On-demand transit in Collin County

Simulation report for Collin County Transit, by Spare Labs Inc.

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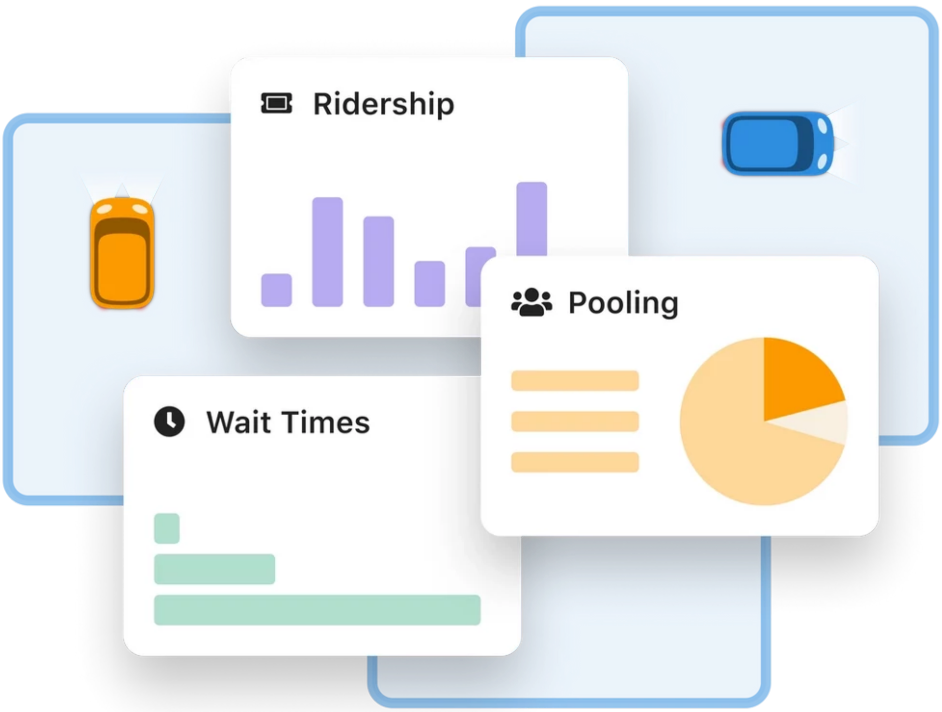

Spare Realize is a fundamentally new way of planning and optimizing transportation networks. At its core, it is a transportation network simulation tool that can be used to run quick and informative transit simulations during the planning and operational stages of a transportation service.

This document, prepared by Spare Labs (henceforth referred to as Spare) for Collin County Transit (henceforth referred to as CCT, provides results and insights from simulations of the potential performance of an on-demand microtransit service across Collin County.

Spare is dedicated to helping CCT identify suitable operational models for this large zone, and to advising on the likely performance of the service. Ultimately Spare seeks to help CCT achieve its objectives to continue to be an innovative provider of transit in Texas.

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Executive summary

CCT currently runs an on-demand taxi service across Collin County, with their operating partner Irving Holdings. With the aim of improving efficiency and cutting costs without impacting rider experience, CCT approached Spare to explore the possibility of introducing microtransit to the county.

Spare used its Realize simulation platform to simulate the expected performance of a fully on-demand microtransit service. Spare ran 54 individual simulations, covering various parameter combinations with different demand scenarios, duty levels and operational models.

This report outlines the simulation methodology and findings, before making best practice recommendations for setting up and operating microtransit in the study zone and the entire region. It also presents the cutting-edge technology that Spare can provide to partner with CCT in the implementation and operational phases of its microtransit plans.

Main findings

- There is **high potential for an excellent microtransit service** in the study zone. Low average waiting times and high efficiency are achievable with relatively few vehicles, at a low-cost option that varies from $520,000 to $870,000 per year depending on actual demand.

- The **pooling** rate (i.e. the proportion of trips that are shared between multiple riders) is expected to be 48–64% using a door-to-door model. This implies that vehicle hours could be reduced significantly compared to the current business-as-usual model where no pooling exists, which would translate into equivalent cost savings for CCT. Adopting a 'great service' model (by increasing the number of driver shifts) would improve the rider experience, but costs could almost double.

- As CCT begins its microtransit journey, it will have to consider several **tradeoffs** between investing in great service or opting for a lower-cost option. A low-cost solution could be as low as $520,000 per annum (p.a.), while a great-service solution could be as high as $1.6 million p.a. A door-to-door service would offer the best increase in performance per additional spend, but if costs need to be minimised, a stop-to-stop service offers the best value for money.

- A **stop-to-stop** operational model would deliver the best value for money in Collin County. Stop-to-stop services tend to have better pooling and shorter wait times than door-to-door services, and the familiarity of stops breeds more efficient behaviour from drivers and riders. However, the target demographic for this service (seniors and those with special mobility needs), combined with high temperatures in Texas, may mean most – if not all – riders require a door-to-door service. Spare Platform does allow for rider segmentation, whereby certain riders are given access to a door-to-door service, while others are on a stop-to-stop service.

- **Extending the service hours** from 6am–6pm to 6am–12am would offer coverage for trips typically undertaken for night-shift work and late night entertainment/recreation, thus increasing ridership as well as spreading demand more evenly throughout the day. Whilst this increased ridership would come at an elevated cost (both in terms of annual costs but also costs per trip), it would advance CCT's mission of providing more equitable transit across the county.

- **Right-sizing** CCT's microtransit service (i.e. purchasing and/or using vehicles that are appropriately sized for servicing the actual demand) could help to cut costs, because smaller vehicles cost less to purchase, run, and maintain than the shuttle vans CCT currently owns and operates.

- CCT could save on operating costs in the long-term by investing in **two additional dedicated vehicles** to serve the majority of expected demand. This is because a dedicated fleet with an hourly unit cost will be cheaper to serve longer trips than using non-dedicated taxis. Using a right-sized dedicated fleet could result in savings of $7 per trip and annual savings of $140,000, assuming a medium-demand, low-cost scenario.

Steps to success

Building on the findings of this report, and applying Spare's proven success in other urban areas similar to Collin County, we outline how CCT is currently at a so-called 'Phase 0' of its transit evolution: a generally unpooled, single-operator model that is expensive and highly inefficient. To propel CCT towards more innovative models, Spare has designed a multi-phase framework that will future-proof CCT's operations for decades to come.

The framework guides CCT towards a fully flexible, regional transit system that commingles multiple services to ensure an unparalleled public transit experience. The different phases are summarized in the diagram below, and are revisited in more detail later in this report.

The clear steps to success for CCT in this framework include:

- In the first instance, a **pooled microtransit system** will deliver modest cost savings. Perhaps the most important benefit it will bring is a **wealth of data** that can be used to better understand the demand for transit and optimize the system further.

- In subsequent phases, adding **multiple operators** to the service will help to create operational efficiencies and introduce time- and location-specific rules such as dynamic pricing. A **mixed supply model**, which involves brokering trips to multiple operators rather than just assigning trips to a single operator, could be rapidly scaled up across the zone using the unique Spare Fleets feature.

- Eventually, it could be possible to introduce **commingling** to Collin County, which involves providing different service types (e.g. microtransit, paratransit, NEMT, school runs) with the same fleet of vehicles, allowing each service to maintain its distinctive nature while sharing vehicle resources. This fully flexible system allows different service configurations, rules and rider groupings to be respected, and provides the same quality of service expected by each rider. Commingling will deliver an amazing rider experience and unparalleled savings for CCT.

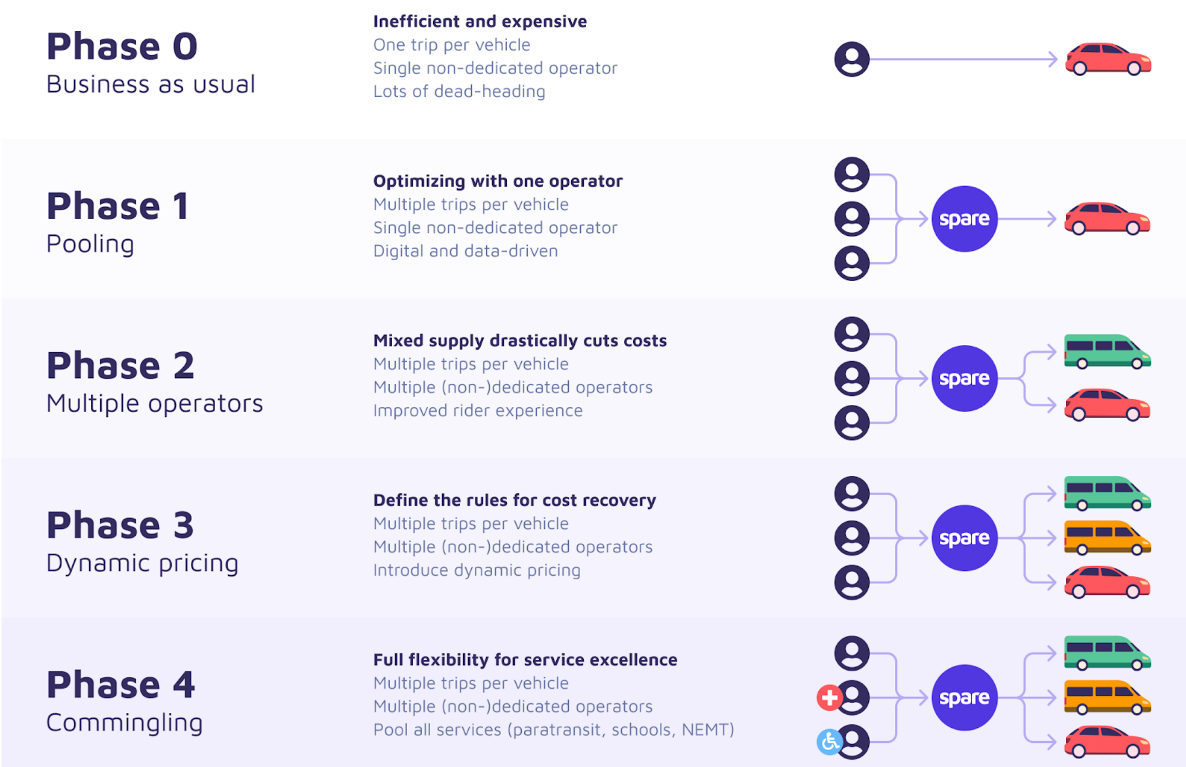

Figure 1. Spare's framework for propelling CCT into the future.

Overview and context

The City of McKinney, the McKinney Urban Transit District (MUTD) and the Denton County Transportation Authority (DCTA) provide Collin County Transit (CCT), a subsidized taxi voucher program. Participating cities include Celina, Lowry Crossing, McKinney, Melissa, Princeton and Prosper (Figure 2). CCT is seeking to maintain the same coverage, whilst improving efficiencies and reducing costs by running the system on a sophisticated trip matching and dispatching on-demand platform.

In the proposed system, trips would be permitted to start and end anywhere in the six participant cities for a set fare ($3 for trips starting and ending within the six cities, and $5 for trips ending in the wider county). No trips would be permitted to start from outside the MUTD cities. A special provision would allow trips to start or end at the Parker Road Light Rail Station in the City of Plano, to improve connection with the Dallas-Fort Worth region via the Dallas Area Rapid Transit (DART) system.

The target demographic for this system is senior citizens and those with mobility issues, although the system will remain open to anybody. This report touches on the benefits of opening up the service to a wider demographic through extended service hours.

