

GLYDWAYS + MITsdm

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What is the problem?

Background context:

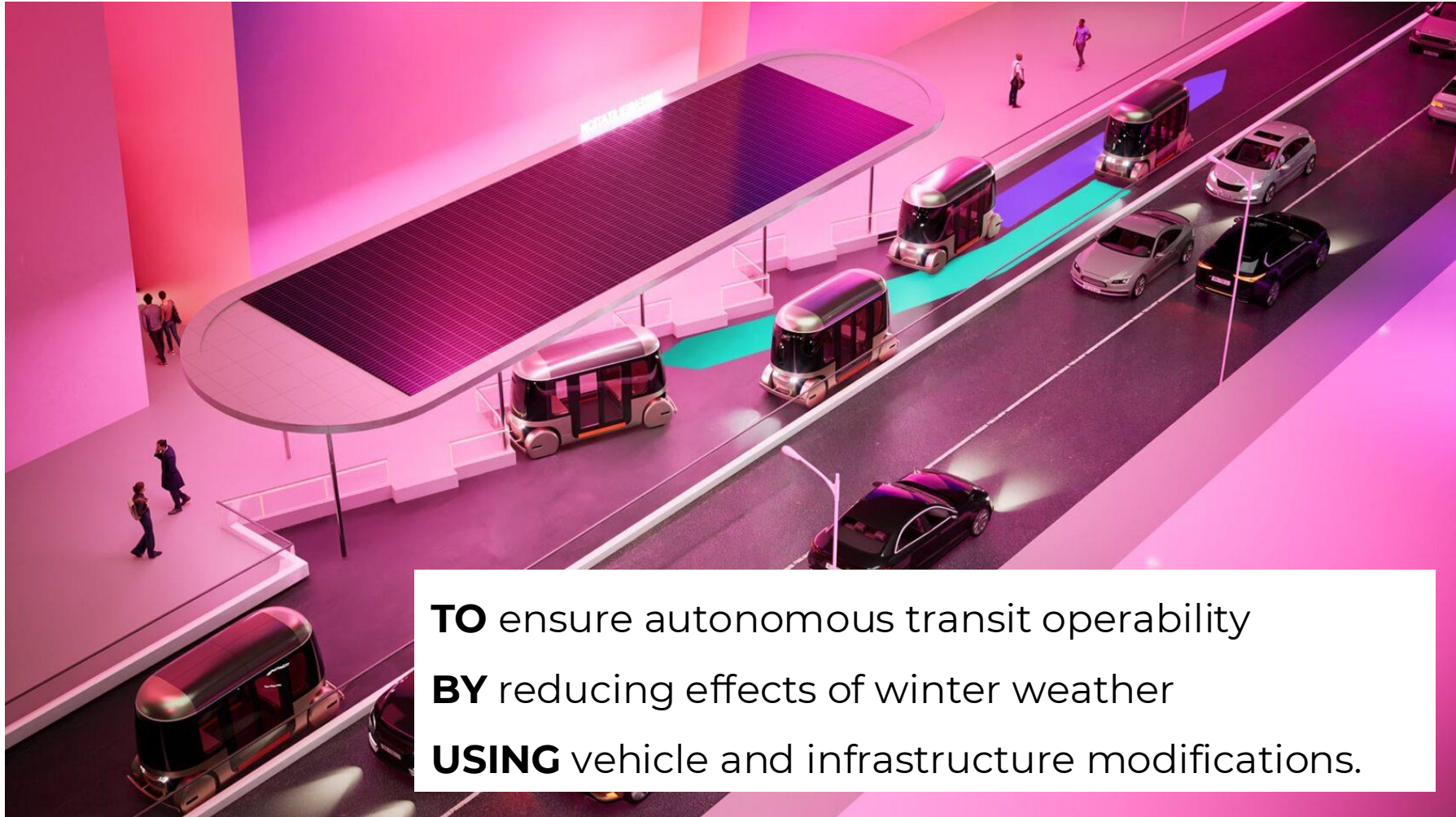
- Glydways provides rapid **autonomous** personal rapid transit on **dedicated tracks** to connect users to a transit network
- Currently developing first systems at airports in **San Jose, CA and Atlanta, GA**

