GNG1103 - Team 10

Deliverable C - Design Criteria and Target Specifications

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Team Members

Eric Wan

Chelse Rose Vadakkeveettilan Hilariyos

Ahmad Hammad

Al-Waleed Al-Hamedi

Introduction

The last deliverable was focused on user needs and problem statements. We had established our user needs, but realized there is space left for improvement in our specification of the user's needs. The design specifications and design criteria was created according to the improved list of user needs. Technical and user benchmarking was used to compare the available products in the market and determine the best solution to our problem statement.

Priority	User Need Specification
1	**Insuring safety, Operating conditions, Melt the snow above it**
2	**Longevity, Relatively low cost, Scalability**
3	**Energy use**
4	**Modularity, Maintainable, Ease of repair**
5	**Environment friendly**

Table 1. Improved user need specification with priority rated on a scale of 1-5, 1 being top priority.

1. Design Specifications (Ahmad Hammad)

For the proposed Heated Sidewalk application, the requirements of the client were further defined by design specifications. This table is used to further describe the user requirements and which aspects need to be focused on.

Number	Need of the design	Design specifications
1	**Insuring safety**	- Width at least meeting the minimum set requirements - Doesn't cause people to trip over it - Wheelchairs can go over it smoothly - Prevents people from slipping, could be through a grip - Warns people incase of an emergency
2	**Longevity**	- Last for at least five years
3	**Operating conditions**	- Not affected by rain, slush, snow, extremely cold weather, hot weather, or other moderate physical factors
4	**Melt the snow above**	- Function at a temperature of 1 °C or more to

	it	melt the snow and prevent water from become Ice
5	**Relatively low cost**	- Total cost of heated sidewalks < 1 Million CAD
6	**Energy use**	- Heaters automatically turns off when there is no snow
7	**Scalability**	- Fits into the universities storage rooms - Flexibility with sizing options
8	**Modularity**	- Can be moved across the campus at any time - Easy to assemble
9	**Maintainable**	- Easy to clean and remove water off
10	**Ease of repair**	- Easy to repair
11	**Environment friendly**	- Does Not cause harm to environment

Table 2. Designer Specifications.

2. Design Criteria (Al-Waleed Al-Hamedi)

Functional requirements	Non-functional requirements	Constraints

- Melts snow above it.
- Energy use.
  - Turns off when there is no snow.
- Operating conditions:
  - Ability to run on extreme conditions.
	- Long lasting.
	- Ensuring safety.
	- Maintainability.
	- Safety.
	- Reliability.
	- Maintainable
	  - Ease of assembly.
		- Cost (as low as possible).
		- Operating specification.
		- Ease of repair.
		- Flexibility with sizing.
		- Environmentally friendly

Table 3. Design Criteria with functional needs, non- functional needs, and constraints.

3. Technical Benchmarking (Chelse Rose Vadakkeveettilan Hilariyos)

After researching the possible solutions to our problem statement, we have decided on the three most effective solutions. Solar Roadways, snow melting cables, and heated mats were chosen to

be the top three solutions available in the current market based on their popularity and user convenience. Solar Roadways is a company that installs roadways and walkways with solar panels that contain LED lighting, snow melting capabilities, and energy renewal technologies installed into it. Snow melting cables is a common solution where cables that are electrically powered are installed around 2 inches under the pavement. Heated mats are made of thermostatic material and are electrically powered. After comparing all products, we have concluded that the best solution from the available products in the market are heated mats because of its cost, modularity and durability.

	Competitive Heated Sidewalk Products		
Specifications	**Solar Roadways**	**Snow Melting Cables**	**Heated Mats**
Insuring Safety	Unknown	Yes	Yes
Modularity	No	No	Yes
Melt snow above it	Yes	Yes	Yes
Scalability	Yes	Yes	Yes
Operating conditions	Effective	Effective	Effective.
Energy Use	Low energy: 48-watt solar panel using 23.7% efficient solar cells. In the Netherlands, it produced a total of 9,600 kilowatts in a year.	High energy. - 214 ft^2, uses 10.016 kW.	Moderate energy. - thermostatic material, it can preserve heat
Removal and Storage	No	No	Yes
Maintainable	Yes	No	Yes
Longevity	Up to 15 - 20 years	Up to 25 - 30 years	Up to 7 - 8 years
Cost	Installation price: $7-$9 a watt, so a 5kW system would cost $25,000 to $35,000. Long term pricing is very low.	Additional costs for building a new sidewalk. High capital cost that needs to be paid upfront. Ex. $2,549 for 214	It can cost around $700 to $1,500 for large mats. Ex. it costs $145 for a 20-inch x 60-inch mat.

		ft^2.	
Ease of repair	Yes	No	Yes
Environment - friendly	Yes; creates renewable energy.	Yes; it's an alternative to salt.	Yes; it's an alternative to salt.