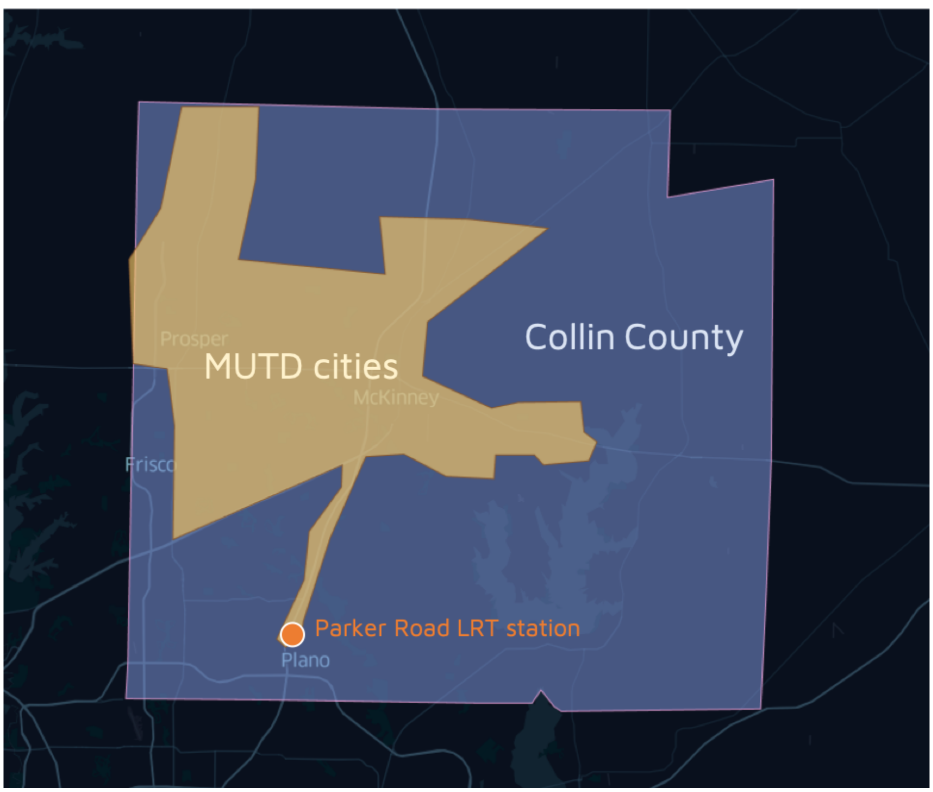

Figure 2. Primary zone for McKinney Urban Transportation District (MUTD) participating cities and Parker Road LRT Station (including a connection corridor), where on-demand trips can start or end. The wider Collin County area, where trips can end but not originate, is also shown.

Project objectives

The Spare team and CCT representatives worked together to outline some key objectives for the wider microtransit project. These can be summarized as:

1. **Boost efficiency**: increase ridership and spending productivity

2. **Improve accessibility**: connect people to fixed routes and POIs in an affordable way, focusing on underserved communities

3. **Innovate**: propel Collin County's transit provision into the future

Together, CCT and Spare outlined target average waiting time for microtransit of 15-30 minutes, with no waiting times exceeding 60 minutes. This helped to shape Spare's experimental setup and duty provisioning (i.e. driver and vehicle shift) scenarios.

CCT currently spends approximately $360,000 per annum (p.a.) on running their subsidised taxi service. They have access to approximately $900,000 p.a. for operating the new proposed on-demand service, although this is fairly flexible given CCT's funding source for 2020/2021. These financial constraints were used to inform realistic duty levels in our simulations.

Methodology[1]

Data sources

We modelled demand as the volume and distribution of ride requests over a given period of time. Model inputs included origin-destination trip data provided by CCT for the existing taxi service that covers the region, open-source census and jobs data, and demand/performance data from other similar services run by Spare (Figure 3). We outline our use of these datasets in the following sections.

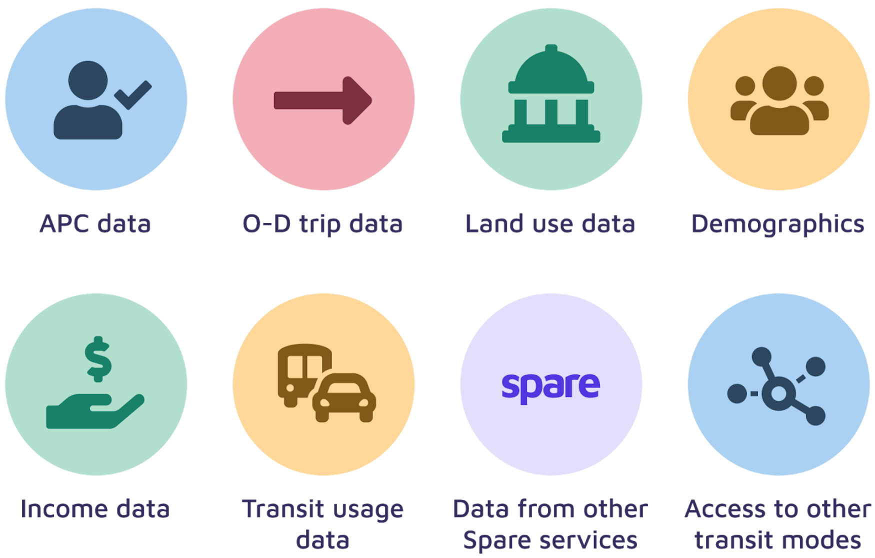

Figure 3. Data sources for deriving estimates of demand volume and distribution.

Spare's framework for simulating microtransit demand

Spare has a tried-and-tested methodological framework for simulating the dynamics of a microtransit service. It involves a multi-stage approach to analyze *where* a microtransit system should operate, *whom* it is likely to serve and therefore impact, during *which times* it should operate, the *service model* it should follow (stop-to-stop, door-to-door), and its potential *costs and returns*.

The four main stages of the approach (Figure 4) are:

1. Estimate trip volume (i.e. total number of expected trips in a zone);
2. Estimate trip distribution;
    a. Assign trip types (e.g. work, recreational, medical) ;

[1] The "Methodology" section contains trade secrets of Spare Labs Inc. that are not to be shared with outside parties, even in the case of a Freedom of Information Act Request - as prescribed by law.

b. Distribute trips spatially (i.e. where trips should start and end);
c. Distribute trips temporally (i.e. time of day when trips should occur);
d. Generate random origin-destination (O-D) pairs from these distributions;

3. Run O-D pairs through Spare Realize, our dedicated trip simulation platform;
4. Analyze results and make recommendations.

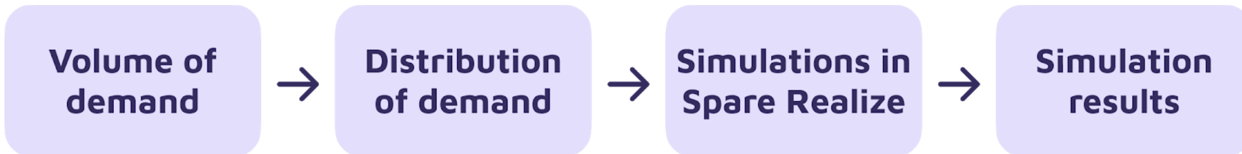

Figure 4. The four stages in Spare's simulation framework.

Stage 1: Estimating volume of demand

The overall volume of demand was calculated based primarily on taxi data provided by DCTA/CCT, and transit ridership data acquired from Dallas Area Rapid Transit (DART) for the Parker Road Light Rail Transit Station in the City of Plano. At the time of writing this report, COVID-19 had affected transit ridership globally, and ridership in Texas (including on DART) had decreased by 70–80%. The volumes calculated here do not consider the impact of COVID-19, because of the huge uncertainty around how it will affect transit ridership in the long term. We assume that ridership will return to pre-COVID patterns.

Taxi ridership data were acquired for the period January 2019 – March 2020, during which over 12,400 trips were undertaken over fourteen months. Long trips with uncommonly small prices were defined as outliers, and so 19 trips were removed from the taxi dataset. The DART ridership data covered the period March–October 2019.

Before calculating the absolute forecasted demand for microtransit across Collin County, it is important to understand that CCT are due to implement a new fare pricing model, which will likely affect demand for the service. Until May 2020, CCT operated a variable fare model, where 75% of the total cost of each taxi trip was subsidized by CCT, and the remaining 25% was paid for by the rider. The new model is based on flat fares, whereby riders pay $3 for a trip, regardless of distance.

To model the baseline historical change in ridership *without* considering a price structure change, we built a Bayesian time series model using Prophet, a powerful open-source modelling Python library. We used Prophet to break down our data into temporal trends of varying length (from yearly to daily), and recombined them to create predicted weekly ridership until October 2020. Weekly ridership over the coming year was averaged and converted into an expected daily average ridership for each trip type.

The historical and predicted total weekly ridership (omitting the effect of the price changes) is shown in Figure 5. On average, baseline ridership is expected to grow to 192 trips per week. The 80% confidence intervals generated in the forecasting model were used to define 'low' and 'high' demand scenarios (see next section).

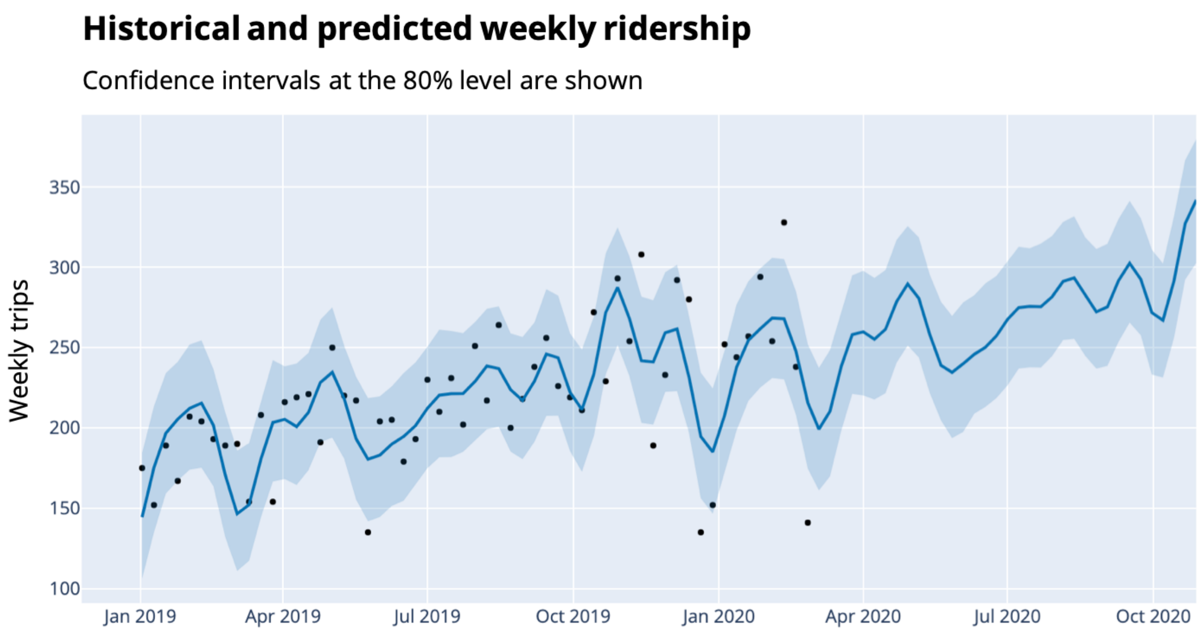

Figure 5. Historical and predicted weekly total on-demand transit ridership in Collin County, omitting price change effects. Historical data (black dots), weekly trends (projected using the Prophet model), and 80% confidence intervals are shown.

We then combined this baseline growth scenario with price elasticity analysis to estimate the additional expected change in ridership due to the planned change in fare model. Spare undertook this analysis as a separate project on behalf of CCT, and the methodology is summarised in Appendix 3. Spare predicted the new $3 flat fare would result in 270 weekly trips (45 trips on average assuming a 6-day-a-week service), which represents a ~30% increase compared with the previous variable-fare service.

On top of the 45 daily trips expected from baseline demand for CCT's taxi service, we expect additional demand owing to the service's planned connection to Parker Road Station in Plano. DART ridership data shows there were ~3,400 trips on an average weekday at Parker Road Station. Separately, a survey conducted by CCT in 2011 to explore commuters' appetite for a bus shuttle suggests that 41% (309) of the respondents would use a service connecting the City of McKinney to Parker Road Station 4–5 times a week. It is difficult to interpret how representative this survey is of the wider community, and how many commuters would actually switch from commuting with their cars to using on-demand transit. Nevertheless, there is clearly an appetite for connecting with Parker Road Station, so we conservatively estimate an additional daily demand of 20 daily riders from the transit station connection.

Combining the anticipated impact of the fare change and the inclusion of Parker Road Station brings the predicted total daily ridership to 65 riders. We use this number as our baseline demand volume for on-demand microtransit across CCT. The number of trips expected to have an origin or destination *outside* of Collin County is very low: over the fourteen months of taxi ridership data available to Spare, only a few dozen trips took place outside Collin County. We therefore consider the demand from outside the zone to be negligible in our simulations.