Challenge:

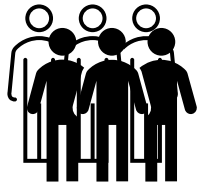
- The ability of the transit system to **perform safely in winter conditions** is not known and has not been tested
- Glydways is unsure of the **profitability** of a transit network in cold regions



System Problem Statement



How is value delivered?



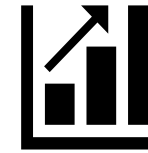
Stakeholder Needs

- Safety
- Fast, reliable transportation
- Accessibility
- Compliance with regulations
- Community preservation
- Energy efficiency



Requirements

- Functional requirements (booking, GPS tracking)
- Non-functional requirements (performance, availability)
- Compliance standards



Value Delivery

- User satisfaction (ratings)
- Reliability (%)
- Profitability (\$)
- Market expansion (# cities)



What are the options?

Decision	Type	Option 1	Option 2	Option 3
Covered Track	Form	Yes	No <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/>	
Snowplow	Form to Function Mapping	Dedicated snowplow vehicle <input type="radio"/> <input type="radio"/> <input type="radio"/>	Snowplow equipment add-on <input type="radio"/>	None <input type="radio"/>
Snow Tires	Form	Yes <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/>	No <input type="radio"/>	
Snow-Melting Chemicals	Function	Salt <input type="radio"/>	Glycol mix <input type="radio"/> <input type="radio"/>	None <input type="radio"/> <input type="radio"/>
Heated Track	Function	Yes <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/>	No <input type="radio"/>	
Human Interaction	Function	Human Operation	Human assistance / intervention <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/>	



