the material of the design must not harm any living species and must not contain any chemicals such as PVC that are harmful to the environment.	The vinyl chloride during the manufacturing process must be avoided, since it may pose a health hazard and may even lead to chronic diseases. The PVC during fire may emit hydrogen chloride gas as well. [15]
Accessibility Signs Required by Rules and Regulations	Section 3.8.3.9 in the National Building Code of Canada 2015 outlines that accessibility signs are required and must incorporate the symbols of access for hearing loss [10]. These signs must indicate the facilities available
Lighting Requirements by Codes and Regulations from NFPA.	The minimum lighting requirements for outdoor spaces from the National Fire Protection Association (NFPA) should be at least 10 foot candles (lux) when walking on the surface[12].

6.0 Idea Generation

For the idea generation process, the team firstly focused on quantity which is to get a large amount of initial ideas regardless of feasibility. For this step, the method was to use a couple rounds of unstructured brainstorming during group sessions. Team members were asked to think of as many ideas as they could in a limited time of 5 minutes. Then followed structured brainstorming, where the team came out with some major topics for the process through discussion. Based on these topics, a list of ideas was obtained (Appendix E.1). After that, through the seven types of computation methods in the SCAMPER approach, new ideas were created by generating or modifying the previous ones through substitution, combination and rearrange. (Appendix E.2) Finally, the team tried analogy methods to enlarge the idea list which included biomimicry solutions and magic solutions (Appendix E.3). A morphology chart was used to combine different aspects of the generated ideas, further expanding the design (Appendix E.4).

7.0 Alternative Design Selection Process

From the ideas generation process, the ideas were consolidated into a list, where similar ideas were removed. From the list, a feasibility check was employed, where ideas which did not meet the constraints and functions were removed or adapted to meet these requirements (Appendix F.2), resulting in 82 feasible ideas (Appendix F.1). During the feasibility check, several ideas caused excessive force on users, so a constraint on the force users experienced was added.

Multivoting was used to narrow down to 10 ideas. Team members voted based on which designs were the most realistic and could best meet the objectives defined in the detailed requirements (Appendix F.3).

From the top 10 ideas, a graphical design chart was used to rank the 10 ideas based on the metric goals for safety and ease of use (Figure 11).

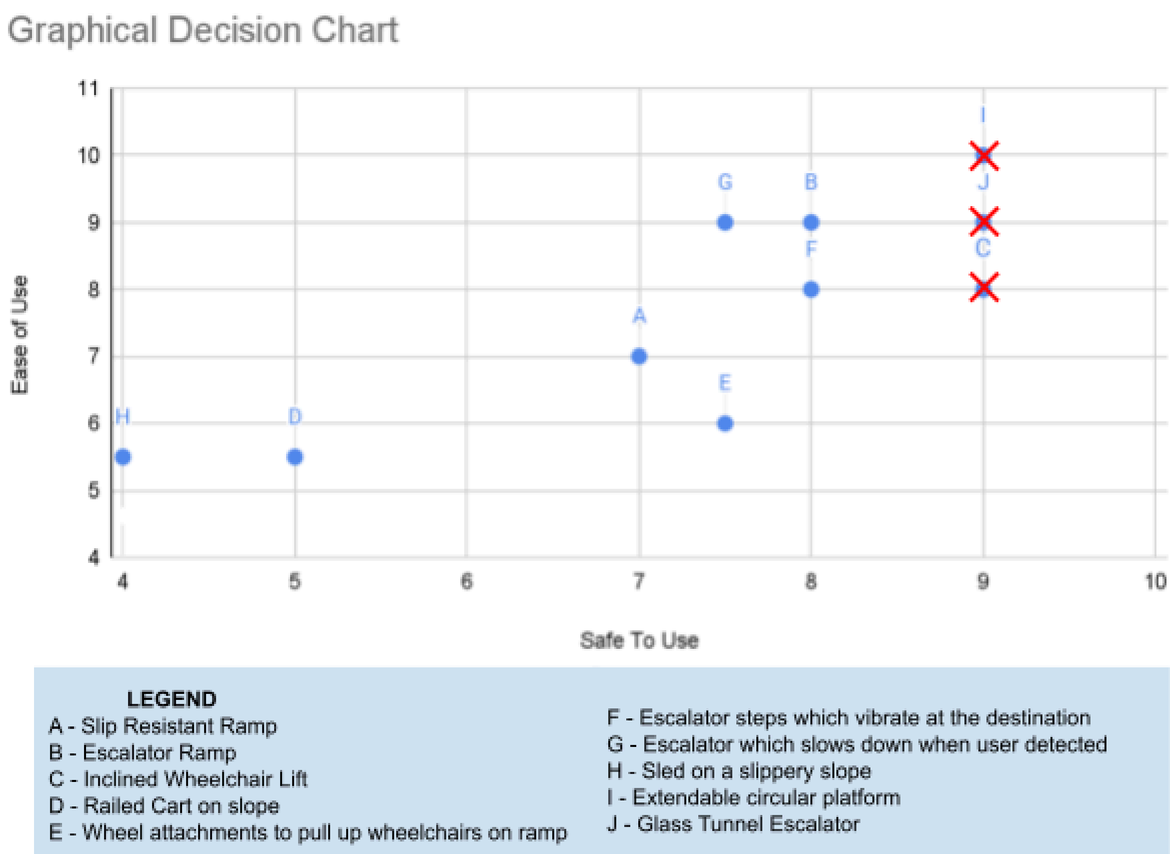

Figure 11: In the graph, ideas were scored on a scale of 1-10 by safety and ease of use, which were the most important objectives. The red crossed points were chosen as the alternative designs.

8.0 Alternative Design Descriptions

The alternative designs were the extendable platform, glass tunnel escalator, and inclined wheelchair lift. Each design's ability to meet the constraints, functions, and objectives were described and diagrammed.

8.1 Extendable Circular Platform

Large circular platform that lifts an individual upon contact for more than 4 seconds. Lights flash before starting to lift. After the platform lifts the user, it extends from its' side to allow the user to walk across it (Figure 7). The platform is enclosed protecting the user and design from the weather. Design meets the secondary function where QR code (via a video), and signs in braille depict how the design should be used. Coloured and textured regions indicate the entrance or exit of the design. To meet the constraints, lights and railings would be placed on the edges of the circular and extended platform. The design includes accessibility signs and following rules and regulations to ensure that design meets constraints.

Table 8. The table provides research or evidence on how the extendable platform meets the objective.

