Livable City Year HPG-13: Winter Weather Route Response Optimization

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Problem Statement

To efficiently utilize the City of Bellevue's resources, we are working to optimize preset routes for covering snow plowing and deicing city operations.

Objectives

This project consists of optimizing a tool for total covered distance that will save cost and time for the City of Bellevue. Also, we plan on identifying and eliminating any repetitive road traffic by developing road clearing operations visibility.

Task 1 Deicing Routes	Task 2 City Wide Snow Event Routes	Task 3 Neighborhood Snow Routes	Task 4 Documentation and Analysis

Current Systems

- ❖ Three supervisors at dispatch
- ❖ Stick Post-It notes with the names of the operators on map
- ❖ Live operations via the city cameras.
- ❖ Monitors with weather information.
- ❖ Two operators (one driving and one navigating) using a binder to navigate

Opportunities for Process Optimization

- ❖ Create a consistent process of deicing and snow plowing operations
- ❖ Recommend an efficient routing order for the operators
- ❖ Provide insight into the Bellevue current operations

Each deicing and snow plowing truck carries a binder that contains all the city maps and regulations.

Process Flow Map

Operator (in the truck)	Coordinator (in monitoring room)
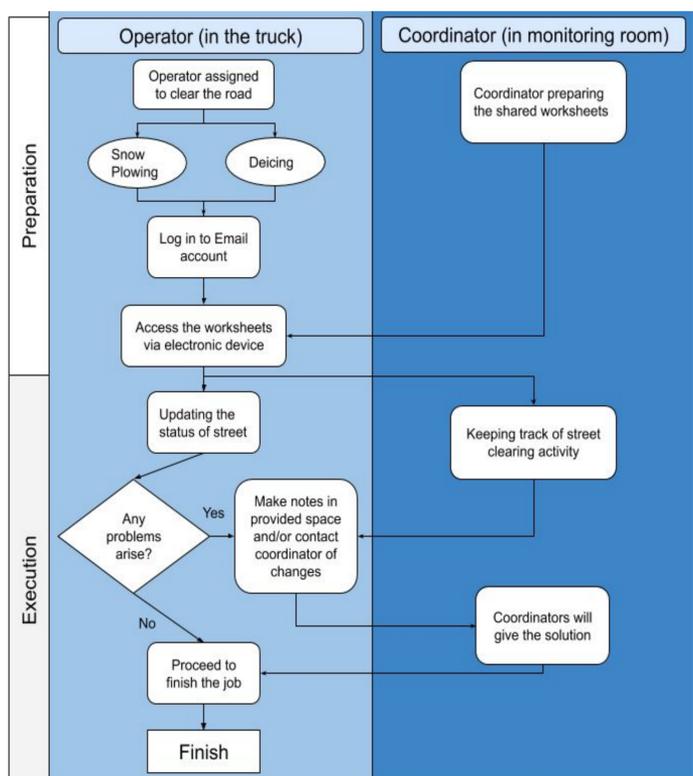
❋ Route Optimization Modeling Tasks ❋

❋ TASK 1 ❋

Deicing Routes

Deicing

Gathering Relevant Information
- ❖ Midpoint coordinates of routes
- ❖ Google Maps Directions API
- ❖ Feasible Assumptions
- ❖ Number of Trucks
- ❖ Number of Routes
- ❖ Number of lanes in routes
- ❖ Total Distances Traveled

Using Same Method

Tools used for Optimization
- ❖ Designed time & distance cross-tabular matrix of distances using Python
- ❖ Implemented Common Vehicle Routing Model using Google-OR.

A streamlined version of work order (csv file) that contains the optimized route recommendation based from model

Assumptions for Deicing

- ❖ No refueling during operation
- ❖ Deicing during 2AM, no traffic to account for
- ❖ Suicide lanes are not covered
- ❖ Deicing truck average speed is 35 mph

Vehicle Routing Model

Route Number

Route Number	BSC	21	5	8
BSC	0	1	1.6	1.7
21	1	0	1	1.6
5	1.4	1.4	0	0.6
8	1.7	1.6	1	0

Sample Matrix of Route Distances (Routes 21, 5, 8)
Distances in miles of the real-time distance cross-tabular matrix between one deicing route to another, collected from the Google Directions API.

Starting Location

Route Combinations	Distance Total (mi)
BSC, 5, 8, 21	3.8
BSC, 5, 21, 8	4.6
BSC, 21, 5, 8	2.6
BSC, 21, 8, 5	3.6
BSC, 8, 5, 21	4.1
BSC, 8, 21, 5	4.3

The data will be fed to the Vehicle Routing Model to output the optimal route based on the best combination of distances.

Image of coordinate results put into Google Maps

❋ TASK 2 & 3 ❋

City wide Routes

Snow Plowing

New Assumptions and Considerations:
- ❖ 15 trucks divided throughout city
- ❖ Midpoints coordinates of Snow Response Routes
- ❖ Clusters based on Bellevue map areas
- ❖ Larger amounts of distances covered

City Wide Route Priority

City Wide Snow Event	Primary Arterial Routes → Highest Priority
	Secondary Arterial Routes
	Primary Neighborhood Routes → Lowest Priority

Standard snow plowing trucks of Bellevue

Bellevue best allocates their resources by borrowing other vehicles.