Heated Track



Covered Track



Snowplow



Salt Distribution



Snow Tires



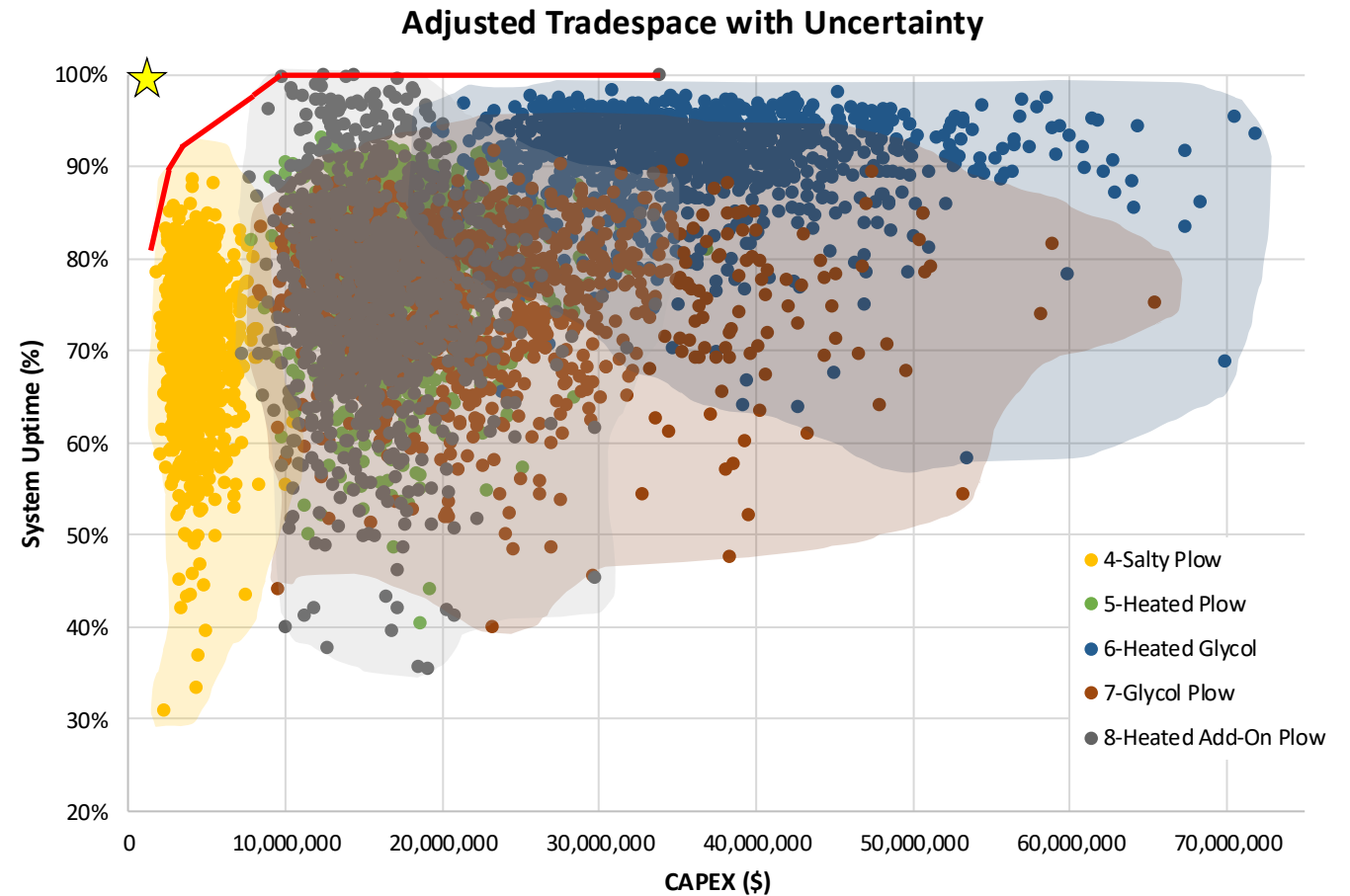
Glycol Distribution

Selected Architecture Concepts:

- Salty Plow: Utilizes a combination of dedicated plow vehicles and salt to remove snow and ice.
- Heated Plow: Dedicated plow vehicles travel on heated tracks without the need for snow-melting chemicals.
- Heated Glycol: Glycol spray is used on heated tracks to prevent snow accumulation.
- Glycol Plow: Dedicated plow vehicles travel on heated tracks with the addition of glycol spray to melt snow and ice.
- Heated Add-on Plow: Each Glydcar has its own plow add-on as it travels along a heated track with no use of chemicals.

How did we compare options?

- Promising architecture options were compared in the trade space of **cost** and a key performance metric (**uptime**).
- Monte Carlo simulations incorporating Probability Density Functions (PDFs) were employed to **account for uncertainty**
- Architectures on the **Pareto Frontier** were identified: Salty Plow, Heated Glycol, and Heated Add-on Plow



What is our preferred solution?

- **Salty Plow**: Utilizes a combination of dedicated plow vehicles with snow tires and salt to remove snow and ice.
- **Low CapEx** solution, highly **adaptable** to differing climates and Glydways network sizes
- Minimal infrastructure modification required; **minimizes OpEx**
- Independent, dedicated vehicle design **minimizes complexity and change propagation risk**
- Leverages **autonomous vehicle control** to dovetail with Glydways ethos



Decision	Type	Option 1	Option 2	Option 3
Covered Track	Form	Yes	No	
Snowplow	Form to Function Mapping	Dedicated snowplow vehicle	Snowplow equipment add-on	None
Snow Tires	Form	Yes	No	
Snow-Melting Chemicals	Function	Salt	Glycol mix	None
Heated Track	Function	Yes	No	
Human Interaction	Function	Human Operation	Human assistance / intervention	

What is the project risk?