Objectives	Evidence
Weight supported from user	2,000 to 2,500 lbs [30]
Slip resistant	Depends on Material used in the platform [31] (commonly stainless steel) has a wet-coefficient of friction of 0.4[32]
Ease of use	To take 1 step onto the escalator and one step off is 0.1kcal (0.05 per step) [20]
Durability of design	20-25 years replaced [21]

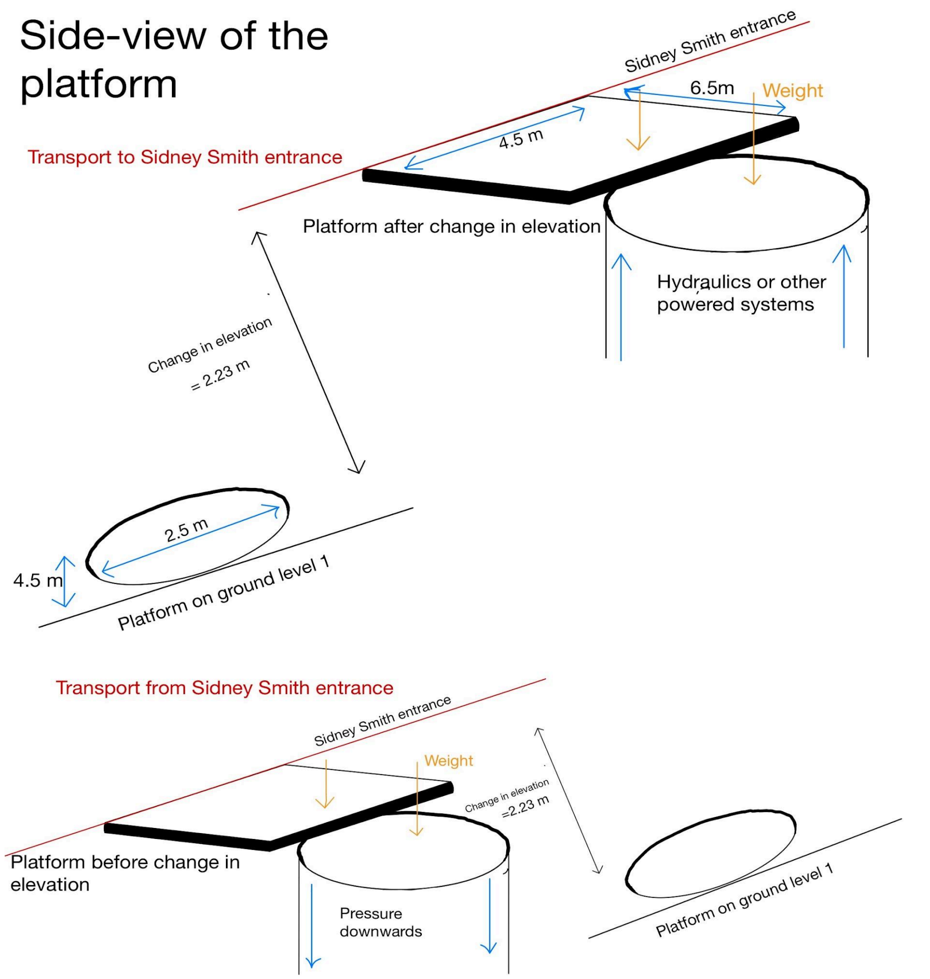

Figure 7.Side view of the platform operating; the platform on level one is situated before the sidewalk starts and the current Sidney Smith stairs.

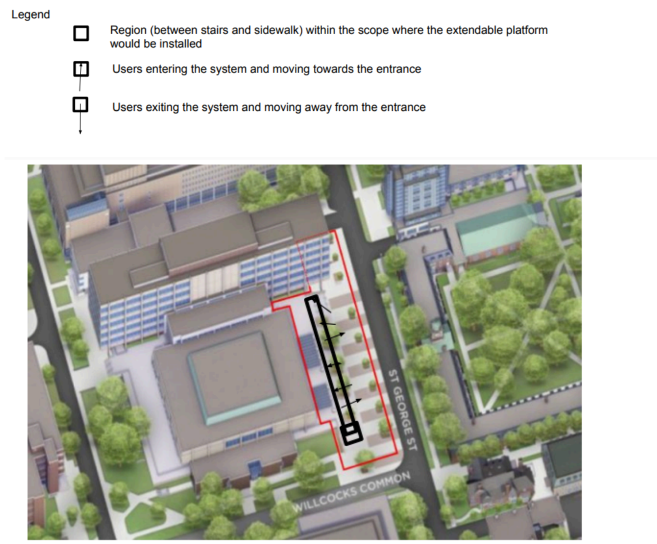

Figure 8. The map depicts the region where the design is implemented and the flow of users.

8.2 Glass Tunnel Escalator

The escalator in a glass tunnel consists of a pair of escalators and is enclosed in a glass tunnel to protect the escalator and users from outdoor conditions. One escalator sends people upwards, while the other escalator brings people down from the platform to the sidewalk. Signs by escalator, indicate the direction of each escalator and to keep the area clear. In the dark, lights turn on in the tunnel, illuminating the area. The steps are deep, allowing mobility vehicles to board the escalator.

Table 9.The table provides evidence on how the escalator meets the objective.

Objectives	Evidence
Weight supported from user	Escalators can support 68 kg to 136 kg per step [22]
Slip resistant	Escalators are regularly cleaned and coated in anti-slip compound which increases grip of steps [23]
Ease of use	To take 1 step onto the escalator and one step off is 0.1kcal (0.05 per step) [24]
Durability of design	Replaced after 40-50 years and modernized after 20-25 years. [25]

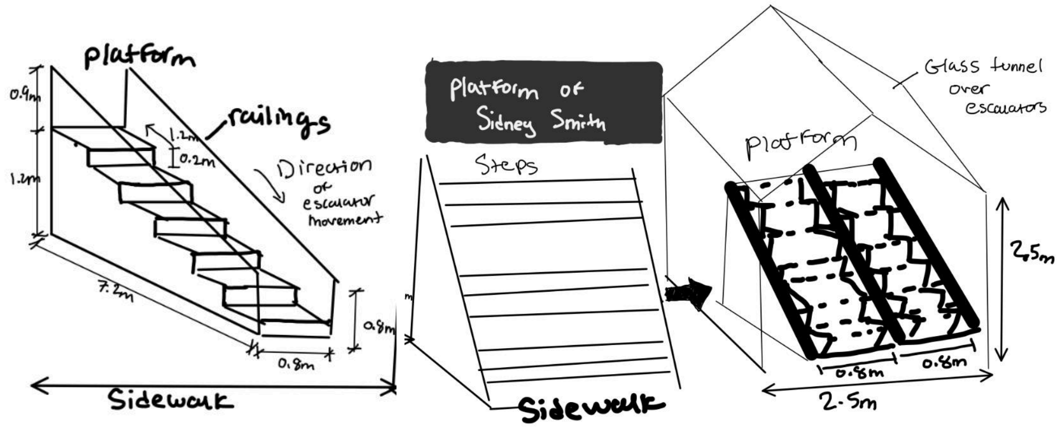

Figure 9. The diagram of the side view of the glass tunnel escalator.

8.3 Inclined Wheelchair Lift

The inclined wheelchair lift consists of a platform where the wheelchair stands, a safe arm to protect the passengers, a control button for the passenger to push when ready to travel. The wheelchair travels on a diagonal path to transport users one way, from the sidewalk to the platform; it is inclined over a ramp to allow wheelchair users to travel the opposite way (from platform to sidewalk).

Table 10.The table provides evidence on how the wheelchair lift meets the objective.