Accounting for uncertainty of demand

There will always be some uncertainty about the precise volume demand that can be expected from a newly introduced microtransit service. The taxi data used to drive our demand model may not be fully representative of 'real' passenger behaviour because of biases or missing data. Riders' awareness of a new microtransit service will directly affect demand volume, and can be influenced by marketing or information campaigns.

To reflect this uncertainty, we calculated a range of expected demand. The baseline calculation provided the 'medium demand' scenario, a 'low demand' scenario was 20% lower than baseline, and a 'high demand' scenario was 30% higher than baseline. These percentage changes were informed by the confidence intervals in our forecasting model.

The final estimates for low, medium and high demand are shown in Table 1.

Table 1. Estimated daily ridership for different demand scenarios, assuming normal service hours.

	Low demand	**Medium demand**	**High demand**
Standard trips	36	45	59
DART connection trips	16	20	26
Total trips (6am–6pm)	52	65	85

Stage 2: Estimating distribution of demand

Once the total volume of demand was estimated, it was necessary to distribute that demand by different purposes throughout the day. We assume a large majority of trips either start or end from a home location, and define four main trip 'purposes':

- Work: commuting trips or travel to college/university;

- Recreation: shopping, dining, entertainment and leisure trips;
- Healthcare: trips to healthcare facilities such as clinics and hospitals;
- DART connection: trips to Parker Road Light Rail Transit Station;
- Visiting others: a home location to visit friends or relatives.

Assigning trip purposes

A travel survey conducted by CCT in 2011 provided data on trip purposes undertaken in the county. 514 respondents were asked to select what activities they would use public transit for, if it were accessible to them (multiple reasons could be given). This question is not the same as asking travellers *why* they are currently travelling, but gives some indication of the rough split in trip types that might be undertaken with CCT's on-demand service.

The majority of respondents said they would use public transportation for work, medical or recreational trips (Table 2). Only 3% claimed they would want to use it to connect to DART, but responses to the community travel survey, combined with data on DART ridership, suggests that a relatively high number of trips could start or end at Parker Road LRT station. The proportions recorded in the survey were used to allocate different trip purposes realistically when running simulations in Spare Realize, with DART-connecting trips being given a higher weighting to reflect expected demand.

Table 2. Breakdown of CCT travel survey by trip purpose. 'Other' includes trips to the airport and church. Respondents could choose multiple categories, which explains why the percentages do not sum to 100%.

Work	Recreation	Healthcare	Connecting to DART	Visiting relatives	Other
52%	44%	45%	3%	3%	3%

Distributing trips spatially

To distribute demand in the most spatially realistic way possible, Spare's 'Demand Generator' tool generates trip origins and destinations based on the five main purposes identified above: *work, recreation, healthcare*, *DART connection* and *visiting friends/relatives* trips.

The Demand Generator tool randomly generates a set number of points per hectare in each zone, and snaps these points to actual roads, to ensure realistic trip request locations. Each randomly generated point is then matched to relevant datasets to contribute to overall home, work and recreation demand metrics. The spatial distribution of each metric across the six MUTD cities is shown in Figure 6.

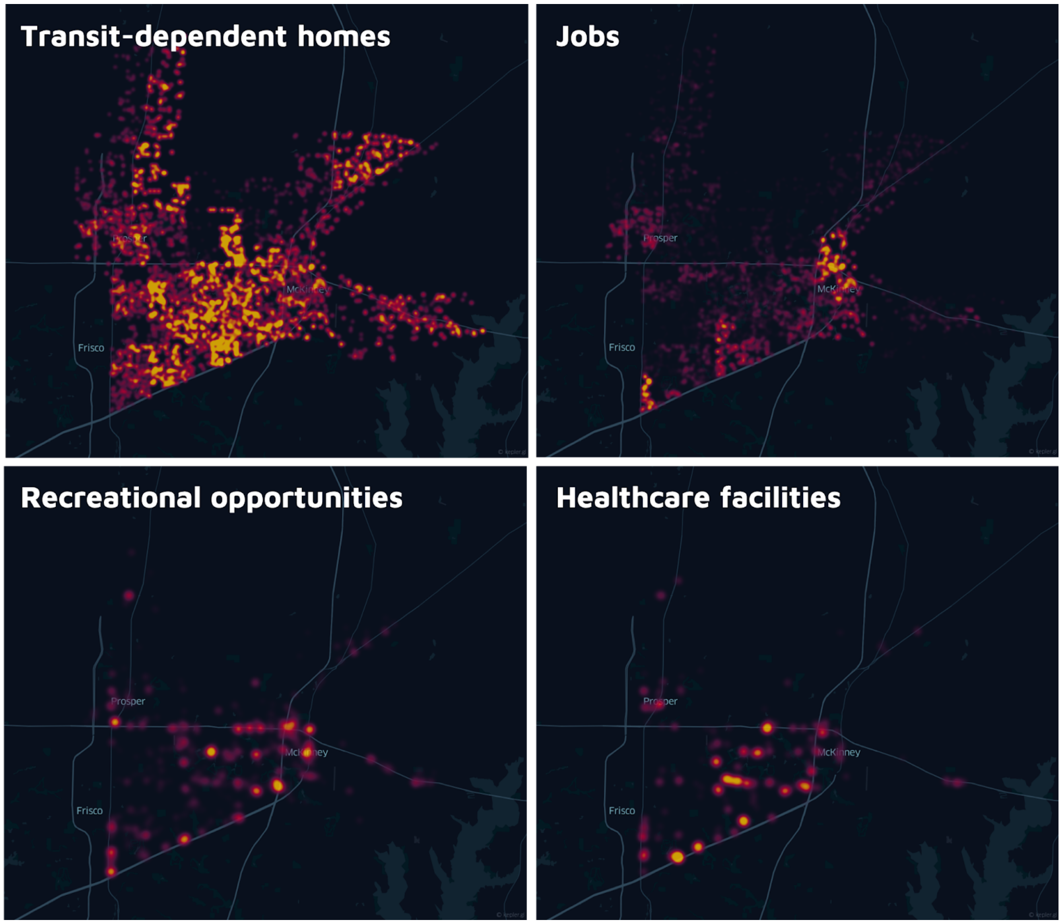

Figure 6. Spatial distribution of expected demand for homes/visits, jobs, recreation and healthcare across the six participating MUTD cities. Demand for DART connection is represented in our model by a single origin/destination at Parker Road LRT Station.

To estimate the home locations from which trips would originate (and also the home locations for visits to friends/relatives), each random point in a zone was matched to its Census Block Group (CBG) and relevant census data acquired. Based on a rigorous review of the academic literature[2,3], we isolated four main demographic features to include in our home demand model:

- Poverty status (% individuals in poverty, as defined locally by the US census)
- Non-white population
- Vehicle ownership (% of households owning zero vehicles)
- Highest level of education (high-school education or less)

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[2] Berrebi & Watkins (2018), 'Who's ditching the bus?'
https://arxiv.org/ftp/arxiv/papers/2001/2001.02200.pdf
[3] Giuliano (2005), 'Low income, public transit, and mobility.'
https://journals.sagepub.com/doi/abs/10.1177/0361198105192700108

We assume that neighborhoods with high proportions of low-income, non-white, carless, high-school-educated residents are the most likely to have high demand for (micro)transit.

To model the 'attractiveness' of a location for jobs, each random point was also matched to total jobs data at the CBG level from the US Longitudinal Employer-Household Dynamics Origin-Destination Employment Statistics (LODES) survey.

To model the attractiveness of a location for recreation, the number of shopping and entertainment points of interest (POIs) available within a 500 m radius of each random point was calculated using a services mapping API. The same was done for healthcare locations (hospitals and clinics) to estimate healthcare demand.

Finally, origins and destinations were randomly paired together, based on the weightings produced by the Demand Generator tool. We added a 'trip distance' weighting to reflect the distribution of trip lengths typically taken on the CCT taxi service. Figure 7 displays the relative distribution trips by distance, which was used to weight the distance of each trip appropriately to ensure mostly shorter trips would randomly occur in our model. We limited the maximum trip distance to 30 miles for all trip types except DART connections, to prevent unrealistically long trips occurring by chance in our trip distribution model. DART-connecting trips were capped at 60 miles in the model, which essentially allows any rider in the MUTD zone to connect with Parker Road Station.

Thousands of O-D pairs were generated in this way, which were then fed into the Spare Realize platform.

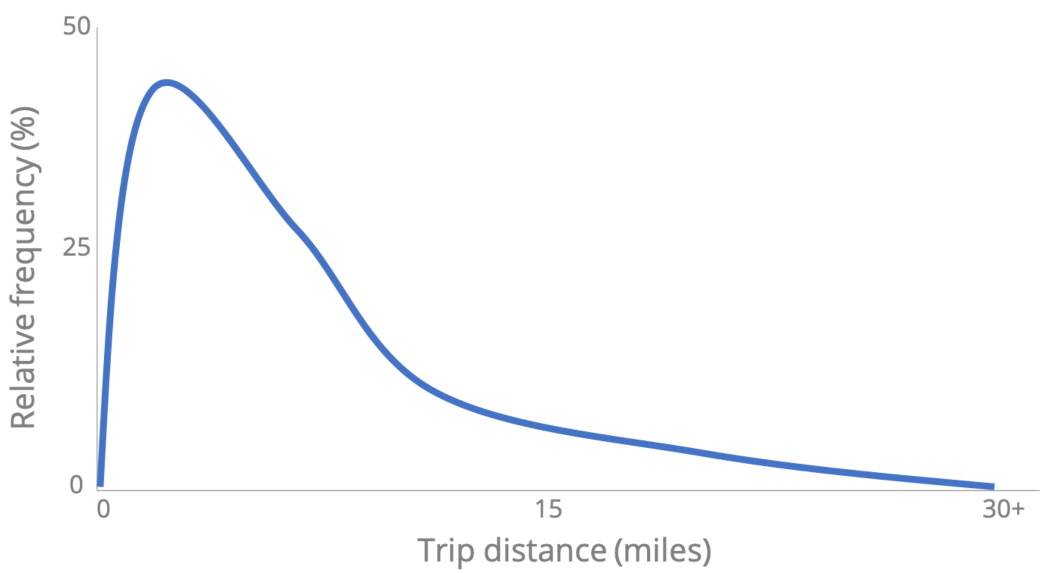

Figure 7.The distribution of trip distances in the CCT service, which was used to weight the likelihood of each randomly generated O-D pair.

Distributing trips temporally

To distribute simulated trip requests realistically, we estimated the distribution of each trip type throughout a typical day. Most trips in Collin County are undertaken by car, owing to the lack of public transportation options. CCT's travel survey asked respondents at which times they were most likely to travel on each day of the week, which gives some indication about demand throughout a typical day.

Figure 8 shows the relative distribution of travel occurring throughout the day in both cars and 'other' modes (principally on-demand such as ride-hailing and taxis, cycling and walking). Peak travel happens between the hours of 3pm and 6pm, and the least busy travel period is from 12pm to 3pm.

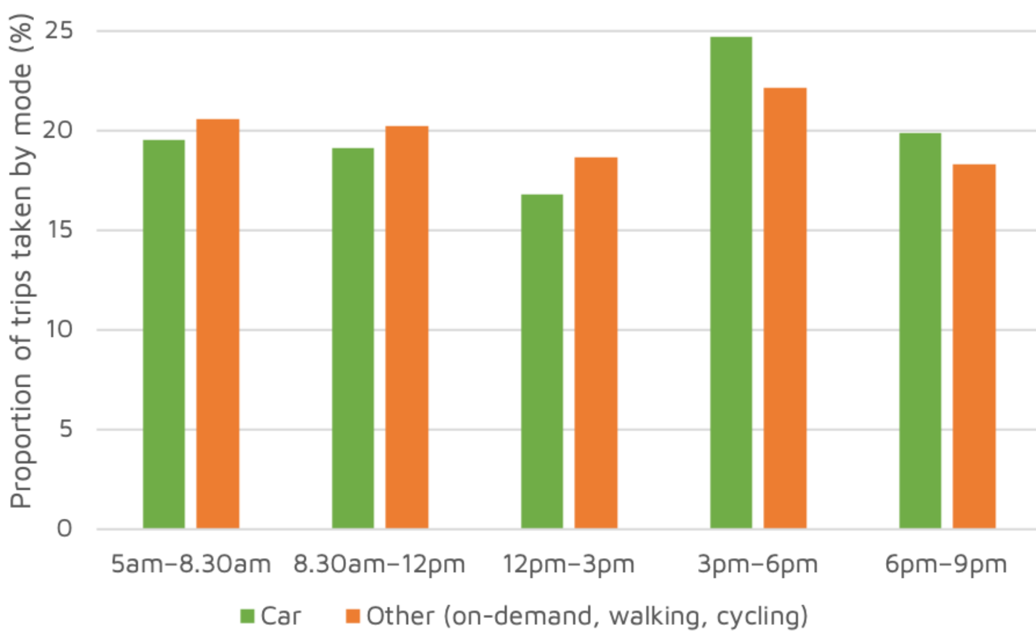

Figure 8.The distribution of transport modes (car vs other) at different times of day in Collin County.