Risk

- R-025:** Strong competitors Appear
- R-010:** Key engineers leave project
- R-018:** Software integration failure



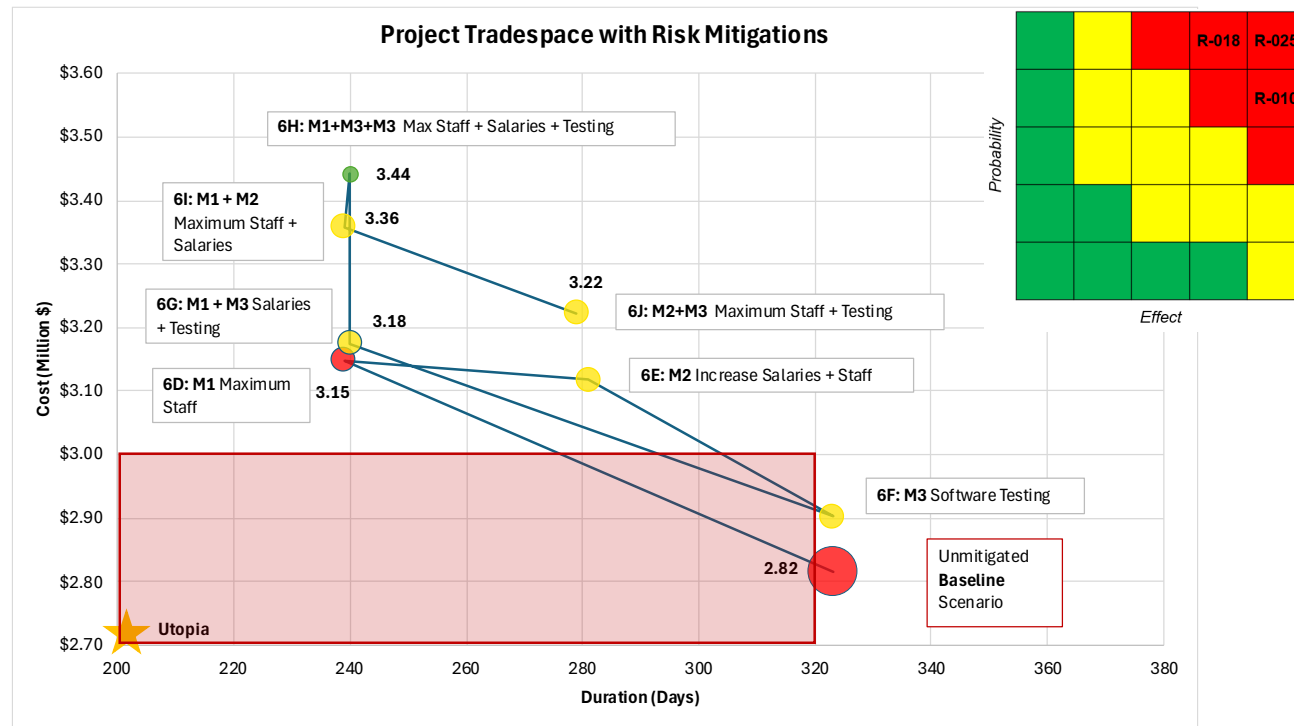
Mitigation

- Compress project schedule
- Increase staffing and pay
- Early & phased integrative testing



Impact

- Reduce probability
- Reduce probability & effect
- Reduce probability



What are the next steps?



Validation & Technical Readiness

- Validate the Salty Plow system on a test course
- Establish validation metrics
- Perform detailed design review