Objectives	Evidence
Weight withstanded	Can support up to 750 pounds. [26]
Slip resistance	Skid resistant floor to avoid wheelchair from slipping during the travel. [27]
Ease of Use	To take 1 step onto the escalator and one step off is 0.1kcal (0.05 per step) [24]
Durability	Should last 10-12 years [28]

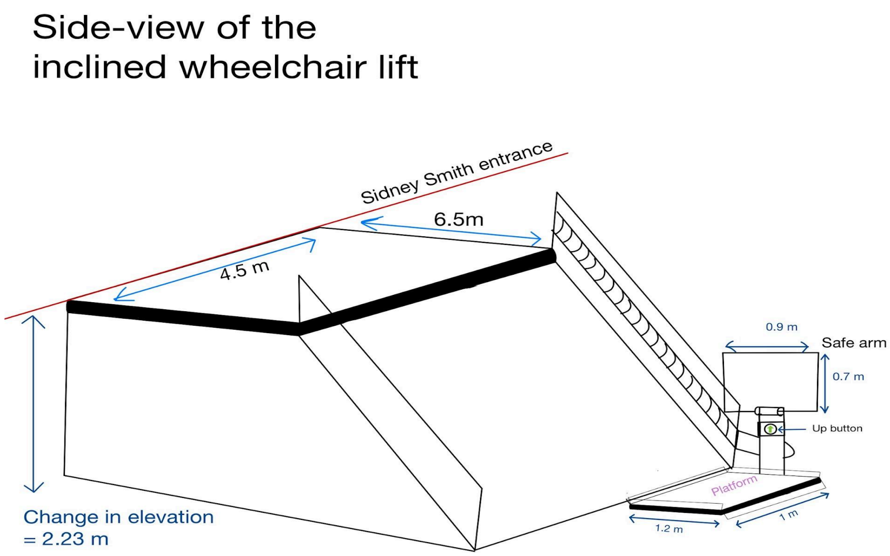

Figure 10. The diagram of the side view of the inclined wheelchair lift.

9.0 Proposed Conceptual Design Specification

From the alternative designs, the proposed design is the Glass Tunnel Escalator that incorporates accessibility signs, textured region at the exit or entry, and lights throughout the design. Based on the Pugh method chart, this design had the highest total score for meeting objective goals (Appendix G). These objectives, based on the service environment and problem statement, ensure the design scores on relevant and unbiased criteria. The design incorporates anti-slip measures, addressing the rainy and icy weather (Appendix A), and can support user's weight, since users need to be elevated upwards. The design requires little energy from users, allowing the design to be accessible for people who have difficulty climbing up stairs. Constraints imposed ensure the design has met accessibility standards. By meeting the requirements, the Glass Tunnel Escalator will be an accessible way for users to travel between the platform and sidewalk, fulfilling the gap.

10.0 Measure Of Success

A measure of success of which to test the proposed design by is the design's static coefficient of friction. As outlined in the objectives and specified by the National Floor Safety Institute's 100-A standard, our team will develop and test a tread with a static coefficient that is greater than 0.6 while wet [7].

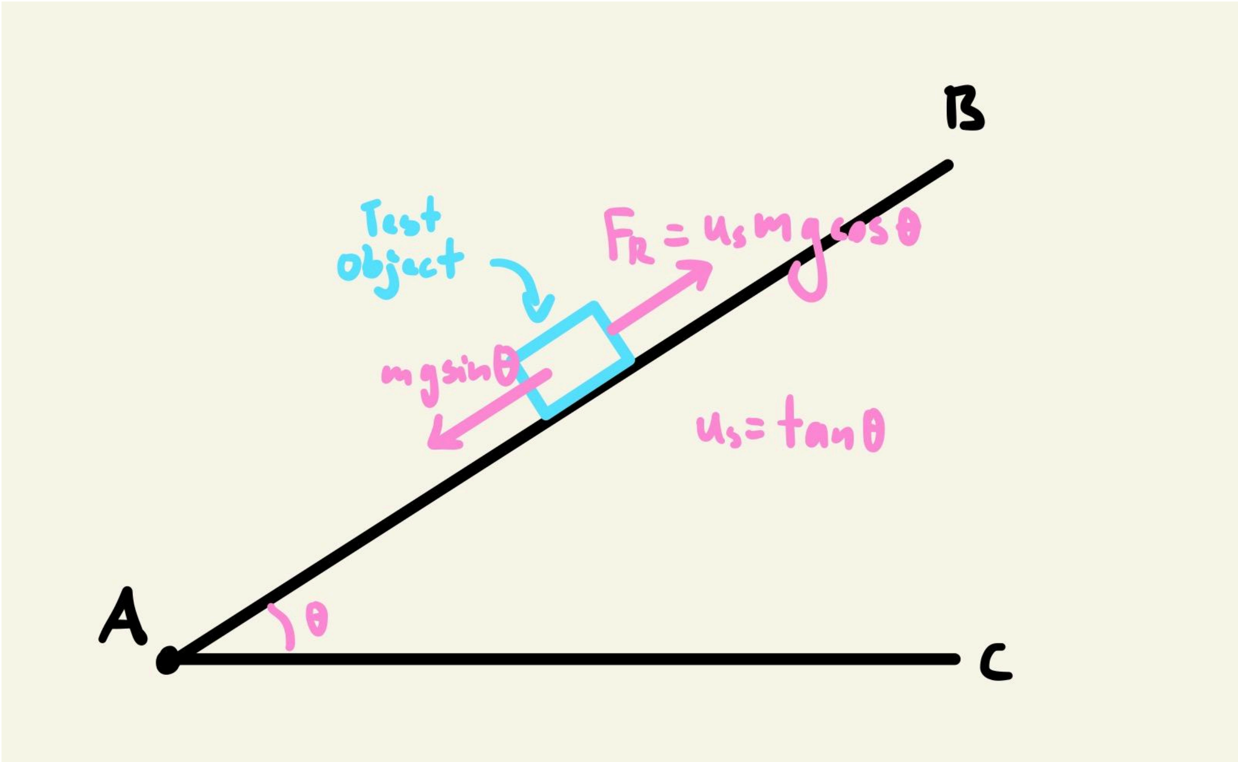

Figure 12. The diagram demonstrates the testing of the tread.

The following procedure will be used. A known mass is placed on a wet, hinged platform covered with the tread. As shown in Figure 12, starting at a horizontal position, the member AB will be rotated counterclockwise until the mass begins to slide. Based on the angle and mass, the static coefficient can be calculated. This procedure is repeated 3 times with the mass perpendicular, parallel, and 45 degrees to the direction of the ribs [35], using the different types of shoes, ensuring that the static coefficient remains greater than 0.6 [7].

Escalators are generally made out of aluminum since "it is stronger and lighter" than other options [36]; however, anti-slip additives such as R13 anti-slip compounds which provide strong grip in wet environments [37], or thermal sprays increasing friction between surfaces may be useful [38].

By Dec. 12, the group will construct a model of the tread in AutoCad. By Dec. 21, the group will finish manufacturing the CAD model prototype. By Dec. 22, the group will complete the test procedure with at least 20 different pairs of footwear. If the test produces any static coefficient values under 0.6, the group will reconvene, and redesign the tread by Dec. 26 so that it passes the test for all footwear. The 4th week should be spent reflecting over the design process to improve the tread.

