Exploring On-demand Transit Options for The Town of Innisfil

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Introduction

In order to assist the Town of Innisfil in designing and operating a high quality and sustainable on-demand public transit service, this study investigated the spatiotemporal demand levels under which crowdsourced transit, dedicated fleet transit, and a combination of both would be more appropriate and efficient.

Methodology

Towards this end, we developed a microsimulation model using Simulation of Urban Mobility (SUMO) platform. Model inputs included demand, supply, supply-demand interactions, and road network information. This information was used to develop three different scenarios. We first simulated Innisfil under the existing service and demand conditions (March 15th, 2021) to estimate the spatiotemporal distribution of the supply that corresponds to the actual situation. The second scenario involved modeling the existing service under varying levels of demand and supply, with and without the option of ridesharing. Last, we simulated different services under different supply and demand levels.

Results

A comparison of Innisfil transit service under various mobility options (Fig. 1) is presented in Fig. 2 in terms of the average waiting time, vehicle time, occupancy, vehicle kilometers travelled (VKM), yearly greenhouse gas (GHG) emissions, as well as the annual net cost. Among all demand levels, the lowest waiting and in-vehicle times were observed with the hybrid mobility option that combines on-demand transit with crowdsourced services and with the crowdsourced mobility option that has supply increasing linearly with demand. However, the latter had the lowest occupancy, as well as the highest VKM per passenger and GHG emissions. On the other hand, the dedicated fleet on-demand transit service had the longest waiting and in-vehicle times, but it had the highest occupancy, as well as the lowest VKM per passenger and GHG emissions, especially at higher demand levels. As for the annual net cost, crowdsourced mobility services had the lowest net cost, followed by the hybrid mobility that combines fixed-route transit with crowdsourced services, whereas dedicated fleet on-demand transit options had the highest.

In general, the performance of the proposed mobility options varied across the different performance measures. Thus, the service quality is evaluated by the utility function U defined as the combination of the key measures of performance:

$$\boldsymbol{U_i = \omega_{wk_i} \times Walk\_time_i + \omega_{wt_i} \times Wait\_time_i + \omega_{in\_veh_i} \times In\_Veh\_time_i + \omega_{VKM_i} \times VKM\_Pass_i + \omega_{cost_i} \times Net\_Cost_i} \quad \textbf{(1)}$$

Where ω_{wk}, ω_{wt}, ω_{in_veh}, ω_{VKM}, and ω_{cost} are weights representing the importance of the performance measure.

When the five performance measures are equally weighted, as shown in Fig. 3, crowdsourced mobility outperforms the other options when the demand is below 2.6 riders/mile^2/day (i.e., 260 riders per day in the Innisfil context), and hybrid mobility, which combines on-demand transit with crowdsourced services, when it exceeds 2.6 riders/mile^2/day. Similar findings can be observed when the average waiting time, in-vehicle time, and VKM per passenger are weighted twice as much as the net cost and walking time.

However, the hybrid mobility option outperforms the other mobility options at all demand levels in the following conditions:

- When the waiting time, travel time, and the VKM measures are weighted three times more than the net costs and walking time.
- When the VKM per passenger measure is weighted two times more than the other performance measures.
- When waiting time, travel time, and the VKM measures are equally weighted, while ignoring the net cost and walking time measures.

On the other hand, if the net cost of the service is considered more important than the other performance measures, hybrid mobility that combines fixed-route transit with crowdsourced services becomes more efficient when the demand exceeds 2.25 riders/mile^2/day (or about 225 riders per day in the Innisfil context).

As Table 1 shows, both the fixed-route and the on-demand transit (ODT) services (Fig. 4) have the potential to serve the future demand in the Alcona area with the current crowdsourced service operating in the other parts of Innisfil. However, the fixed-route transit has slightly higher performance in all measures compared with the on-demand transit service.

Table 1. The performance of the proposed fixed-route and on-demand transit service in the Alcona area

Service	Scenario	Demand (Trips)	Walking Time (min)	Waiting time (min)	In-vehicle time (min)	Route Length (km)	Avg No. of Veh (veh/hr)	Avg. Occupancy (veh/hr)
ODT	New Go Station	61	0	9.8	12	8.6	1.95	1.56
	Sleeping Lion	76	0	9.5	13.05	8.9	2.05	1.85
	Orbit Phase 1	93	0	11.3	22.1	11.914	2.7	1.72
FRT	New Go Station	61	5.5	8.2	12.2	8.1	2	1.52
	Sleeping Lion	76	5.8	8.4	12.7	8.3	2	1.9
	Orbit Phase 1	93	6.1	8.8	13.8	8.2	2	2.33