By disaggregating the stated travel times from the survey by trip type where possible, and combining the data with that of Spare-run microtransit services in similar cities, it is possible to derive approximate distributions of likely travel times across a day in Collin County. The distributions shown in Figure 9 were used to assign realistic (yet randomized) travel times to each trip in the O-D generation step.

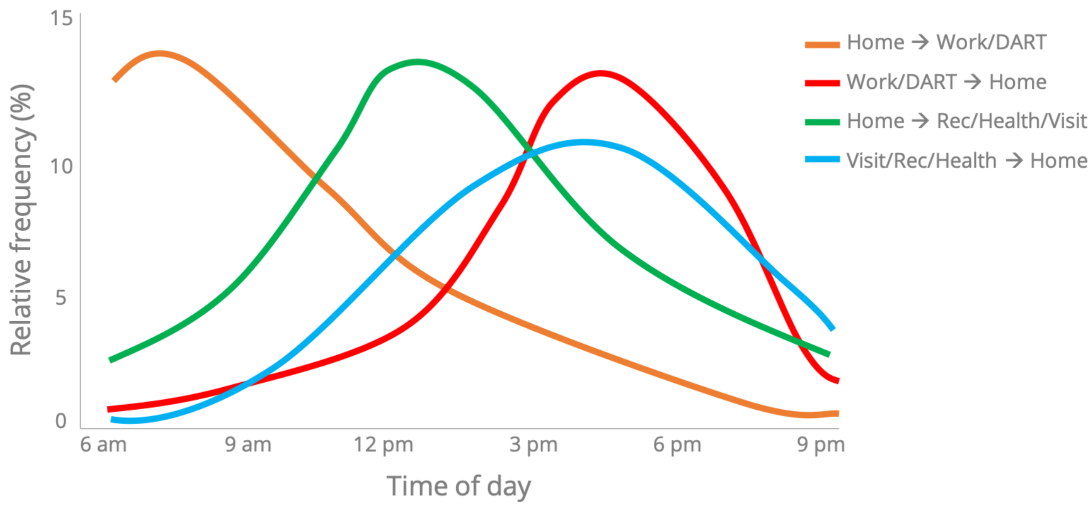

Figure 9. Modelled time distributions for each major trip type, based on travel survey data and known distributions in similar microtransit services operated by Spare.

CCT's current operations run from 6am to 6pm on weekdays and 8am to 6pm on Saturdays, and are set as a function of dispatcher shifts. There are no services on Sundays. CCT's travel survey suggests that 10–20% of respondents tend to travel after 6pm, either for night shift work or from entertainment and dining venues. Given the vast improvements offered by Spare Platform in administrative and operational functions, it is possible to run these services for longer hours at a proportional lower operational cost. We therefore ran a separate set of simulations assuming extended service hours, from 6am to midnight (12am).

In this report we present results from simulations of both current weekday service hours (6am–6pm) and extended service hours (6am–12am). Based on the travel survey data, we estimate that running longer service hours will boost service utilization by 15%, so the total ridership in these simulations is adjusted accordingly (Table 3).

Table 3. Estimated daily ridership for different demand scenarios, assuming extended service hours.

	Low demand	**Medium demand**	**High demand**
Total trips (6am–12am)	60	75	98

Stage 3: Simulation setup in Spare Realize

Simulation matrix

Spare uses a matrix-based approach to structure the simulation experiments. The matrix is designed to evaluate system performance and related operational costs at different demand levels, as well as different service provisions (ranging from a cheaper, more efficient service to a more rider-centric service that is more expensive to run):

	Low demand 20% lower than baseline	**Medium demand** Baseline	**High demand** 30% higher than baseline
Low duty Fewer vehicles Cheaper to run	3 repeats	3 repeats	3 repeats
High duty More vehicles More expensive to run	3 repeats	3 repeats	3 repeats

Figure 10. Simulation matrix showing experimental setup in Spare Realize (three demand scenarios, each run under two duty scenarios, with three simulation repeats per combination).

Three repeat simulations were conducted for each combination of duty level and demand, and for both door-to-door and stop-to-stop models. This allowed us to replicate random service variability in our analyses. We assumed door-to-door and stop-to-stop models for 'normal' service hours (6am–6pm), and only door-to-door for extended service hours (6am–12am). In total, 54 individual simulations were run for this report.

Input parameters

Each simulation in Spare Realize can be fully customized to suit the needs of the study. Pulling the levers on various parameters allows us to investigate the impact of different service structures and operational models in high detail. Adaptable parameters include:

Demand	Low, Medium, High
Duty Level	Low, Medium, High
Stop Type	Door-to-door, Stop-to-stop

Figure 11. Parameters that were varied for each batch of Spare Realize simulations.

A few key parameters were kept stable throughout all simulations: the base boarding time (the amount of time the system adds to its estimates for each pickup/dropoff stop) was set at 60 seconds, the per-passenger boarding time (the additional amount of time, per passenger, the system adds to its estimates for each pickup/dropoff stop) to 15 seconds, and the pickup flexibility (the time a rider can be made to wait for a pickup from their initial estimate) was set at 10 minutes. These are standard parameter settings in Spare's services.

In all simulations, the impact of traffic congestion on travel times was integrated by pulling from the Google Traffic API.

Operational model

We ran simulations assuming two operational models, on CCT's request:

1. Door-to-door model, where riders get pickup and dropped off as close to possible to their chosen location (for both normal and extended service hours);
2. Stop-to-stop model, where riders get picked up and dropped off at optimally selected 'virtual stops' (for normal service hours only).

Stop-to-stop operations usually require riders to walk some distance, but the advantage is that it generally reduces waiting and travel times, increases system efficiency, and reduces costs.

62% of all respondents to CCT's transit survey stated that the walking distance from a transit stop to a destination was one of the most important components of public transportation. Since the on-demand service is designed to cater primarily to senior citizens and those with mobility issues, and daytime temperatures can be very high in Collin County, a stop-to-stop model would always have to be paired with a door-to-door model for those who need it most.

To simulate a stop-to-stop model across the microtransit zone, we designated stops based on the highest weightings in each of the home-based, work-based, recreation-based and healthcare-based demand maps. The resulting collection of points were mapped and visually inspected to remove any duplicates, and low-density areas were supplemented with an appropriate number of additional points (Figure 12).

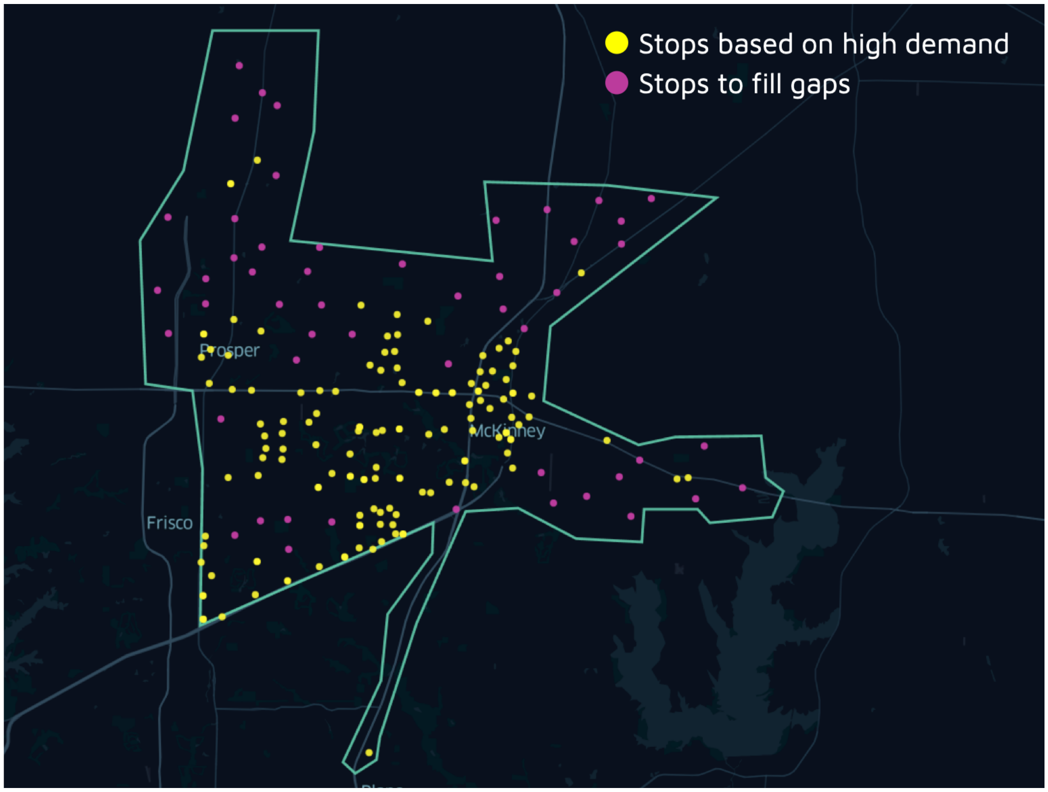

Figure 12. Locations of 'virtual stops' used in the stop-to-stop model.

In total, we designed 196 'virtual stops' around the proposed zone, equating to approximately 0.9 stops per square mile. In all urban areas, there was a stop at least every ~500 yards. This is a widely-used standard for fixed-route transit.

Example of model input

Once the demand models were run and the correct service configuration was set up in Spare Realize, it was left to randomly select the relevant number of trips for each of the 54 individual simulations. An example of the randomly selected pickup and dropoff points in a single simulation are shown in Figure 13.

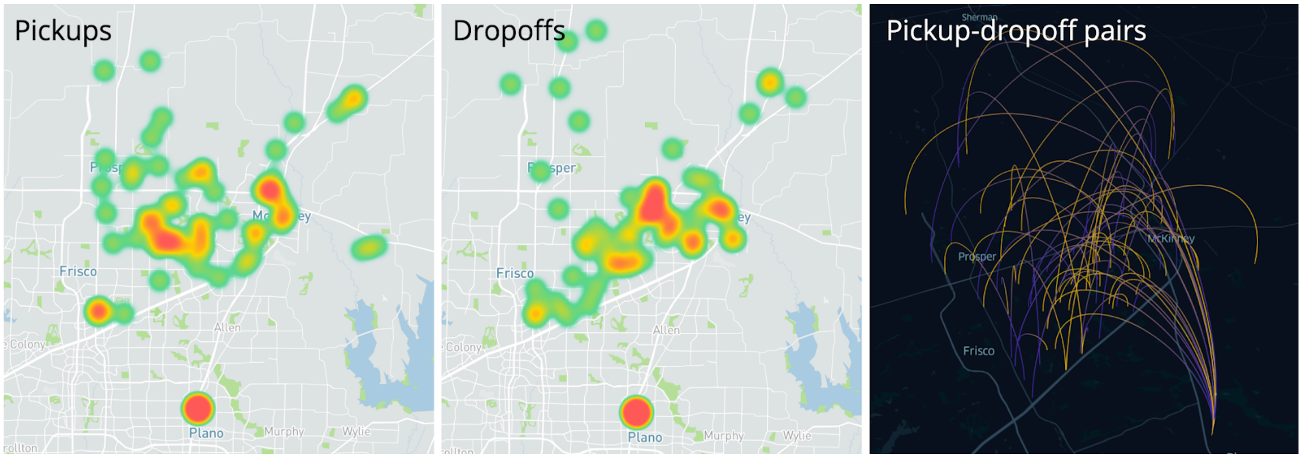

Figure 13. Heatmaps of pickups and dropoffs, and origin-destination arcs, showing trips simulated in a medium-demand scenario.