11.0 Conclusion

Sidney Smith’s Front entrance requires redesigning to ensure accessibility. The transition from the end of sidewalk to the Sidney Smith’s front entrance accounts for constraints initiated by the service environment, regulations, and stakeholders. Generating the ideas from the morphology chart, structured brainstorming, SCAMPER approach, and even biomimicry unearthed a variety of solutions. After iterations of constraints and objectives, the feasibility check ensures the design ideas are realistic; top ideas were selected by multi-voting, ranking, graphical analysis, and pugh chart that led to alternative designs along with a proposed design. The design accounts for universal design principles and is tested based on described measures of success. The proposed design, after analysis, is an escalator with a glass covering. The next step is to execute testing the friction on the escalator and implement the design by consulting the client.

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Appendix A: Weather in Toronto

Based on the following graphs, the types of weather conditions describing our service environment were determined.

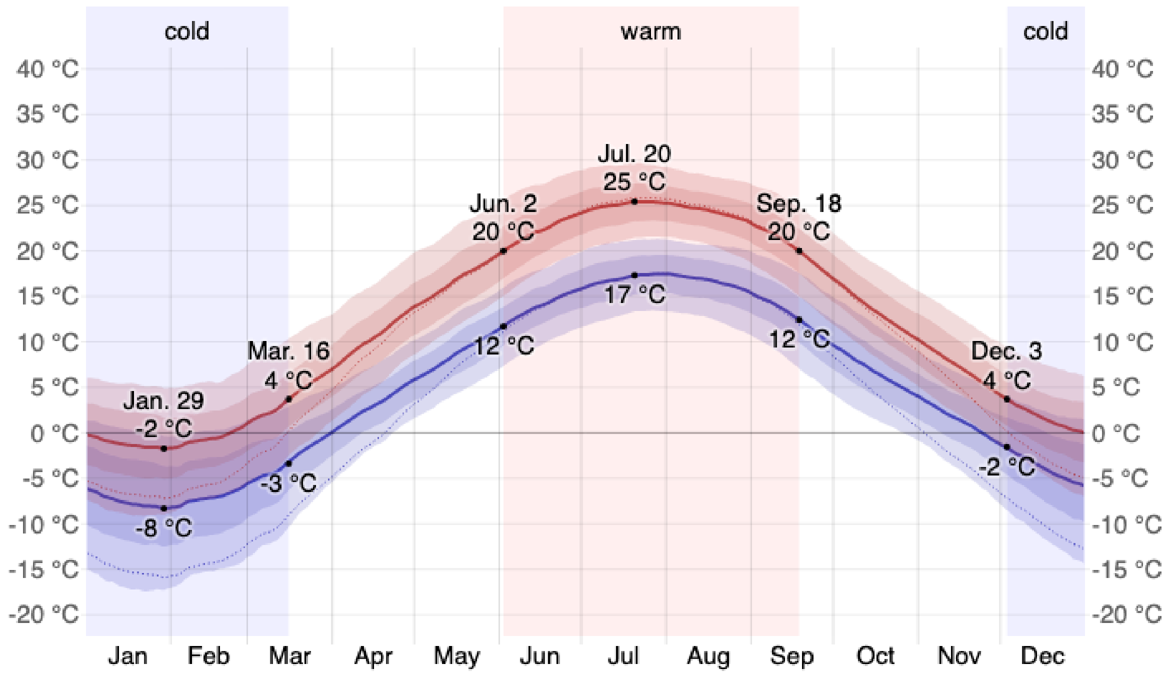

Figure 4. The following graph retrieved from Weatherspark.com represents the average monthly temperatures in Toronto, with the red line representing the average high, and the blue line representing the average low [2].

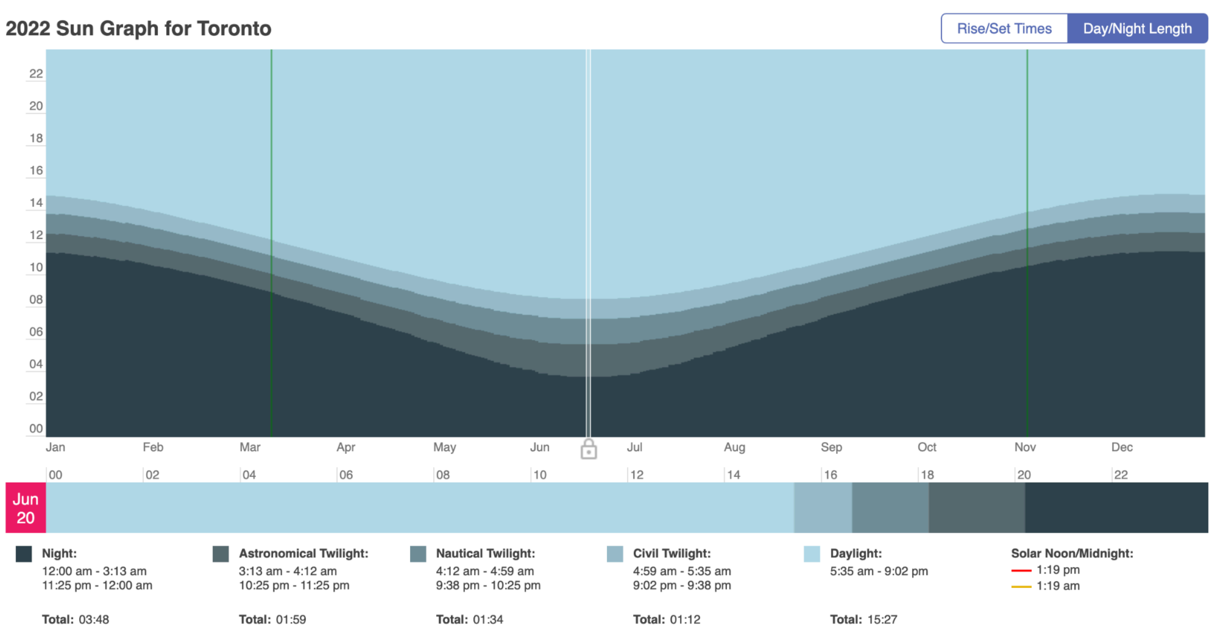

Figure 5. The following graph retrieved from timeanddate.com represents the hours of sunlight per day throughout the year in Toronto. Based on the graph the upper and lower ranges of the hours of sunlight

exposure at the Sidney Smith entrance were determined to range from 15 hours and 27 minutes to 8 hours and 56 minutes [3].

Appendix B: Methods determining Functions

The functional basis of the design is to move mass and communicate information to users.
Table 3. The black box method illustrates the inputs and outputs of the design in the form of energy, information, and mass that is necessary to generate the functions of the design.

Input		**Output**
Energy Mechanical, chemical and/or electrical energy used by the design; there may also be energy input in the form of chemical or mechanical energy provided by the user.	←Design→	**Energy** Gravitational potential energy caused by one's change in elevation due to the design.
Information Information on how to get on/off design or use the design.		**Information** Indication of the entrance or exit of the design.
Mass Individuals that come on and off the design solution have a mass.		**Mass** Individual's mass is the output.