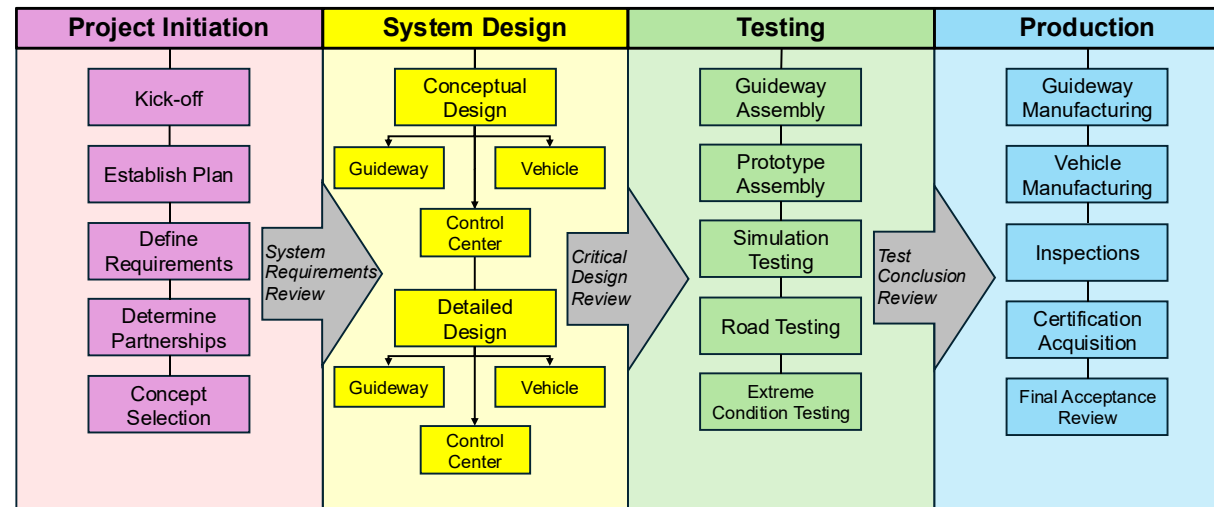
Deployment & Scaling Strategy

- Identify pilot testing location
- Conduct mixed architecture analysis for specific cities
- Define modular strategies



Execution & Partnership Strategy

- Identify strategic suppliers
- Explore grant funding or public-private partnership
- Develop rollout roadmap



A digital rendering of a modern transit station at dusk. A long, covered walkway with a white metal frame and translucent panels extends from the foreground into the distance. The walkway is illuminated by recessed lighting. To the right, a building with a gabled roof and the word "GLYDWAYS" in glowing teal letters above the entrance. A small, dark, rounded autonomous vehicle is stopped at a platform. Several people are walking along the path. In the background, a road with light trails from cars and trees are visible under a twilight sky. Blue signs with the numbers "01" and "2" are mounted on the walkway's structure.