Limitations of Spare Realize simulations

By its very nature, simulating a human system relies on the concepts of *probability* (i.e. likelihood to occur) rather than *determinism* (i.e. predictions of certainty). The randomness and unpredictability in human behaviour, traffic and urban dynamics means that the findings presented in this report should be interpreted as probability-based statements.

Spare Realize does not simulate human behaviour *per se*, so no-shows or cancellations are not taken into account. Drivers are assumed to behave precisely as stipulated in the model parameters (i.e. they wait as long as they are permitted for a rider, they take no breaks, adhere to traffic rules, and so on).

The starting locations of duty vehicles were assumed to be the centre of the zone's road network, which was in downtown McKinney. In practice, vehicle depots may not be located in central areas, so vehicles may incur additional hours and costs in travelling to the zone for the start of shifts.

Stage 4: Analysis of results

Key Performance Indicators (KPIs)

Spare Realize reports back on key KPIs from each simulation, including waiting times, pooling ratios, efficiency measures (e.g. passenger per vehicle hour), and more. Maps of pickups and dropoffs are also generated, to validate the accuracy of the model and to enable in-depth assessment of system performance. Passengers-per-vehicle-hour (PPVH) is provided as a standard measure of system efficiency, which will be relevant to CCT's future cost recuperation models.

Costs

Costs per trip and per operational year are reported for all scenarios to aid decision-making. CCT already owns three dedicated vehicles, which, according to DCTA invoices, cost $58 per hour to run (including base hourly rate, fuel and administrative costs). On average, this equates to $94 per trip provided by CCT's dedicated vehicles.

Since CCT already owns three vehicles, we use the $58 operational cost in our model, and assume that each vehicle can be used for any on-demand trip if needed. In simulations where more than 3 vehicles are placed on duty, any extra vehicle is assumed to be a non-dedicated vehicle, which incurs costs to CCT on a per-trip (rather than per-hour) basis. As explained in the Recommendations section, maximum vehicle occupancy data from our simulations can help to inform right-sizing of the microtransit system. If CCT wanted to purchase new vehicles that were most appropriate for their system, right-sizing insights could help lower operational costs.

Analysis of invoices from CCT's single non-dedicated operations supplier (Irving Holdings) suggests that the average trip cost is $19 per trip. Rather than use this average trip price in our cost model, we instead use the average per-mile cost ($2.40 per mile) and multiply it by the distance of each trip in our simulations. This provides a more realistic estimate of the costs incurred by CCT to serve the actual trips simulated in Realize.

Finally, we subtracted trip fares ($3 flat fare per trip) from the full costs to present the net costs in this report.

Costs per trip were calculated as follows for dedicated and non-dedicated vehicles:

Dedicated vehicles

$$\frac{\text{Operating costs } (\$50\text{ / hr}) \times \text{Duty hours / day } (12\text{ hours})}{\text{No. trips / day (e.g. } 65\text{)}}$$

Non-dedicated vehicles

$$\text{Avg. trip distance (e.g. } 11\text{ miles)} \times \text{Avg. trip cost } (\$2.40\text{ / mile})$$

Costs per annum (p.a.) were calculated as follows:

$$\left(\text{Dedicated vehicle costs} + \text{Non-dedicated vehicle costs}\right) \times \text{No. service days } (312)$$

Results: Door-to-door service (normal hours: 6am–6pm)

Structured for low cost

	Low Demand (52)	**Medium Demand** (65)	**High Demand** (85)
No. duties	3	4	4
Avg. wait time	28 mins	26 mins	28 mins
Max wait time	57 mins	58 mins	62 mins
<15 min wait	23%	25%	27%
PPVH	1.2	1.2	1.4
Pooling ratio	64%	54%	55%
Cost per trip	$36	$43	$38
Annual cost	$520,000	$830,000	$870,000

Structured for great service

	Low Demand (52)	**Medium Demand** (65)	**High Demand** (85)
No. duties	5	6	8
Avg. wait time	20 mins	15 mins	16 mins
Max wait time	47 mins	43 mins	49 mins
<15 min wait	37%	56%	58%
PPVH	0.8	0.8	0.8
Pooling ratio	48%	53%	52%
Cost per trip	$59	$59	$61
Annual cost	$950,000	$1,200,000	$1,600,000

Results: Door-to-door service (extended hours: 6am–12am)

Structured for low cost

	Low Demand (60)	**Medium Demand** (75)	**High Demand** (98)
No. duties	3	4	4
Avg. wait time	27 mins	19 mins	26 mins
Max wait time	54 mins	58 mins	61 mins
<15 min wait	28%	59%	39%
PPVH	1.0	0.8	1.2
Pooling ratio	40%	31%	53%
Cost per trip	$42	$50	$42
Annual cost	$780,000	$1,100,000	$1,300,000

Structured for great service

	Low Demand (60)	**Medium Demand** (75)	**High Demand** (98)
No. duties	5	6	8
Avg. wait time	20 mins	14 mins	17 mins
Max wait time	50 mins	37 mins	46 mins
<15 min wait	39%	64%	46%
PPVH	0.7	0.7	0.7
Pooling ratio	20%	35%	41%
Cost per trip	$69	$67	$67
Annual cost	$1,300,000	$1,600,000	$2,000,000

Results: Stop-to-stop service (normal hours: 6am–6pm)

Structured for low cost

	Low Demand (52)	**Medium Demand** (65)	**High Demand** (85)
No. duties	3	4	4
Avg. wait time	23 mins	17 mins	25 mins
Max wait time	66 mins	55 mins	62 mins
<15 min wait	38%	56%	34%
PPVH	1.2	1.2	1.3
Pooling ratio	78%	75%	34%
Cost per trip	$36	$43	$38
Annual cost	$520,000	$830,000	$870,000

Structured for great service

	Low Demand (52)	**Medium Demand** (65)	**High Demand** (85)
No. duties	5	6	8
Avg. wait time	11 mins	10 mins	7 mins
Max wait time	50 mins	43 mins	36 mins
<15 min wait	73%	72%	86%
PPVH	0.8	0.8	0.8
Pooling ratio	61%	45%	53%
Cost per trip	$59	$59	$61
Annual cost	$950,000	$1,200,000	$1,600,000

Comparative analysis

Comparing low-cost and great-service options

To help assess the different tradeoffs between low-cost and great-service options, we compare the performance KPIs of both options under medium demand and a door-to-door operational model. The best performance for each parameter is highlighted in green.

It is clear that waiting times are lower in the great-service option, but service efficiency declines compared to the low-cost option. The maximum waiting time for the low-cost service, while high, is not representative of the vast majority of trip durations, which are generally (far) below 60 minutes. Supplementing the baseline number of vehicles with non-dedicated vehicles at peak times help to significantly reduce the chance of long waiting times. We explore this in more detail in the Recommendations section.

An important question for CCT to consider is whether the extra spending on a 'great service' option is value for money; this question is addressed in the Recommendations section.

	Low cost (Medium demand, 4 duties)	**Great service** (Medium demand, 6 duties)
Avg. wait time	26 mins	15 mins
Max wait time	58 mins	43 mins
<15 min wait	25%	56%
PPVH	1.2	0.8
Pooling ratio	54%	53%
Cost per trip	$43	$59
Annual cost	$830,000	$1,200,000

Comparing door-to-door and stop-to-stop services

In the table below, we present the performance KPIs to compare door-to-door with stop-to-stop models for the normal service hours, assuming medium demand and the 'low cost' option. The best comparative performance for each parameter is highlighted in green.

Results show that, for the same level of demand and duty provision, the stop-to-stop model provides a far superior efficiency, which translates to better waiting times for customers. However, a stop-to-stop service comes at the expense of convenience for riders, because they have to travel to their nearest bus stop to take advantage of the service. This might require walking, which could create problems for those with ambulatory problems, or in more remote areas, it may require driving to the nearest stop.

In our simulations, the average walking duration to the nearest stop was 11 minutes, which is a function of the layout of virtual stops in our model. It may not be appropriate for those with ambulatory difficulties or indeed users not willing to walk long distances in the Texan heat. Increasing the density of virtual stops would reduce the average walking time, but also increase waiting times and reduce efficiency accordingly. These issues are discussed in more detail in the Recommendations section.

	Door-to-door (Medium demand, 4 duties)	**Stop-to-stop** (Medium demand, 4 duties)
Avg. wait time	26 mins	17 mins
Max wait time	58 mins	55 mins
<15 min wait	25%	56%
PPVH	1.2	1.2
Pooling ratio	54%	75%
Cost per trip	$43	$43
Annual cost	$830,000	$830,000

Comparing normal service hours and extended service hours

In the table below, we present the performance KPIs to compare the effect of extending the service hours, assuming medium demand and the 'low cost' option. The best comparative performance for each parameter is highlighted in green.

Results show that extending the service hours by 6 hours (until midnight) helps to spread demand slightly across the day, in spite of the expected 15% boost in demand. Averages wait times therefore decrease, and the proportion of riders expecting short waits vastly increase under extended service hours.

However, this improvement in rider experience comes at the expense of a slightly less efficient service, which becomes more expensive on both per-ride and annual bases. CCT will have to decide whether it values investing an additional ~$200,000 per annum (p.a.) to provide access to services and jobs for socio-economic groups other than seniors and those with mobility difficulties. Ultimately, this may require re-assessing and restating the ultimate aim of such a microtransit service.

	Normal service hours (6am–6pm) (Medium demand, 4 duties)	**Extended service hours (6am–12am)** (Medium demand, 4 duties)
Avg. wait time	26 mins	19 mins
Max wait time	58 mins	58 mins
<15 min wait	25%	59%
PPVH	1.2	0.8
Pooling ratio	54%	31%
Cost per trip	$43	$50
Annual cost	$830,000	$1,100,000

Summary of simulations

Booking success averaged 94% across all door-to-door simulations, and 93% across all stop-to-stop simulations. The size of the service region could make it challenging to dispatch a vehicle to serve demand from isolated areas, but in almost all cases Spare's trip-matching algorithm enabled any simulated rider to book a successful trip.

If CCT pursued a 'low-cost' approach to this service (3–4 vehicles as a mix of dedicated and non-dedicated vehicles), the expected average waiting times would be around 27 mins, with maximum waiting times around 60 minutes. The system would be relatively efficient, with up to 1.4 passengers per vehicle hour (PPVH) and relatively high pooling ratios (54–64%). Annual costs would range from $520,000 to $870,000, depending on the number of dedicated vehicles placed on duty.

Switching to a 'great service' option (relying on 5–8 vehicles) would reduce average waiting times by 8–12 minutes, and maximum waiting times would decrease by up to 15 minutes. However, this convenience would come at a cost to CCT, with passenger occupancy decreasing to 0.8 PPVH and annual costs rising to between $920,000 and $1.6 million.

Implementing a stop-to-stop service in this region would result in significant average time savings of up to 9 minutes, and would significantly improve pooling ratios, at no extra cost to CCT. However, a stop-to-stop service requires some riders to walk to their nearest stop, which may be problematic for those with mobility issues, especially when temperatures are high. It is worth noting that the lower waiting times enabled by a stop-to-stop service could, in time, lead to greater uptake of the service thanks to higher customer satisfaction compared with a door-to-door service. A higher number of trips would ultimately result in a lower cost per trip for CCT.

The primary aim of the simulated microtransit service is to provide mobility to seniors and those with ambulatory issues, although the service would theoretically be open to all. However, CCT has the opportunity to deliver a world-class on-demand transit service to all riders across MUTD cities, by extending the service hours to cater for other socioeconomic groups (late-night shift workers, restaurant/bar/cultural event attendees, etc.)

All these issues are considered in more detail in the Recommendations section.

Recommendations

Summary of recommendations

- There is **high potential for an excellent microtransit service** in the study zone. Low average waiting times and high efficiency are achievable with relatively few vehicles, at a low-cost option that varies from $520,000 to $870,000 per year depending on actual demand.