Appendix C: Research and Methods Used to Determine Objectives

C.1 Calculation for the user energy expenditure objective

According to a report on the calories required to climb up a single step of stairs, it requires 0.11kcal [8]. Multiplying this figure by 11 steps (referring to the number of step of the stairs of the Sidney Smith Hall platform, which is recorded in the Service Environment section), gave a total of 1.21 kcal spent to climb up the current steps of the entrance.

C.2: Calculation for the durability objective

The average time between major renovations is 21 years. This was calculated based on the time between major renovations of the Sidney Smith Hall. Construction of the building was completed by 1961, and 2 major renovations occurred in 1984 and 2003 respectively. Taking the difference in time between each major construction event and dividing it by two gives us an average time period of 21 years [9].

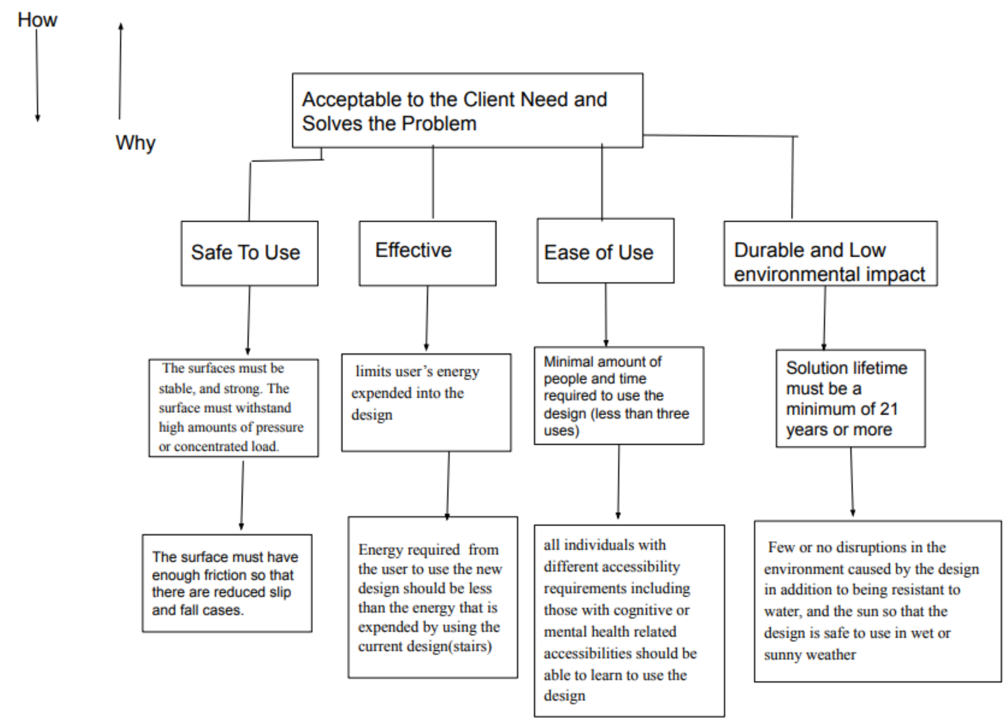

Figure 6. The chart demonstrates how the objectives should be acceptable to the client's needs; how the design would satisfy these objectives and why following certain criteria satisfy the objective. The objectives were generated from the how-why tree.

C.3: Pairwise Comparison

The criteria with the most amount of scores elucidate the highest priority and pairwise comparison was conducted by reasoning as well as the majority team vote.

Table 4. The pairwise comparison to rank the importance or priority of the objectives.

Objectives	**Safe to use**	**Effective**	**Efficient**	**Ease of Use**	**Low environmental Impact and Durability**	**Score**
Safe to use		1	1	1	1	4
Effective	0		1	0	0	1
Efficient	0	0		0	0	0
Ease of Use	0	1	1		1	3
Low environmental Impact and Durability	0	1	1	0		2

Appendix D: Research Questions:
How long does it take for an individual to walk up the entrance of Sidney Smith via stairs? Primary Research.
How much concentrated force or pressure should the material support?[1]
How much friction should there be on the concrete to be considered “safe”? [2].
Does the design interfere with the natural environment? Primary Research and observations.
How many calories are spent after traveling each step (number of steps analyzed for Sidney Smith)?
[3] Objective: to match the amount of energy needed to walk up the current steps. Stepping up one step takes 0.11 kcal, so multiplying this by 11 gives us a total expenditure of 1.21 kcal.
How long does it take the building steps made of concrete to deform until a replacement is required? When was the last maintenance of the Sidney Smith Building outdoor stairs?[4]

Additional Research Based on the Current Stair Design of Sidney Smith
Note: The design should support enough weight. The shear, tensile, and compressive forces act upon the material used on the design and the strength must also be considered.

Maintenance Costs	Less than $35 dollars per square foot	The design maintenance cost should be less than that of the existing design within reason. The cost accounts for possible inflation in recent years compared to the article’s publication. Similarly, costs related to implementation of the design, transportation of the materials, and construction cost may also need to be considered **[16].**
Energy needed to operate design	Less than or equal to 481 KWH per year	For an average lift with approximately 20 lift movements that travels about 3.6 meters (in length), requires 481 KWH per year**[17].** Note: the goal of the design should be less than or equal to the maximum limit in order to make the design energy-efficient, and requiring less maintenance.

Efficiency: Time it takes to use design	Less than 5 to 10.5 seconds	Obtained from primary research by measuring the time taken at various speeds at which users can walk up and down, the design should aim for less than 5-10 seconds (one way).

Calculations:
The weight that the concrete can withstand is 199.8 pounds per average person (x 2 safety factor). Thus, the design should be able to withstand 399.6 pounds per user accounting for additional weight that may be placed onto the system [13].
In the constraints section, the user's safety may be monitored by asking for feedback of their experience with the design and if they felt it was safe to use through the QR-code when exiting the design.