Questions

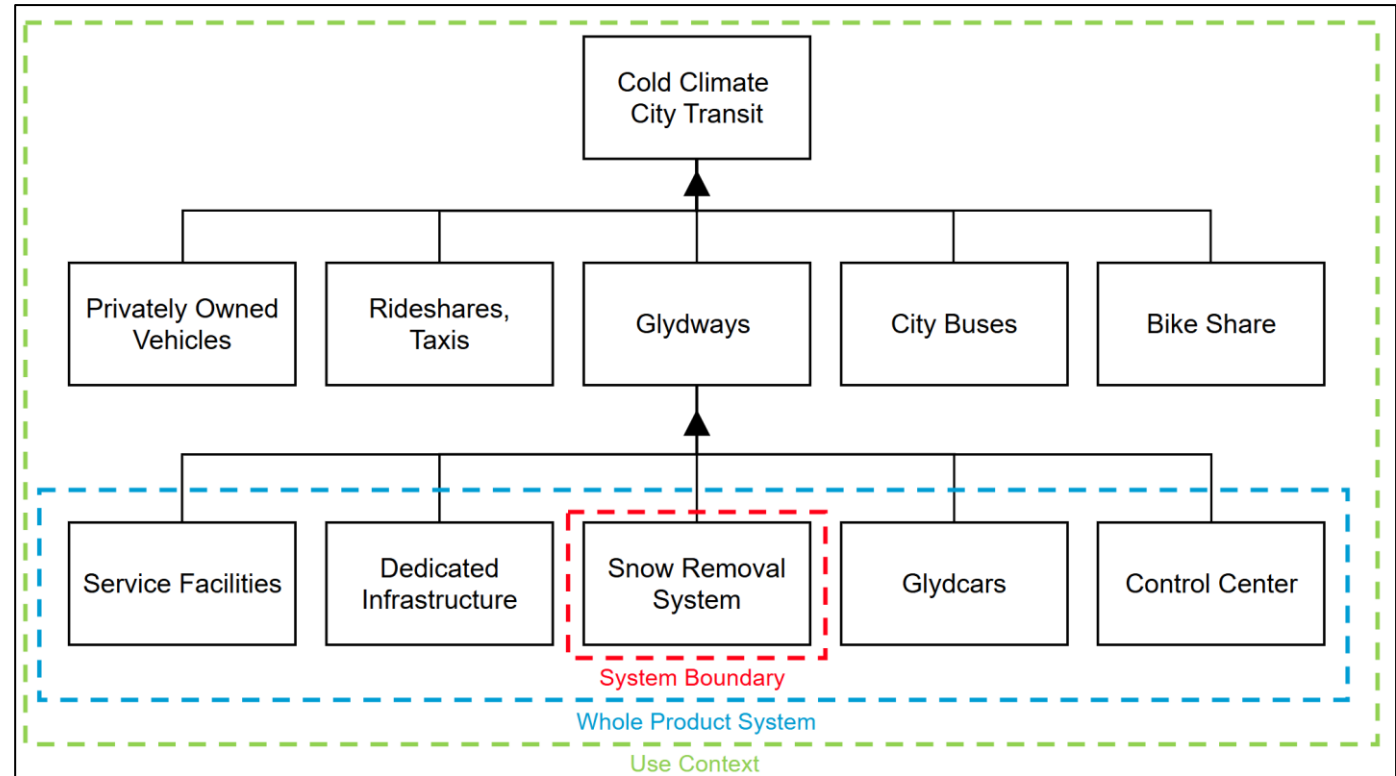
Appendix



System context



System Boundary:



Stakeholder needs and system requirements

Stakeholder	Need	Requirement
Users	Fast transportation	System shall be capable of autonomous travel regardless of weather conditions
		System shall be capable of operating at speeds of up to 30 mph
Users, local jurisdictions	Accessibility	System shall be ADA-compliant regardless of weather conditions
Users, local jurisdictions, investors, communities	Safe transportation	Incident rate per passenger-mile shall be less than 1 per 100,000
Environmental agencies	Energy efficiency	Reduction in transfer energy shall be less than 10%
Users, investors	Reliable transportation	Reduction in operating efficiency shall be less than 10% in winter conditions
		Waiting time shall be less than 10 minutes during peak hours
		Arrival at destination shall be late less than 5% of the time
Communities, environmental agencies	Community preservation	The noise level produced by the system shall be less than 50 dB.
		The snow removal system shall not release toxic chemicals into local communities.



Architectural Decision	Option 1	Option 2	Option 3
Covered Track	Yes	No	
Snowplow	Dedicated Snowplow Vehicle	Snowplow Add-on	None
Snow Tires	Yes	No	
Snow Melting Chemicals	Salt	Glycol Spray	None
Heated Track	Yes	No	
Human Interaction	On-site human operation	Off-site human intervention	