- The **pooling** rate (i.e. the proportion of trips that are shared between multiple riders) is expected to range between 48% and 64% in a door-to-door model. This implies vehicle hours could be significantly reduced compared to the current model where no pooling exists, which would translate into equivalent cost savings for CCT. Adopting a 'great service' model (by increasing the number of duties) would improve the rider experience, but costs could almost double.

- As CCT begins its microtransit journey, it will have to consider several **tradeoffs** between investing in great service or opting for a lower-cost option. A low-cost solution could be as low as $520,000 per annum (p.a.), while a great-service solution could be as high as $1.6 million p.a. A door-to-door service would offer the best increase in performance per additional spend, but if costs need to be minimised, a stop-to-stop service offers the best value for money.

- A **stop-to-stop** operational model would deliver the best value for money in Collin County. Stop-to-stop services tend to have better pooling and shorter wait times than door-to-door services, and the familiarity of stops breeds more efficient behaviour from drivers and riders. However, the target demographic for this service (seniors and those with special mobility needs), combined with high temperatures in Texas, may mean most – if not all – riders require a door-to-door service. Spare Platform does allow for rider segmentation, whereby certain riders are given access to a door-to-door service, while others are on a stop-to-stop service.

- **Extending the service hours** to 6am–12am would offer coverage for trips typically undertaken for night-shift work and late night entertainment/recreation, thus increasing ridership as well as spreading demand more evenly throughout the day. Whilst this increased ridership would come at an elevated cost (both in terms of annual costs but also costs per trip), it would advance CCT's mission of providing more equitable transit across the county.

- **Right-sizing** CCT's microtransit service could help to cut costs because smaller vehicles cost less to purchase, run, and maintain than the shuttle vans they currently own and operate.

- CCT could save on operating costs in the long-term by investing in **two additional dedicated vehicles** to serve the majority of expected demand. Using a dedicated fleet could result in savings of $7 per trip and annual savings of $140,000, assuming a medium-demand, low-cost scenario.

Moving forward, there are clear steps to success for CCT:

- In the first instance, a **pooled microtransit system** will deliver modest cost savings. Perhaps the most important benefit it will bring is a **wealth of data** that can be used to better understand the demand for transit and optimize the system further.

- In subsequent phases, adding **multiple operators** to the service will help to create operational efficiencies and introduce time- and location-specific rules such as dynamic pricing. A **mixed supply model** could be rapidly scaled up across the microtransit zone using the unique Spare Fleets feature.

- The eventual introduction of **commingling** between different service types (microtransit, paratransit, NEMT, schools) would ensure a fully flexible system that delivers both an amazing rider experience and unparalleled savings for CCT.

These recommendations are discussed in more detail in the rest of this section.

Cost tradeoffs when investing in greater service

When designing and implementing microtransit in Collin County, CCT will have to consider the tradeoffs between the overall cost and quality of service to riders. The cost of running a microtransit service can vary widely depending on a number of factors, including (but not limited to) the local price of labor, vehicle types, fare structures, service/vehicle hours, service configuration, and administrative and technology costs.

The annual cost estimates (excluding administrative or ancillary costs) for a low-cost system range from $520,000 to $870,000 per annum (p.a.), while implementing a great-service system would cost $950000 to $1.6 million p.a. Extending the service hours by six additional hours would result in annual costs of $780,000–$1.3 million p.a. for a low-cost system, or $1.3–2.0 million p.a. for a great-service system.

Whether additional investment beyond the basic low-cost, normal-hours option is worthwhile is a highly pertinent question for CCT, because it is a public agency and therefore must ultimately provide value for money to the taxpayer.

To give CCT a better understanding of the tradeoffs when investing in service quality improvements, we quantify the average effect on service performance of spending an additional $100,000 p.a. in the normal-hours option (FIgure 14). Positive changes include average waiting times improving by 2–2.4 minutes per additional $100,000 p.a., and the proportion of riders waiting < 15 mins increasing by 2.7–6.7 percentage points. However, additional spending negatively impacts the efficiency of the system: PPVH decreases by 0.1 per additional $100,000 p.a., and pooling ratios decrease by 1.3–1.8 percentage points.

For every additional $100,000 spent on providing great service for riders:

	Door-to-door	Stop-to-stop
Avg wait time	−2.0 mins	−2.4 mins
<15 min wait	+2.7%	+6.7%
PPVH*	−0.1	0.1
Pooling ratio	−1.3%	−1.8%

*Passengers per vehicle hour

Figure 14. Changes in average performance metrics for every additional $100,000 p.a. spent on improving service quality for riders, in the normal-hours scenario (i.e. excluding extended hours).

These results suggest the biggest performance-based return on investment would likely occur in a door-to-door service. In other words, spending more in a stop-to-stop service would not yield as much value in reduced waiting times for riders. It should be noted that this 'additional value' analysis is only valid within the ranges of spending examined in this report. Additional spending above the maximum costs presented here may not yield the same value.

Extending the service hours to midnight would be beneficial to socio-economic groups that have traditionally been underserved by transit in Collin County. Perhaps the biggest of these groups is night-shift workers, who currently have no other option but to drive or rideshare to work. Providing service late at night could therefore help to increase the equity of CCT's offering, although more in-depth analysis will be needed to ascertain the holistic impact of such a strategy, which is beyond the scope of this report.

Door-to-door vs. Stop-to-stop

Door-to-door transit services are highly convenient for riders and therefore often prioritized by transit agencies looking to provide value to their communities. However, in some cases, a slightly less flexible stop-to-stop system can result in essentially the same convenience for riders, while significantly boosting efficiencies for the operator (Figure 15).

In a stop-to-stop service, having a set of specific stops speeds up rider identification and boarding times because both driver and rider are more familiar with exactly where they should meet. This familiarity creates consistency, avoids confusion, and reduces the chances of a passenger no-show or long idling times for vehicles.

Another benefit of a stop-to-stop service is the use of designated stop signs as marketing tools for the service itself. Spare's implementation plan includes providing expertise in marketing strategy and marketing assets (such as graphics, content, etc.). Spare would also be able to help CCT to create custom sign graphics, although permission for installation would have to be sought from relevant authorities by CCT.

	Door-to-door	Stop-to-stop
Avg. waiting time	17 mins	9 mins
Avg. walking time	0 mins	11 mins
Pooling ratio	51%	53%

Comparisons made for 'great' service provision

Figure 15. Comparison of metrics between door-to-door and stop-to-stop services for the 'great service' option, averaged across all demand scenarios.

Factors to consider when designing a stop-based microtransit system include:

- **Stop spacing and walking distances:** Gains in waiting times come at the expense of requiring riders to walk – in our simulations, average walking times were 11 minutes. Maximum walking distances can be tweaked by increasing the density of stops, which in turn reduces efficiency gains. Spare would provide expertise in designing stop configurations during an implementation.
- **Vehicle parking and accessibility:** Stops must be chosen in places where vehicles can park safely and conveniently. Riders must be able to get in and out of vehicles quickly and easily, unimpeded by obstacles or traffic. Sufficient sidewalk space is required for riders to wait for their vehicle to arrive.

- **Side of road:** Stops must be placed on roadsides that are most optimal for onward travel and which maximize the potential of pooling as many passengers as possible. This is especially important to consider for passengers with ambulatory issues.
- **Points of interest and land use:** Stops must be placed as close as possible to POIs and take into account restrictions linked to certain forms of land use.

Stop-based services are simple for administrators to design, manage, and run using the sophisticated Spare Launch Admin Panel. There is also a very low barrier to entry for riders to navigate a stop-based system in the Spare Rider app. Clear written and schematic instructions guide riders to walk a few blocks to meet their driver (Figure 16). User reviews and feedback on the Spare Rider app are constantly monitored to improve the product. The response from riders in stop-based Spare-run services has been consistently excellent.

Manageable walking distances for most mobile individuals is often a beneficial tradeoff for lower average wait times. CCT could consider implementing a tailored system, whereby certain riders with mobility issues have access to a fully door-to-door service, while most other riders access a stop-to-stop service. The flexible nature of Spare Platform makes this complex task easy to design and operate.

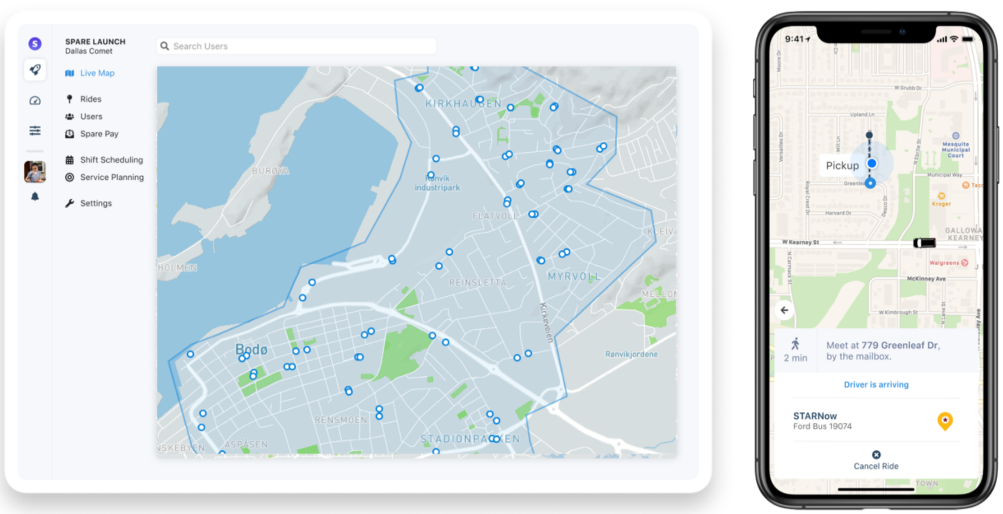

Figure 16. Example layout of stops in the Admin Panel of Spare Launch, and instructions in the Spare Rider app for reaching a 'virtual stop'.

The importance of right-sizing CCT's vehicle fleet

In all the simulations undertaken by Spare, vehicle occupancy never exceeded 4 passengers (Figure 17): in other words, the maximum vehicle size required to service the zone would be a 4-passenger vehicle.

Right-sizing transit vehicles (i.e. purchasing and/or using vehicles that are appropriately sized for servicing the actual demand) can substantially lower transit agency costs, because smaller vehicles cost less to purchase, run, and maintain than traditionally sized buses. Smaller vehicles also tend to have lower licensing requirements than commercial transit vehicles, meaning that the labor pool from which CCT could recruit drivers will be larger and cheaper.

Since CCT currently makes use of taxis from Irving Holdings, many of the vehicles are presumably smaller and therefore right-sized for this particular zone. However, CCT could save on costs if they invested in new dedicated shuttle vehicles that were fit for purpose.

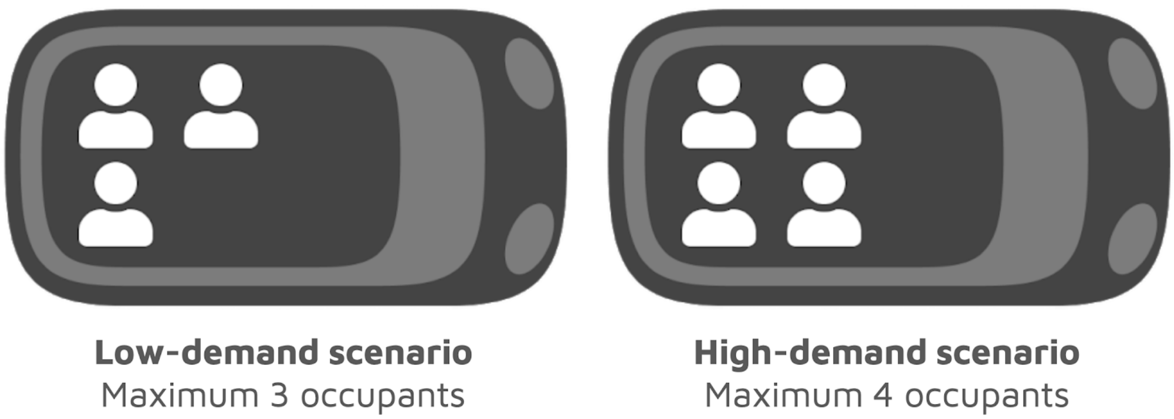

Figure 17. Maximum simulated vehicle occupancy in all simulations

The financial model underpinning the figures in this report assumes that CCT makes full use of its three dedicated vehicles, with one vehicle being mainly reserved for the use of low-mobility riders, while being used for general microtransit during idle periods. Any additional vehicles are assumed to be supplied as non-dedicated taxis by an operator such as Irving Holdings.