Appendix E: Idea Generation Methods and Tools

E.1: Brainstorming

In this session, quantity (getting the most amount of ideas) was prioritized in a limited time of approximately 5 minutes. The brainstorming occurred in a group session. Likewise, the structured brainstorming ideas involved major topics to discuss solutions.
Main topics to discuss solutions on:

- ❖ Accessibility (mobility, vision impairments, etc)
- ❖ Design about safety
- ❖ Transport people from the bottom of the stairs to the top (and back)
- ❖ Indication of start or end of design

The following is a list of ideas being presented combined from both sessions:

- ❖ transition vehicle
  - ➢ Wheelchair lift
- ❖ pulley
  - ➢ Electrical
  - ➢ Lifting up a platform
- ❖ escalator with fixture for wheelchair chair on both sides
- ❖ hire someone to lift the wheelchair
- ❖ water route circulating with floating boats on it
- ❖ cableway
- ❖ Slip resistant ramp
- ❖ Acorn stairlift
- ❖ Escalator ramp (like at grocery stores)
- ❖ Trampoline

- Electromagnetic levitation platform (like maglev trains but more powerful)
- Beep to indicate the entries for blind people
- Include a sign language translation under any texts
- Have coloured squares to trace the path to the entries to help people with vision disabilities to access easily the building (on platforms and stairs)
- Elevator
- Escalator
- Ladder
- Rock climbing
- Slide
- Swing
- Cart that pulls people up
- Spring
- Parachute/hot air balloon
  - Air-powered device - like a pulley system but using air
- Boat/river crossing (canal)
  - Like a pulley but with water power
- Roller coaster-like design
  - Where people step onto a cart which pulls them up or down
- Mini-train
  - Similar to rollercoaster design but enclosed
- Tunnel (underground or aboveground connected to buildings)
- A box with a slider up and down
- End with different coloured (bright color) and textures at the end of the design
- Sound (reconsider the volume of sound and the time it will last) when users reach the end
- Flashing lights at the end and throughout the design
- See-Saw (with weight being placed at one end, and bungee jump at the other end)
- Trampolene
- Soft and firm surface for ease of walking

Other accessibility issues

- Coloured stairs (to differentiate edges)
  - Inclusive to color blind people
- Sound /light/ different texture of the ground to indicate the end/start of the design solution.
- People who work at the entrance to support users
- Using solar power
- For blind people - a mechanical stick pulls person around (like someone's hand to hold)

E.2: The Scamper Approach

The SCAMPER approach is used to generate multiple ideas by substituting , combining, adapting, modifying(minifying or magnifying) , putting to other use, eliminating, and rearranging/reversing existing ideas to create unique ideas. The list below includes some of the ideas that were significantly altered by using SCAMPER in the idea generation section. At this stage, the quantity of ideas are considered rather than checking for feasibility. This allows for the exploration of the design space.

- Substitute
  - Maglev mini-train
  - The platform which is lifted by water, but instead, a balloon underneath a platform inflates
- Combine
    - bungee ropes and seesaw
    - Tunnel (above or underground) combined with a train
    - Extra large cylinder (with the insides being hydraulics)
    - Escalator with wheelchair lift
    - Underground tunnel with water (boat)
    - Stairs with ramp
    - Combine the stick which guides people with the escalator ramp (on the ramp, a rail which people can hold onto)
    - Moving swing (+ slider)
    - Square pathways with a trampoline section added for each stair
- Adapt
  - For the sound which indicates to blind people where they are (vibrating plates)
- Modify, Magnify,Minify
  - Mini hot air balloon
  - Colour blocks but they glow in the dark
  - Android - can lift people up or can just guide them as a human would
  - Extra-large swing (with a large length to fit many users)
  - Large steps (wider ones with less height)
  - Motion sensor that modifies the handrails; handrails come up when one pushes a button or motion sensor
- Put To Other Use
  - Roller coaster, water route (like disneyland theme parks)
- Eliminate
  - Coloured pathways instead of squared paths
- Rearrange, Reverse
  - Upside down escalator (like a ski lift chain)

E.3: Analogy Methods

The analogy methods such as biomimicry and magic solution allow for further exploration of the design space by taking inspiration of how to apply the functions of biotic factors or living things to fulfill the existing function. Magic solutions, however, inspire a broad range of creative ideas but may or may not be feasible in reality.

Biomimicry

- Kangaroo - mechanical device person climbs into and it jumps upwards
- Python stomach simulation,similar to movement of blood cells inside a blood stream pumped by the heart. Similar "squeeze"forces can be used for the change in elevation of the object.
- Just like capillaries , the escalator branches up into different directions each at a different elevations

Magic Solution:

- A way for the ground to lift upwards when a person walks onto it, without needing the user to do anything
  - Solution is that the platform is open but textured (allowing for the user to be aware that it moves up and down) and senses if a weight is on the platform, changing the elevation of the platform when a weight is sensed.
- Teleportation: users enter the design and become automatically transported to the entrance or the sidewalk.

E.4: Morphology Chart

The morphology chart enables several ideas to be explored and a combination of methods (for example, combining one means in each row to create a larger idea) ensure that unique ideas are produced. An example of combining ideas is highlighted in the table 12.

Table 12. The morphology chart displaying various ideas by which a particular function is obtained by the design.

	means	means	mean	mean	mean	mean
Change elevation	ramp	Lift the person (crane)	elevator	escalator but enables person to sit on the seat	spring	plane
Move them forward	A conveyor belt	have another person to help them on the path	Cart that runs on a cable	the cables found in roller coasters (chains) to move the cart forward	Provide a path for users to navigate themselve s	someone pushes u forwards
User should know how to use	Sign which indicates how to use it	lights on the design itself to show the path/end (at night only)	QR code which instruct people	braille or auditory instructio ns	distinct colors on the facility	Repetitive ly playing instructio n video on a monitor

Appendix F: Idea Selection Methods and Tools

F.1: Consolidated List of Ideas

The list below were the ideas the team were left with, after removing duplicates and combining ideas. As well, ideas which did not meet the feasibility check, where designs had to meet the constraint and fulfill the functions, were removed. In total, the team was left with 82 feasible ideas.

1. A slip resistant ramp located along the stairs.
2. Stairlift (seat attached to stairs railing and rides up and down stairs)
3. Escalator ramp (without stair-like design)
4. Escalator
5. Ladder
6. An elevator

7. A canal which surrounds the platform, with floating platforms on it. The water level of the canal can increase and decrease, allowing the user to step onto the platform and change their elevation as the water level changes.
8. A wheelchair lift attached to the railings, operating on top of the stairs. It allows the wheelchair users to sit on the platform as it moves up and down the stairs.
9. Ramps which are blended with stairs, where the ramp cuts through the steps at an angle (e.g. Robson Square Steps)
10. A person who can help people who have difficulty accessing the steps, by guiding visually impaired people, and lifting up people who have mobility disabilities.
11. Electromagnetic levitation platform which floats over the ground to change the user's elevation and position
12. A miniature gondola attached to a cable running above the platform.
13. A seat attached to a cable on top of a slide. To navigate down the slide, the seat slides down due to gravity. To navigate up the slide, the cable, which is attached to a motor, pulls the seat up.
14. A slide for users to go down, with a set of stairs next to it.
15. Poles which have beepers at the entrance and along the steps, to indicate to visually impaired people where the path to the entrance is.
16. Brightly coloured blocks which line the stairs and show a path to the entrance, to help visually impaired people navigate the platform. These coloured blacks may glow in the dark, to help people navigate at night.
17. A lever. People stand on the lower side of a lever, and a counterbalance on the other side elevates the people to the upper platform. When the counterbalance is released, people can lower their elevation.
18. A cart which runs on rails built on top of the stairs (similar to a roller coaster).
19. A tunnel which is slanted, so that people can walk through it to get from the sidewalk to the platform.
20. Platform for users to stand on which uses spring power to jump from the lower elevation to the top of the steps.
21. Platform for users to step onto with an inflatable balloon underneath, which inflates to elevate the person.
22. Platform attached to a tethered hot-air balloon. When the user wants to go up, the burner is turned on.
23. Blinkers are located at the entrance and along the path to the entrance, to guide visually impaired people to the entrance.
24. Sticks attached to the ground which move along the sidewalk to the entrance. People can hold onto the stick and be guided towards the entrance.
25. Tunnel which holds pods for people to sit in. The tunnel wall contracts and constricts, like a python's stomach, and pushes the pod forwards and backwards.
26. A robot which can lift people and wheelchairs, and can guide people along the entrance.