Concluding Remarks

- Converting Innisfil Transit to Dedicated-Fleet ODT Service has the potential to:
  - Reduce up to 37% of the yearly GHG emissions.
  - Reduce up to 37% of the VKM/passenger.
  - Increase the waiting time of users up to five times (when the demand doubles).
  - 1% increase in demand results in 1.5 mins increase in the waiting time of ODT users.
  - Doubling the in-vehicle time for users (when demand doubles).
  - Cost the town triple what it does now.
- The ODT System may be suitable when the demand exceeds two times the existing value
- Converting Innisfil Transit to a hybrid Service (ODT/FRT + Crowdsourced) has the potential to:
  - Reduce up to 33% of the yearly GHG emissions.
  - Reduce up to 33% of the VKM/passenger.
  - Maintain the current performance of Crowdsourced even when the demand doubles.
  - Outperform the other alternatives when the demand exceeds 2.25-2.6 riders/mile^2/day (in most cases).
- In future, we intend to design and conduct a stated preference (SP) pivoted on revealed preference (RP) survey, which will be used to:
  - Develop individual level behavioural models for activity, location, time, and mode choices.
  - Explore the design options that can be aligned with the future improvements in Innisfil, including the population growth, land use changes, and the construction of the new Go station.

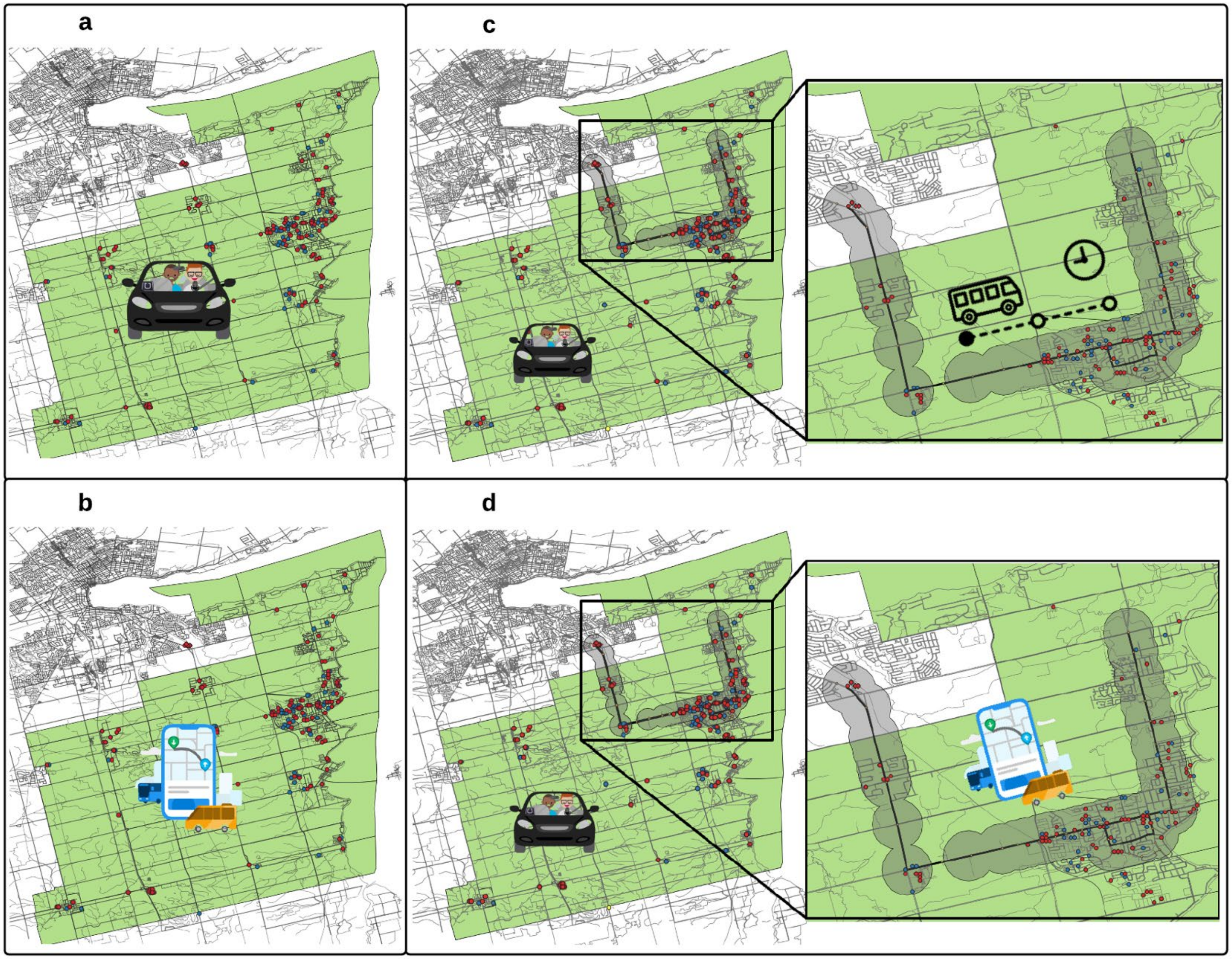

Fig. 1: Innisfil transit service under various mobility options: (a) crowdsourced mobility service, (b) dedicated fleet on-demand transit service, (c) hybrid mobility that combines fixed-route transit with crowdsourced services, and (d) hybrid mobility that combines on-demand transit with crowdsourced services

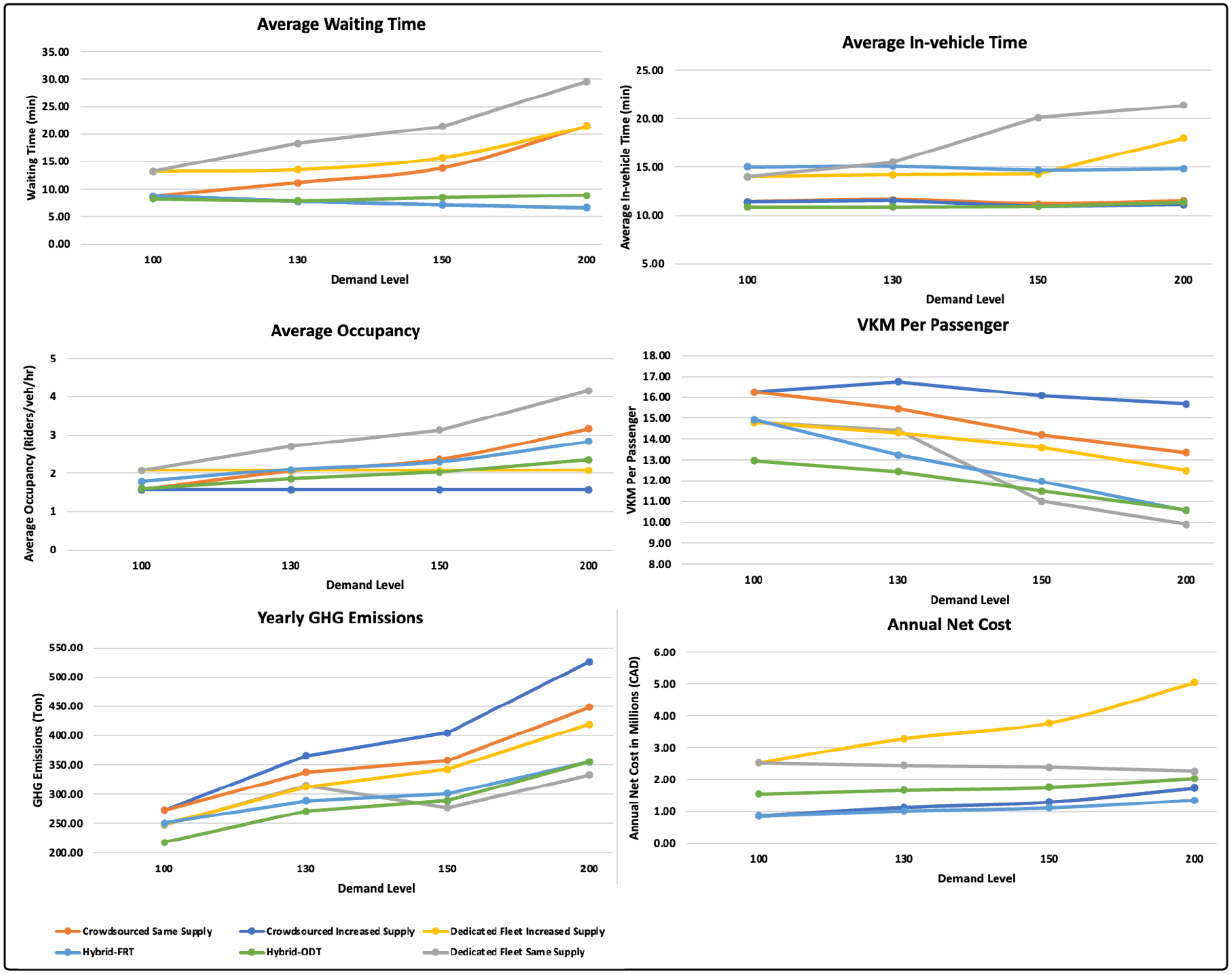

Fig. 2: The performance of Innisfil transit service under various mobility options.