Table 4. Technical Benchmarking of Solar Roadways, Snow melting cables, and heated mats. Rating of technical benchmarking: 1(low rating) - red, 2 - yellow, 3(high rating) - green.

4. User Benchmarking (Eric Wan)

This benchmark will be based on feedback, complaints, and reviews provided by users of these products. User perceptions may vary drastically, hence this report will gather the most consistent data to reduce illogical feedback.

Solar Roadway

Notable features expressed by users:

Environmental friendliness

Solar roadways are able to generate electrical energy with limited impact on the environment. In the face of issues such as global warming, green energy production is extremely important to the sustainability of humanity. Reported by US solar panel users, in 2018, roughly 66.6 terawatt-hours (TWh) or 1.66% of total US electricity was generated using this technology.

Flaws expressed by users:

Inconsistency and unpredictability of these panels

According to the many roadway projects built in different countries, the biggest recurring concern is the inconsistent energy generated by these panels. As a result of depending on power provided by the sun, a lot of times unforeseeable weather conditions are able to greatly set back the desirable power production. For example, the first solar roadway "Wattway" was built in France and stretched one kilometers long. The estimated cost for this project was $5.2 million and the engineering company Colas expected an output of 280 megawatts-hour of energy to be generated annually. Unfortunately Wattway was only able to generate 409 kilowatt-hours of energy per day during its first year of operation, this was only half the expected energy production that engineers were hoping for.

Cost

Possibly the biggest challenge faced by engineers when constructing solar roadways is the upfront cost and maintenance of this technology. Assuming the entire US used solar roadway, it would be $56 trillion dollars out of the national budget just for the maintenance of roads. Furthermore, solar panels double or triple the cost of asphalt per square foot. Many companies believe it is not worth the labour, money, and time to develop such projects as the technology is still costly and undeveloped. In addition to this, the factor of inconsistency also adds to the fact that most solar roadways are not cost-effective.

Durability
The current solar roadway technology has not been able to solve the durability problem. Roads must be able to withstand extreme force exerted by cars, trucks, and sometimes 18 wheelers with a full load. This is something that the material asphalt has been effectively handling. In the situation of above average weight and impact applied to these panels, they are certain to break. The durability issue of this technology adds to its maintenance cost issue.

Snow Melting Cables

Notable features expressed by users:

Installation
Snow melting cables come in various versions and forms but they are oftentimes very user friendly. One of the most popular versions is called the ice tape, this coil is extremely easy to install and users might not even need the help of a contractor for the installation process. In general, users express satisfaction regarding the installation of snow melting cables.

Flaws expressed by users:

Cost
Snow melting cables run on electricity and users often express a significant increase in electricity bills. Users complain that electricity is an expensive way to provide heat and isn't very cost-efficient. In some cases, snow melting cables are able to detect temperatures therefore only using electricity when needed to, this feature will help users save on electricity bills.

Function
Although snow melting cables work well when properly installed, it only melts snow that it is surrounded with. Users express that there needs to be the presence of many cables in order to properly clear a large area (for example sidewalk) of snow. Furthermore, these cables generally leave behind melted water and could be a cause for concern.

Heated Mats

Notable features expressed by users:

low initial cost
The biggest attraction of heated mats is its low initial cost and maintenance cost. A quality heated mat can be purchased on amazon for roughly $100-$300 dollars with considerably large size, Whereas a solar panel of the same size could be easily in the range of $1000. In addition, these mats are also very economical to run with the HeatTrak mats averaging about $1 per day for each individual mat.

Modularity and scalability
Each individual mats can be simply connected by wires that come with the product so it is extremely scalable and modular. Mats can be easily deployed or collected by plugging or unplugging wires then stored indoors.

Repair and Warranty
In the case where a mat is damaged or nonfunctional, it can be easily unattached then repaired by a professional. Furthermore, most mats come with a two year warranty so users do not have to worry about damage in the short term.

Durable and safe
Users report that heated mats are very safe and durable as the heating element is positioned in between two protectie non-slip rubber surfaces, this allows additional traction for users to walk on. Furthermore, the thermoplastic materials used are also as durable as automobile tires, which allow the mats to withstand harsh weather conditions.

Conclusion

There are various solutions available but efficient heated sidewalks remain a growing market as all the current solutions have certain drawbacks. Solar Roadways has a great future in creating a greener campus, but is not cost efficient enough for the school's budget. Snow melting cables are also an effective solution to keeping the sidewalks snow- free, but consumes a lot of energy and lacks the ability to be easily repaired. Heated mats do offer a promising solution as they are modular and maintainable, but lack high longevity periods as the other two solutions. In conclusion, we are going to follow heated mats as the referral for our product design.

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