27. A ski lift
28. A vehicle which can climb up stairs (instead of wheels, it has mechanical legs).
29. A person is attached to a harness and they are hoisted up a ledge to the top steps.
30. Zipline extending from the sidewalk to the platform.
31. Sky train to transport people with mobility disabilities
32. Porch lift
33. Presence detection lighting on escalator to avoid lamp switches to be too high for wheelchair users hung over a ramp
34. Lights embedded into the stairs
35. Ramp with rubber bumps, allowing users to grip onto the ramp.
36. Declining path to an elevator entrance which saves energy of lifting
37. Fixture attach to wheels of wheelchair and allowing sliding up and down
38. Stairs which can fold out and extend to turn into a ramp.
39. Crane arm which carries a platform for the user to get on. The crane lifts and moves the person forward. The users are seated in the cart/large box. There are strong metal wires holding the cart.
40. A helicopter hovering over the platform. When people need to get on the users can hang on the ladder from the helicopter, which will lift the user up.
41. Users climb down the tunnel at the end of the sidewalk and enter the underground tunnel (ramp) which leads up to the first floor of Sidney Smith.
42. Trampoline for users to jump onto to lift their elevation. They can jump down onto the trampoline if they want to lower their elevation.
43. The users can be “launched” by sitting on a large spring and are mechanically controlled to launch the spring.
44. Users stand on a platform that sits on a slippery slope. They hold onto a rope which is pulled up through a motorized pulley.
45. Swing that is mechanically controlled.
46. Seats attached to a moving-wheel system that moves the seats up.
47. Soft sponge-like path up the stairs or ramp.
48. Wind tunnel that blows upwards. Users hold onto a parachute and get lifted up.
49. Miniature rockets launch with you inside and re-land in front of the entrance
50. Jet pack with a line connected to the ground for stability
51. Motorized exoskeleton that encases user and walks up the stairs
52. Trained service dog carries user up the stairs
53. Robotic kangaroo, using AI, encases users in a pouch and takes users up stairs.
54. Escalator, but as the last step is reached, the step vibrates, indicating to the user, particularly those who are visually impaired to step off
55. Escalators with steps wide enough for a wheelchair, which also moves at a slower rate and can pause when it detects someone getting on.

56. Miniature ferris wheel which rotates one direction. Users step into the platform (orientation remains parallel to the ground) and as the wheel rotates, their elevation changes.
57. Ramp but with railings that operate as a conveyer belt, allowing wheelchair users to grip onto the railing to push themselves up, rather than pushing themselves up the ramp.
58. Large textured platform on the ground, which automatically changes elevation (down or up) when it senses a weight on it.
59. Automated “bicycles” to transport users up along the ramp; users would not be required to put any effort, a seating arrangement would hold a maximum of 5 people.
60. From the entrance to the bottom of the elevation, a large sled (with brakes) is used. To transport from the bottom of the height to the entrance, the sled has wheels.
61. Hoverboard that automatically transports users up the smooth ramp.
62. Large circular platform that lifts an individual upon contact for more than 4 sections. Lights flash before starting to lift. QR code shows how to operate the design. After the platform lifts the user, it extends from its’ side to allow the user to walk across it. It is essential to note that the thickness and width of this design would need to pass the safety constraints in the design.
63. A glass roof, allowing only a certain amount of light to pass through it covering an escalator.
64. Have at least one available wheelchair fixed to the ramp to allow people with medical disabilities like restricted endurance to be transported up the ramp
65. Ramp and signs indicate how to use the entrance with text to allow people with auditory or cognitive disabilities to access the building easily
66. Elevator but include a sign language translation under any texts, the color and font used take into consideration all the types of disabilities.
67. Use snow machines to create sufficient snow for snowmobiles to transport individuals
68. Use a moderated and strategic explosive to knock a container holding the user to the entrance. To ensure the user’s safety, the user is strapped into the container and the container lands on a cushion to lessen the impact.
69. Give individuals a rope to pull someone up
70. Use electrical stimulation on their bodies to move muscles in a manner that transports them up stairs
71. Give users a magnetic suit and use an electromagnet to carry them up
72. Tunnel that leads directly into the Sidney Smith Building so that access to an elevator is available inside
73. Escalator that can transport users from and to Sidney Smith (with a button indicating the direction of movement)
74. Roller skates are attached with a mini-roof to protect users from the rain,snow or sun.
75. Tunnel going up the ramp with a smooth sponge surface with railings attached to the sides.

76. Automated inflatable one person mini hot air balloon in which users can use to transport them to the platform of Sidney Smith
77. Solar powered underground heating system to melt ice or snow on existing textured stairs; underground cooling system to prevent concrete from being warm during high temperatures
78. Wheelchair operates by having a large fan behind the wheelchair from behind.
79. Mini-bungee jump connected to the sides of the building and users would sit inside a cart while strings move them towards or from the entrance of the building.
80. Solar powered robot that can answer any questions about the design and can guide users to and from the entrance.
81. Users sit on a horizontal wheel-like structure that moves at an angle; users can safely come off the ride when they reach the end or start of the system
82. Users can hold onto a moving-sliding rope from the top and be transported to and from Sidney Smith

F.2. Feasibility Checklist

To ensure the consolidated list had ideas which were feasible, the following checklist was used as a feasibility check. The list was written based on the functions and constraints of the design:

- [ ] Transports user between sidewalk and platform
- [ ] Changes user's elevation
- [ ] Informs user how the design should be used
- [ ] User must not experience a force over 1800lb
- [ ] Must not contain PVC
- [ ] Should have signs indicating how to use the design
- [ ] Should be well lit (10 foot candles (lux))

F.3: Multivoting

To further narrow down the design space, the team used multivoting, which was a quick, efficient tool used to incorporate different opinions and select the best ideas. Each member was given 10 votes and had to spend each vote on an idea (Table 5). Votes were summed up, and the 10 ideas with the most votes were selected to be further analyzed (Table 6).

Table 5: Votes from each member are listed in the table. The numbers refer to the number of the ideas on the consolidated list (Appendix F.1).

Member	Laura	Siaa	Jesse	Daniel	Dora
Voted Ideas	1, 32, 8, 55, 13, 37, 62, 19, 60, 3	1,3,8,24,37, 46,47,60,62, 63	1,3,6,10,18,24,37,39,54,55	1, 9, 3, 63, 54, 7, 25, 58, 18, 72	1,3,8,18,37,54,55,60,62,63

Table 6: Summed up votes for ideas which received a vote. The highlighted ideas were the top ten.