Measures of Performance

Architectural Decisions	Measure of Performance												Total Sensitivity
	Avg speed (mph)	Avg snow removal speed (sq ft/min)	System downtime (%)	On time performance (%)	CAPEX (\$)	OPEX (\$)	Average Passenger wait time (min)	Average noise level (dB)	Incident Rate (%)	Traction measurement accuracy (%)	Average Passenger loading time (min)	Average Trip time (min)	
1. Covered Track	High (9)	High (9)	High (9)	Med (4)	High (9)	Med (4)	High (9)	Med (4)	Med (4)	Low (1)	Low (1)	Low (1)	64
2. Snowplow	High (9)	High (9)	High (9)	High (9)	Med (4)	Med (4)	Med (4)	High (9)	Med (4)	Low (1)	Low (1)	Low (1)	64
3. Snow Tires	High (9)	High (9)	High (9)	Med (4)	Low (1)	Low (1)	Med (4)	Low (1)	Med (4)	Low (1)	Low (1)	Low (1)	45
4. Snow-Melting Chemicals	High (9)	High (9)	High (9)	High (9)	Med (4)	Med (4)	Med (4)	Low (1)	Med (4)	Low (1)	Low (1)	Low (1)	56
5. Heated Track	High (9)	High (9)	High (9)	High (9)	High (9)	High (9)	High (9)	Low (1)	Med (4)	Low (1)	Low (1)	Low (1)	71
6. Human Interaction	Low (1)	Low (1)	Med (4)	Low (1)	Low (1)	Med (4)	Low (1)	Low (1)	High (9)	Low (1)	Med (4)	Med (4)	32

- How sensitive each architectural decision is to each measure of performance
- Overall most sensitive: **heated track** decision – has largest potential impact on measures of performance

Connectivity of Architectural Decisions

Column Affects Row	2. Covered Track	3. Snowplow	4. Snow Tires	5. Snow-Melting Chemicals	6. Heated Track	7. Human Interaction	Total
1. Covered Track					X		1
2. Snowplow							0
3. Snow Tires		X				X	2
4. Snow-Melting Chemicals						X	1
5. Heated Track	X						1
6. Human Interaction			X	X			2
Total	1	1	1	1	1	2	14

Connectivity:

$$C_{\text{Covered Track}} = 2/14$$

$$C_{\text{Snow-Melting Chemicals}} = 2/14$$

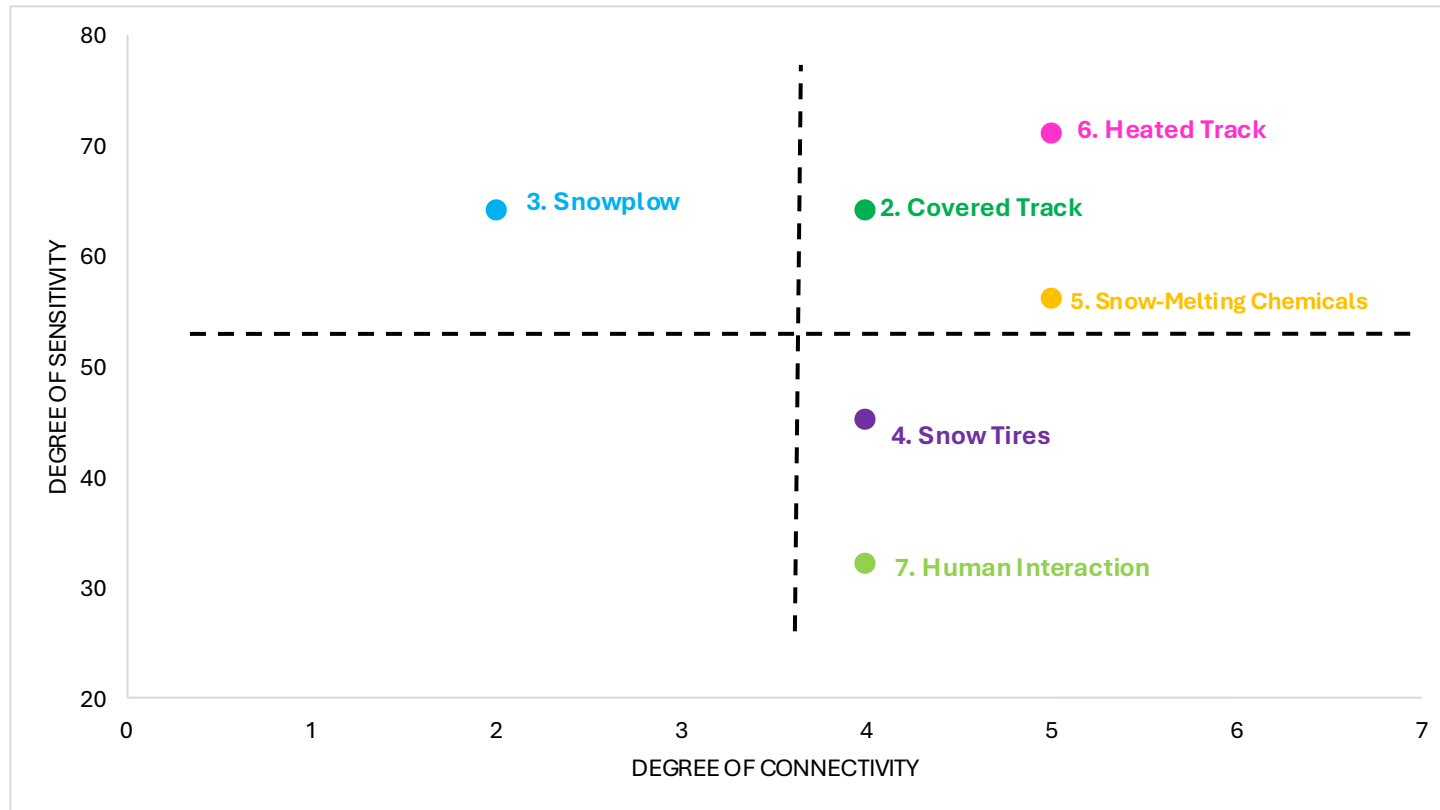
$$C_{\text{Snowplow}} = 1/14$$

$$C_{\text{Heated Track}} = 2/14$$

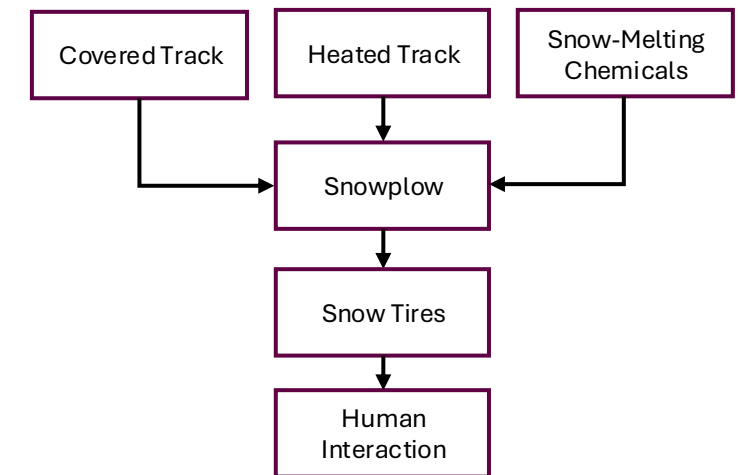
$$C_{\text{Snow Tires}} = 3/14$$

$$C_{\text{Human Interaction}} = 4/14$$

Connectivity versus Sensitivity of Architectural Decisions



Example of architectural decisions hierarchy:



Initial ConOps and Reflections

Overview of envisioned system:

An adapted autonomous personal rapid transit system that can perform safely in winter weather conditions without the risk of slippage from snow or ice

Rationale:

- Cold climate operations enables Glydways to expand to new markets
- Glydcars can lose traction under snowy conditions which decreases safety of riders, especially along ramps and curves
- System can provide a safer, more reliable option compared to current transit systems by providing each rider or group a personal vehicle on a dedicated track with no outside traffic

Proposed mission:

Explore possibilities to enable the current Glydways system to meet the need for safe and reliable transportation in cities with colder climates



Reflections:

- System concept meets more consumer needs than current public transportation systems
- Personal rapid transit pilots are underway globally
- More seamless customer adoption is possible since users understand rideshare requesting process