Each vehicle needs two operators, a driver and a navigator.

Neighborhood Routes

Neighborhood routes are completed during a city wide snow event.
The routing orders are optimized using the midpoints of the secondary arterial and neighborhood loop clusters.

Snow Response Priorities
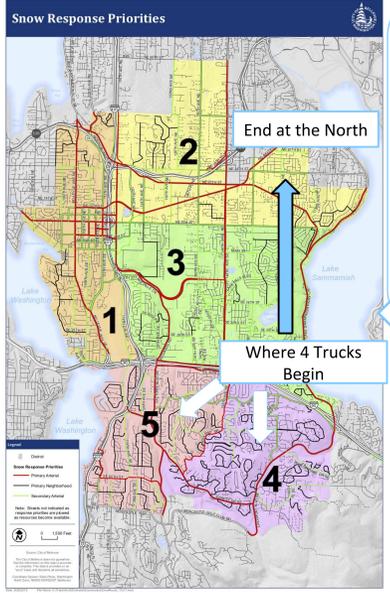
City Wide Routing
- ❖ 11 trucks on the primary arterial routes
- ❖ Remaining 4 trucks will work on secondary arterial and primary neighborhood routes from South to North as the South experiences heavier snowfall

Neighborhood Routing

Midpoints of the neighborhood routes are calculated based on its relative location inside the cluster.

Cluster 5-A of Neighborhood Routes
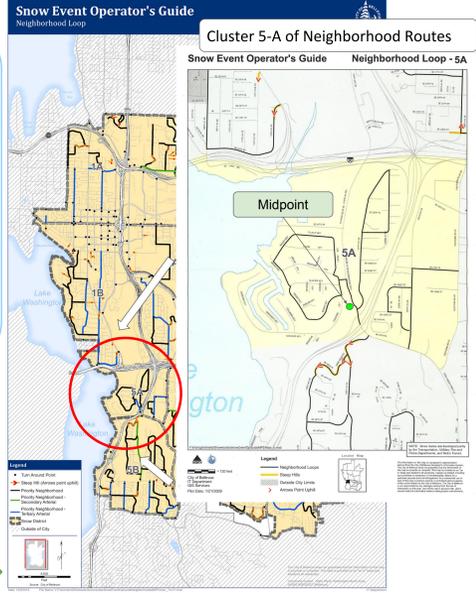
❋ TASK 4 ❋

Recommendations
- ❖ Implement the routing order recommendations
- ❖ Digitalize mapping and current operations
- ❖ Implement recommended routes into fleet navigation platform

Validation
- ❖ Test drove Google-OR's generated routes in Bellevue
- ❖ Simulation model, Simio
- ❖ Implemented the Google-OR generated route orders into Google maps

SnowDawgz Test Driving Routes

Worksheets used in Deicing operators → Optimization modeling with new order of Deicing routes

Master Routes
Expanded Routes
Large Truck Routes
Small Truck Routes
Simio Modeling
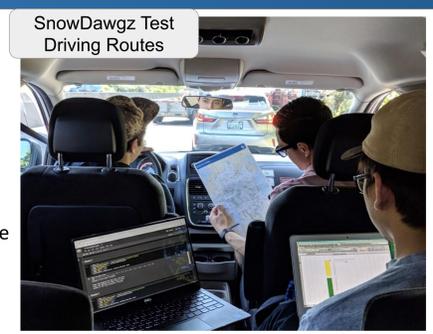
Cost-Benchmark Analysis for Deicing Solution
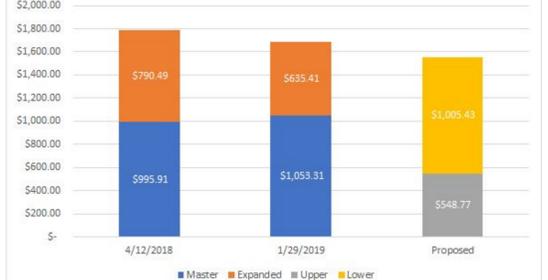
Continuous Improvement

The **digital worksheet** will provide a way for identifying gaps for improvement. This system could be further utilized when AVL (Automatic Vehicle Locator) becomes available. This project serves as a transition from the current method of operations towards AVL.

Current System: Manual Processing	Recommendation: Digital Processing	Future: AVL Systematic Processing

Cost Analysis and Goal Budgeting for Deicing

Cost Considerations: Labor, Type of Truck, Fleet Size, $CaCl_2$

Cost Analysis:
1) Labor: hourly rate
2) $CaCl_2$ (deicing solution): $191.38/ton
3) One ton truck spreading rate: 20 gallons/mile. Seven yarder truck spreading rate: 15 gallons/mile

Total estimated cost required to complete deicing is $2500 - $2700