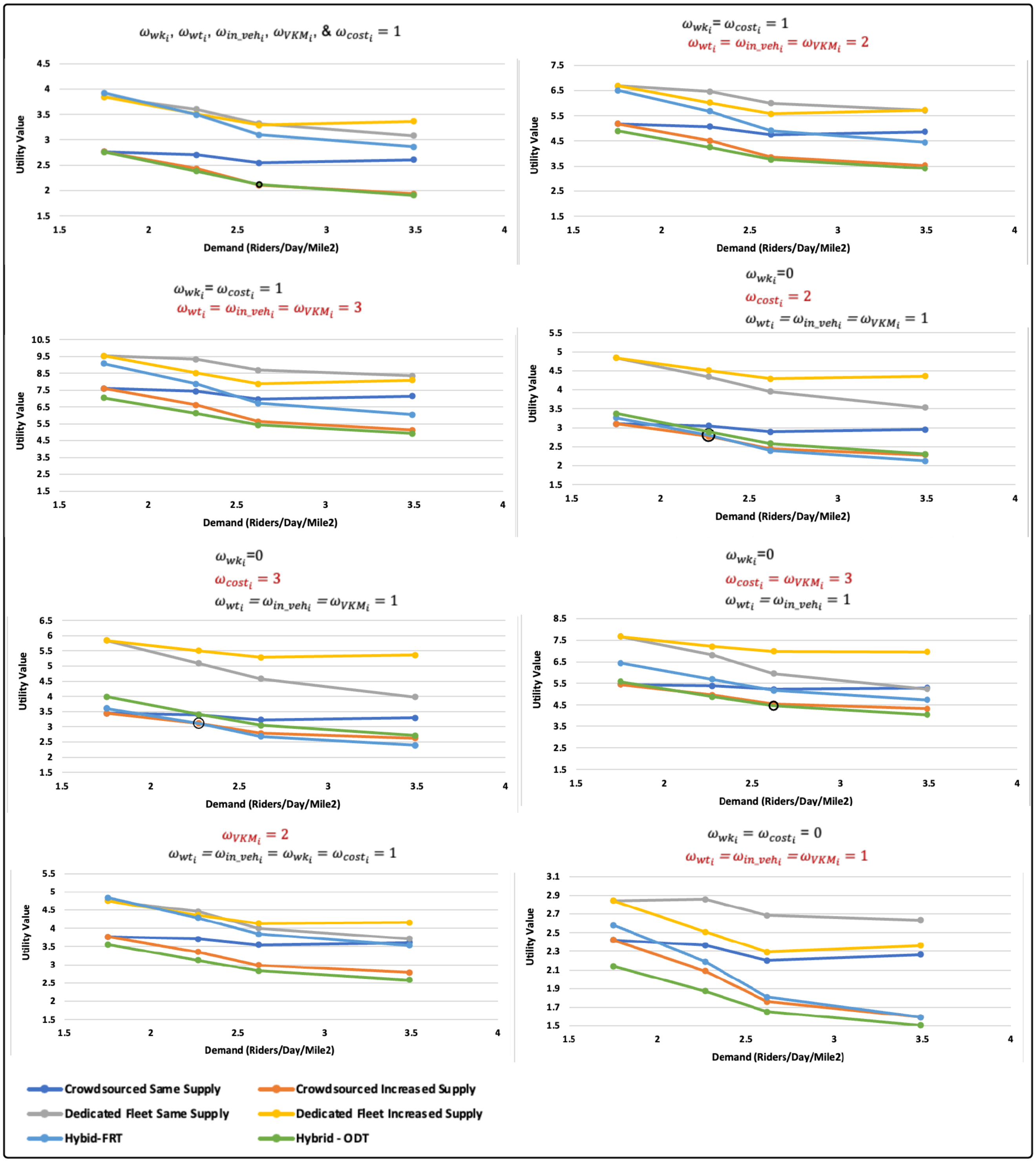

Fig. 3: Innisfil transit mobility options compared in terms of utility.

Fig. 4: The conceptual fixed-route and on-demand transit service for the Town's future developments.