However, the annual and per-trip costs would ultimately decrease if CCT were to run the entire service solely using dedicated vehicles. This is because running a dedicated vehicle at a cost of $50 per hour is cheaper than employing a taxi to serve long (10–15 mile) trips at $2.40 per mile. CCT's recently approved $3 flat fare is expected to incentivize riders to take slightly longer trips than before (when a variable fare had been in place), and the inclusion of Parker Road LRT station in the zone will increase average trip distances. Therefore, a dedicated fleet with a unit cost per hour is likely to pay off in the long run for CCT. The table below shows that using a dedicated fleet to meet the majority of demand could result in savings of $7 per trip and $140,000 annually under a medium-demand, low-cost scenario.

	2 dedicated vehicles + **2 non-dedicated vehicles** (Medium demand, 4 duties)	**4 dedicated vehicles +** **occasional non-dedicated trips** (Medium demand, 4 duties)
Cost per trip	$43	$36
Annual cost	$830,000	$690,000

CCT could therefore consider purchasing one or two additional vehicles to meet the capacity needed to cover a medium demand scenario, and only use non-dedicated taxis to cover any additional demand at peak times. This is easily achieved through the innovative Spare Fleets trip brokering feature.

CCT's new vehicles would not have to be large shuttle vans; instead, they could purchase smaller 5-person vehicles that are cheaper to maintain, insure, fuel and staff. Replacing one of CCT's three existing cutaway vehicles with another smaller vehicle that is more fit for purpose would also deliver additional savings over the lifetime of the service.

In any case, the potential savings of using smaller vehicles should be weighed against regulations and passenger preferences for accessible, comfortable, and safe vehicles. Many of CCT's riders on this service may have medical and/or ambulatory issues. In Spare's experience, riders can be apprehensive about climbing into a small vehicle with strangers, especially seniors and those with ambulatory difficulties, although most riders soon become accustomed.

An advantage of Spare Platform is that it can restrict which vehicle types are assigned to certain riders depending on need or preference. Riders who have issues with smaller vehicles could therefore be seamlessly matched with more adequately sized vehicles for their needs, with zero or minimal coordination from CCT's operations team.

The steps to success for CCT

By launching microtransit across Collin County, CCT is in a position to launch itself into the future. CCT is currently in what we call, 'Phase 0': a generally unpooled service with plenty of dead-heading, that is costly to run due to its built-in inefficiencies (Figure 18). As a private enterprise, the aim of Irving Holdings is understandably to maximize profit, so there are few incentives to drastically cut costs on CCT's behalf. Moving away from this model is key if CCT is seeking to deliver better value for money. We discuss the benefits that each subsequent phase could bring to CCT.

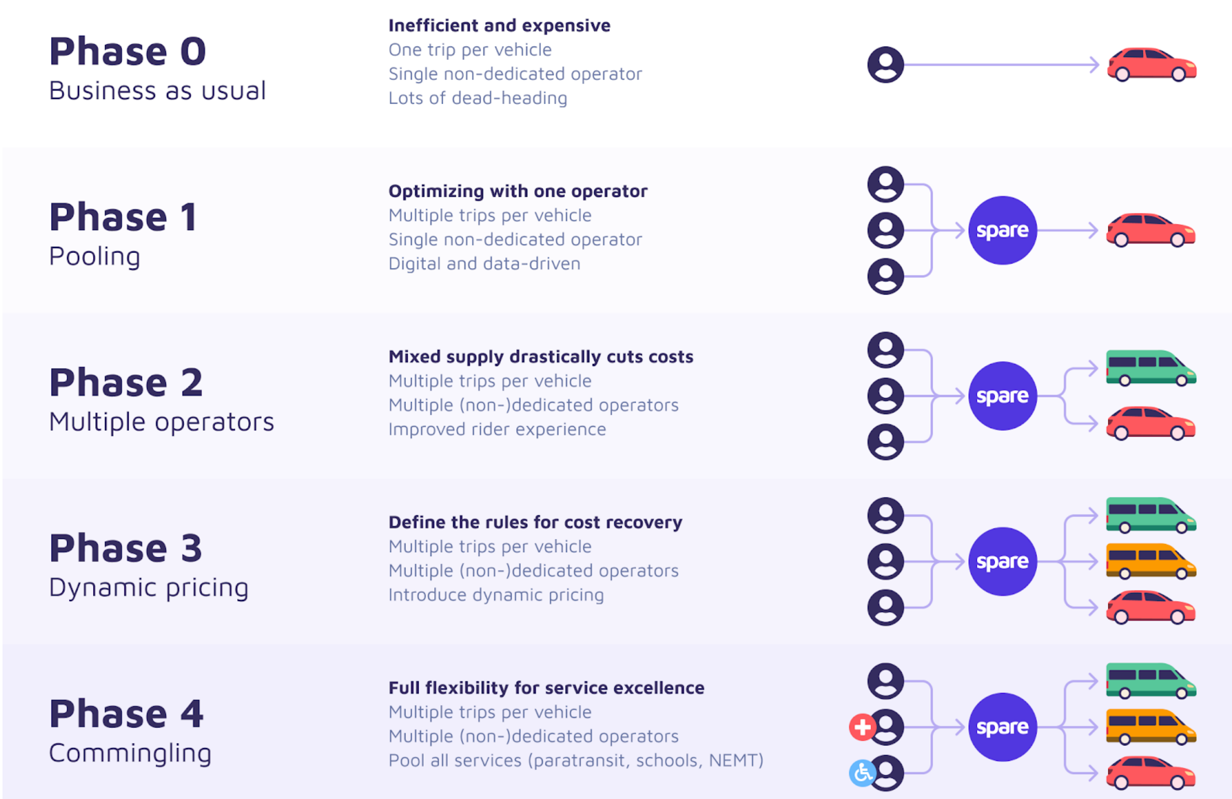

Figure 18. Spare's framework for propelling CCT into the future.

Phase 1: The power of pooling and data

Simply put, the first phase of CCT's journey will be about pooling. A microtransit platform such as Spare's will propel CCT away from the one-trip-one-taxi system that is currently in place. Our results show pooling rates of 48–64% are achievable under the low-cost option, which could translate into similar reductions in operational costs.

As our simulations show, the pooling ratio is affected by the number of vehicles placed on the road: generally, the fewer the vehicles, the higher the pooling ratio, although this comes at the expense of rider convenience. Spare Platform allows CCT to tweak other parameters in the service configuration to increase pooling. The 'Detour Flexibility' parameter can be set to low, medium or high, depending on how much CCT is willing to deviate a given rider for the sake of overall system efficiency.

The per-trip costs presented in this report may seem relatively high compared to current trip costs incurred through the non-dedicated service with Irving Holdings. However, on average they are significantly cheaper than the average trip cost of $94 incurred using CCT's dedicated fleet. Pooling reduces the amount of vehicle hours required to service a given demand, so Phase 1 is expected to deliver some initial savings. However, this is just the beginning: by pursuing subsequent phases and unlocking their potential across Collin County, CCT could see much bigger savings whilst maintaining, if not exceeding, the current levels of service.

One of the other main benefits of introducing microtransit will be the wealth of data it produces. At the moment, CCT suffers from not having instant access in a digestible way for it to make quick decisions when they are required. This lack of data also makes it difficult to conduct rigorous long-term transit planning. By digitizing transit in the region, the Spare Platform would empower CCT to collect, analyze, and take action on huge mobility datasets.

At Spare, we operate on the principle that microtransit can 'flip transit on its head'. Many transit agencies design their fixed bus routes on the basis of imprecise historical data, anecdotal evidence, or even gut feeling by planners. By introducing microtransit in different areas, transit agencies can far better understand rider needs, and can use that knowledge to redesign their fixed routes.

The rich datasets collected by Spare Platform can be used to identify where demand exists for more fixed-route transit - for example, along commuter routes to major towns. This data helps identify the best locations and timings for fixed bus routes, and to nudge riders to adapt to more rigid schedules if needed. In areas where the volume or reliability of demand is high enough to run a fixed route, it might not be the cheapest option to maintain on-demand microtransit, and Spare would recommend launching timetabled buses or hybrid systems such as deviated fixed lines. But without the initial rich data provided by microtransit, it will be incredibly difficult for CCT to pinpoint exactly where microtransit and fixed routes make most sense in Collin County.

Phase 2: A mixed-supply model drastically cuts costs

The biggest contributor to the operational cost of a microtransit service is the cost and allocation of labor. Dedicated, specialized, unionized labor often cannot compete on price with independent contractors, while independent contractors, such as taxis and

Transportation Network Companies (TNCs), often cannot compete with the reliability and consistency of dedicated labor.

By involving multiple operators, CCT could begin to unlock true savings in public transit provision. A mixed supply model, where dedicated labor is used for the majority of demand while independent or non-dedicated labor is used during periods of peak demand, can offer the same high service quality expected by customers, but allocates labor more efficiently across the demand spectrum. Instead of providing enough dedicated labor to always accommodate all demand in a timely fashion, CCT could maintain enough capacity to meet the majority of demand with a single provider, while brokering trips to other providers when required (Figure 19).

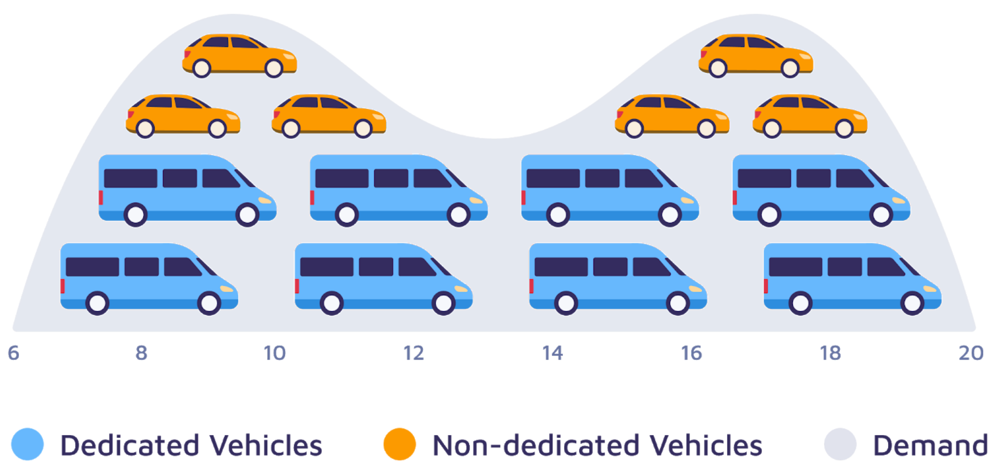

Figure 19. How a mixed-supply model enables transit agencies to slightly under-supply for any given demand, by brokering trips to other non-dedicated operators when needed.

If CCT were to adopt a mixed supply model, its transit system could dynamically respond to demand spikes without having to pay higher capacity throughout the day. Spare enables such mixed supply systems via its Spare Fleets feature, which allows dedicated and non-dedicated vehicles to be combined in a dynamic and automated way.

Spare Fleets is a far more equitable solution than a ride-hailing platform like Uber or Lyft, because – unlike those private platforms – it is all-inclusive and does not arbitrarily lock out other operators. The main motivation in this phase is ramping up efficiency, and providing riders with options whenever they need them.

Phase 3: Defining your rules in a thriving transit ecosystem

As the number of operators increases so that trips can be brokered out to any vehicle, regardless of whether it is dedicated or non-dedicated, CCT will be able to set sophisticated 'game rules'. For example, dynamic pricing could be introduced, whereby riders pay slightly more as a function of demand, to help CCT recoup costs at particular times of day, and to encourage a flattening out of demand peaks, which can put a strain on on-demand systems.

Another option could be to create stricter time rules in certain parts of a larger zone. For instance, pickups from smaller population centres connecting with main road arteries may be restricted to once an hour, which would ensure much higher pooling and more predictable (and therefore optimizable) vehicle patterns. For instance, this could be applied to the region within Collin County that is outside of the MUTD zone.