Idea #	Idea statement	Votes
1	**slip resistant ramp**	**5**
2	stairlift	1
3	**Escalator ramp**	**5**
6	elevator	1
7	A canal	1
8	**Wheelchair lift**	**3**
9	ramp blended with stairs	1
10	Person aiding others	1
13	Slide and cable system	1
18	**A cart which runs on rails built on top of the stairs**	**3**
19	Slanted tunnel	1
24	Guiding sticks	1
25	tunnel wall contracts and moves user forward	1
32	porch lift	1
37	**Fixture attach to wheels of wheelchair (slide up/down)**	**4**
39	Crane Arm	1
46	Moving-wheel system	1
47	sponge like path	1
54	**escalator with vibration**	**3**

55	**Slow wheelchair wide escalator with user detection**	**3**
58	weight sensor platform	1
60	**Convertible sled with wheels and brakes**	**3**
62	**Extendable circular platform**	**3**
63	**glass roof**	**3**
72	tunnel	1

Appendix G: Idea Selection from the Top Three Ideas using the Pugh Method

Pugh Chart

The Pugh chart scores the alternative design ideas against the current Sidney Smith entrance on how the design meets the objectives. Negative scores means the alternative design is worse than the current design, while positive scores mean that the alternative design is better than the current design in meeting the objective.

Table 7. Pugh chart displaying the top three ideas and the relative scores based on objectives.

Objectives	**Datum (Sidney Smith entrance)**	**Platform**	**WheelChair Lift**	**Glass Roof Escalator**
Safe to Use	S	+4	+3	+4
Ease of Use	S	+5	+5	+5
Durability of Design	S	+1	-3	+3
Total		+10	+5	+12

Table 11. The following chart summarizes the justification of the scores assigned to each design.

Objectives	Datum (Sidney Smith entrance)	Platform	WheelChair Lift	Glass Roof Escalator
Safe to Use	Concrete steps may become icy or wet from weather, reducing slip resistance. (Appendix A)	Users do not need to take steps on the platform, which will reduce falls, as the static coefficient of friction is higher than the kinetic coefficient of friction [33] The platform is enclosed, protecting the surface from ice and rain, which improves slip resistance [34].	Involves static friction, since users do not need to move, but the lift is not enclosed, which exposes the surface to outside weather, reducing slip resistance.	Slip resistance is similar to the platform.
Ease of Use	Requires 0.11kcal from user (Appendix C.1)	Requires 0.1 kcal of energy from the user, since approximately 2 steps are used to get on and off the design which requires 0.05kcal per step [24.]	Requires 0.1 kcal of energy from the user, since approximately 2 steps are used to get on and off the design which requires 0.05kcal per step [24.]	Requires 0.1 kcal of energy from the user, since approximately 2 steps are used to get on and off the design which requires 0.05kcal per step [24.]
Durability of Design	Sidney Smith is renovated once every 21 years on average (Appendix C.2)	Vertical home lifts are replaced every 21 years [21]	Inclined wheelchair lifts are replaced every 10-12 years [28]	Escalators are replaced every 40-50 years on average and modernized in 20-25 years [25].
Total		10	5	12

Other procedures that may be used to further solidify the analysis are weighted decision matrix for instance.

Attribution Table: Conceptual Design Specification

Please note: other documents used in creating the CDS processes display accurate representation of version history are made prior to combining into this document, including appendix, idea generation/selection:

- **100 Ideas List**
- **Ideas Generation**
- **Conceptual Design Specification Idea Generation Section**

Tutorial #:	0127	Team #:	0160
Assignment:	Conceptual Design Specification	Date:	12/04/2022

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The Attribution Table should accurately reflect each team members' contribution to the document. Be sure to keep a copy of this form for the team's records.

If there are irreconcilable differences that are preventing all team members from signing the attribution table then each team member must write a letter (<one page) explaining their position on the difference and suggest a solution. These letters much be submitted to the TA.

As with any engineering statement this attribution table must be backed by credible evidence. In most cases this will be found either in the Google Docs document revision history, or your engineering notebook. Making fraudulent claims in an Attribution Table displays intent to deceive and is a serious academic offence.

Section	Student Names					
	[redacted]	[redacted]	Siaa	[redacted]	[redacted]	
Executive Summary	ET	MR	MR,ET, WD			
1.0			WD,MR,ET		WD, ET	

2.1	WD,MR					
2.2	ET		MR	WD ET FP	ET	
3.0		WD, MR, RS2				
4.0		MR	MR, ET	RS WD	ET	
5.1	WD,MR		OR1		ET	
5.2	ET	MR, RS2	WD, MR, RS1	ET	ET	
5.3		ET	WD, MR, RS1			
6.0		WD	MR,ET	WD		
7.0		WD				
8.1	MR	MR	WD,MR			
8.2	MR	WD, RS2	ET	WD, RS		
8.3	WD, MR,RS2		ET			
9.0		WD	ET			
10.0					WD,MR,ET, RS3	
11.0			WD,MR		WD, MR, ET	
References	ET, MR		ET,MR	ET	ET,MR	
Appendix	ET	WD	WD,MR,ET	ET	ET	
Overall	ET		ET			

Fill in abbreviations for roles for each of the required content elements using the abbreviations found on the next page. You do not have to fill in every cell.

RS – Research (give details below) WD – Wrote Draft MR – Major Revision ET – Edited	FP – Final Proofread of COMPLETE DOCUMENT verifying for flow and consistency OR – Other (give details below)

If you put RS (research) please add a number identifier such as RS1, RS2, etc. Give the research question / topic:

RS1: Research questions are added in appendix C: for example the compressive pressure and force the concrete can withstand:
How much concentrated force or pressure should the material support?[1]
How much friction should there be on the concrete to be considered "safe"? [2].
Does the design interfere with the natural environment? Primary Research and observations. The minimum lighting requirements that are required and the signs that are required for accessibility from codes and standards.

RS2: The range of temperature, sunlight exposure, and precipitation (Service environment)
The amount of calories used to walk up a step of stairs and the average rate of renovations of Sidney Smith Hall (objectives)

RS3 What materials are escalators made out of?
How can the friction upon a metal surface be increased?
What types of tests and methods are used to determine the static coefficient?
What anti-slip substances have the highest static coefficients?

If you put OR (other) please add a number identifier such as OR1, OR2, etc. Explain the role below:

OR1: Black Box Method (Appendix for details)

OR2:

By typing your name below to sign, you verify that you have:

- Read the attribution table and agree that it accurately reflects your contribution to the associated document.
- Written the sections of the document attributed to you and that they are entirely original.
- Accurately cited and referenced any ideas or expressions of ideas taken from other sources according to the standard specified by this course.
- Read the University of Toronto Code of Behaviour on Academic Matters and understand the definition of academic offense includes (but is not limited to) all forms of plagiarism. Additionally, you understand that if you provide another student with any part of your own or your team's work, for whatever reason, and the

student having received the work uses it for the purposes of committing an academic offence, then you are considered an equal party in the offence and will be subject to academic sanctions.

Student #1 Name [redacted]

Student #2 Name [redacted]

Student #3 Name [redacted]

Student #4 Name Siaa Gor

Student #5 Name [redacted]

Student #6 Name

Student #7 Name