This level of flexibility and dynamism is simply not possible without a digitally run transit platform. Digitization will empower CCT to eventually create a transit system that is highly tailored to Collin County, where a mix of optimized fixed bus lines operate in harmony with more nimble on-demand shuttles. Public transit would then exist along the entire spectrum between a highly personalised taxi service to a predictable fixed-route system.

Phase 4: Commingling helps to share resources across services

Traditionally-operated public transit suffers from the static allocation of resources to specific specialized services. For example, a paratransit vehicle usually cannot receive non-paratransit trips, even when it is idle and could be put to work elsewhere in the system. Similarly, two trips going to and from similar locations at similar times may be allocated to separate vehicles because the riders are accessing different services.

The Spare Fleets feature throws out this outdated model and allows different services to maintain their distinctive nature while sharing vehicle resources with each other. This approach, which is known as 'commingling', respects different service configurations, rules and rider groupings, and continues to provide the same quality of service expected by each rider. Commingling is a hallmark of efficiency in the airline and logistics industries, but its application to the transit industry is groundbreaking.

Implementing full-scale commingling would require working with multiple government departments (e.g. those responsible for paratransit, school transportation, senior communities), which may face political and bureaucratic hurdles. However, there is massive potential for a fully flexible system such as this to deliver unparalleled savings to CCT, and simultaneously create amazing service for riders.

We therefore recommend that CCT should consider implementing Spare Fleets in Collin County. CCT may only see true differences in cost and efficiency between their new microtransit system and the existing taxi service if they deploy a truly flexible solution such as commingling. Spare would be glad to advise further on this option.

Meeting CCT's objectives

It is important to us at Spare that we revisit the objectives of this project to reflect on how our analysis and recommendations help CCT to achieve its goals.

Boost efficiency

- Microtransit helps to increase coverage while lowering costs and increasing ridership. Efficiencies will only keep improving if CCT moves through the phases outlined in this report.
- Having a fully digitized transit platform will allow CCT to use data far more effectively to identify inefficiencies and opportunities for improvement. It helps create a vastly configurable system that can be adjusted in real time.
- A feature like Spare Fleets, which facilitates fleet sharing across different services, will help CCT optimize the use of its resources for further efficiency gains.

Improve accessibility

- Microtransit will help make CCT's transit offering more rider-centric: it will allow riders to access convenient and sustainable transport which is transparent and provides them with real-time information.
- A fully digitized on-demand platform empowers riders to search for, plan, and book trips independently and to suit their needs.

Innovate for resilience

- In partnering with Spare to explore the possibilities of microtransit, CCT is demonstrating it is prepared to try new things and push the boundaries of transit.
- Through the use of innovative technology, CCT will have the ability to gather and analyze vast amounts of mobility data, to allow it to respond more quickly and comprehensively to a changing environment and rider behaviour. The COVID-19 crisis is a good example of where this would be useful.
- Microtransit will launch CCT on the road to truly flexible transit. It will empower CCT not only to respond to rider demand today, but also to future-proof its operations for years to come. Riders and CCT win in the long-term!

Appendices

Appendix 1: Census data acquisition

Census data were downloaded from the US Census Bureau's 2016 American Community Survey, via SafeGraph (https://www.safegraph.com/open-census-data). Jobs data were downloaded from the US Longitudinal Employer-Household Dynamics Origin-Destination Employment Statistics (LODES) survey for 2017 (https://lehd.ces.census.gov/data/).

All data were downloaded at the Census Block Group (CBG) level, the smallest standard geographic unit available to join both datasets. The respective tabular sources and calculations are summarised in Table A1.

Table A1. Summary of demographic variables, their respective census tables, and calculations.

Variable	Source (ASC / LODES)	Calculation
Total population	Table B02001e1	-
Median household income	Table B19013e1	-
Poverty level	Tables B17021e2, B17021e1	[Individuals below poverty level] / [Total individuals assessed for poverty]
Non-white population	Tables B02001e1, B02001e2	[Total population] - [White only population]
Zero vehicle ownership	Tables B25044e10, B25044e3, B25044e1	([No. of occupied renter units with zero vehicles] + [No. of occupied owner units with zero vehicles]) / [Total occupied units]
High-school education or less	Tables B15003e10 to B15003e18, B15003e1	[educational attainment until end of high school for people aged 25, including GED] / [Total population aged 25+]
Total number of jobs	Michigan Workplace Area Characteristics (WAC) Table MI_WAC_S000_JT_2017	-

Appendix 2: Spatial distribution of demand metrics

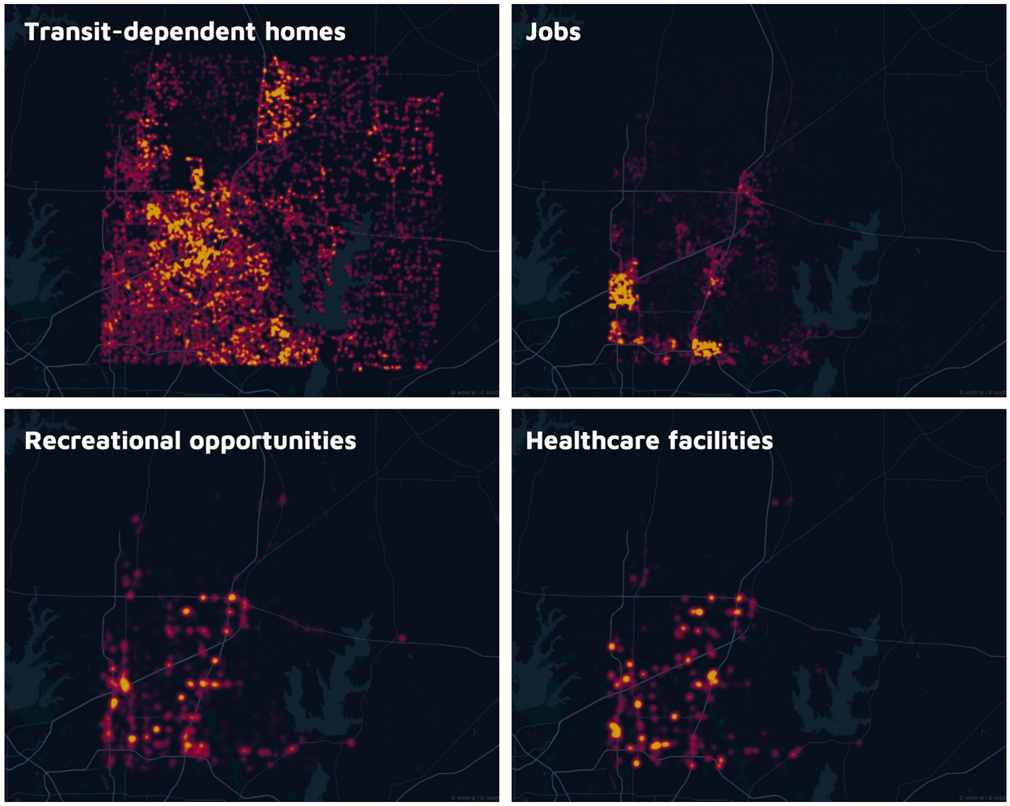

Figure A1. Spatial distribution of expected demand for homes/visits, jobs, recreation and healthcare for all of Collin County.

Appendix 3: Methodology for price elasticity calculations

To calculate the cost of running the service under a new pricing structure, we account for two main factors in our financial model:

1. The predicted underlying growth/decline in ridership based on historical data, regardless of whether pricing changed;
2. The expected growth/decline in specific types of rides in response to the change in pricing.

The distribution of trips by price (which is correlated with distance) is shown in Figure A2.

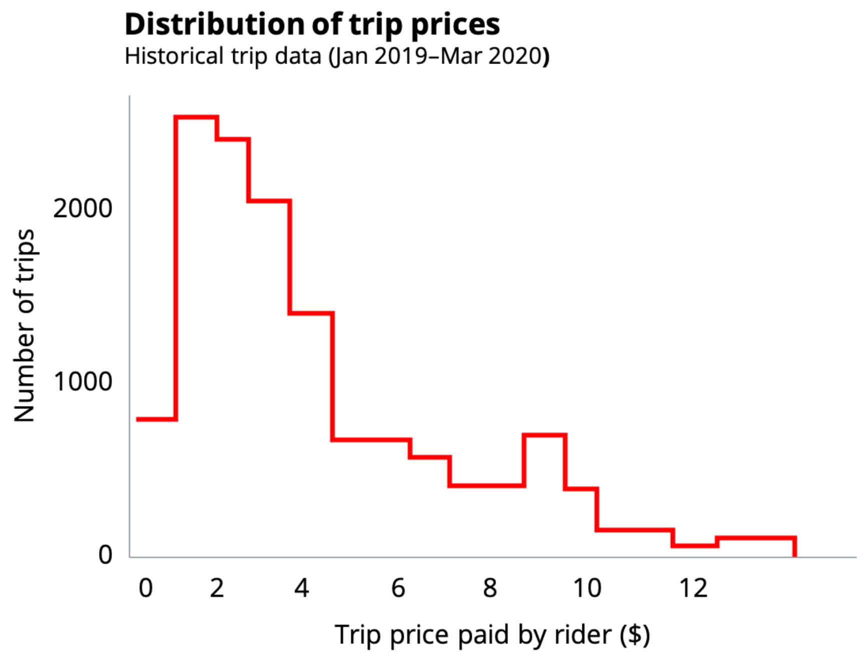

Figure A2. Distribution of historical trips by price paid by the rider (CCT pays the remaining 75%).

Only 55 trips were taken outside the MUTD zone ('private pay' trips), and most of them were undertaken by only a few individuals. The exceptionally small proportion of non-MUTD trips prevented us from reliably accounting for these in our model, so we only model MUTD trips.

A major point of consideration in any ridership forecasting model is the differentiation of trends for different trip lengths. Changes in demand will reflect the difference between the new flat fare and the current price of a trip. For instance, if a trip's price were to decrease under the new pricing regime, the propensity of riders to take such a trip would differ to a situation where a trip's price would increase (this is explored in more detail in the following sections).

To account for this, we divided trips into different price bands. In both scenarios, one price band encompasses all trips that would cost *more* in the new regime (i.e. all trips <$2 in scenario 1, and all trips <$3 in scenario 2). Of the remaining trips that would cost less in the new regime, we defined a 'low gains' category (trips costing more than $2 but less than $4 in scenario 1, and trips costing more than $3 but less than $5 in scenario 2), a 'medium gains' category (trips costing more than $4 but less than $9 in scenario 1, and trips costing more than $5 but less than $9 in scenario 2), and finally a 'big gains' category (trips costing more than $9 in both scenarios). These bands were defined according to the distribution of trips displayed in Figure A2.

As shown in Table A2, almost 75% of all trips taken with CCT are short trips costing less than $5. Under Scenario 1, a quarter of historical trips would end up paying more than they do currently, whereas under Scenario 2, almost half of historical trips would end up paying more than they do currently.

Table A2. Statistics of trip price categories in each scenario.

Scenario	Trip price category (paid by rider)	Average trip price paid by rider ($)	Average number of trips per week	Proportion of all trips (%)	Average trip distance (miles)
Scenario 1 ($2 flat fare)	$2 or less	1.4	52	25	1.7
	$2–$4	2.9	82	40	4.7
	$4–$9	6.2	61	29	12.6
	$9+	10.2	14	6	19.7
Scenario 2 ($3 flat fare)	$3 or less	1.9	97	47	2.6
	$3–$5	3.7	53	25	6.3
	$5–$9	6.8	44	21	14.6
	$9+	10.2	14	6	19.7

The sensitivity of riders to transit pricing is traditionally measured using elasticities. Elasticities are the percentage change in consumption resulting from a one-percent change in price, all else held constant.

In the context of transit, a high elasticity value indicates that an individual's choice to ride transit *is* price-sensitive (i.e. a small change in price will dramatically affect how likely they are to ride transit). A low elasticity value indicates that prices have relatively little effect on ridership. Factors that affect transit elasticities include:

- User type
- Trip type
- Transit type
- Geography
- Type of price change
- Direction of price change
- Time period

While many of these are outside of the scope of this short study, we account for the *direction* of price change and the *time period* of changes. For the *direction of price change*, we note that price change elasticities are asymmetric: that is, an increase in fare will tend to cause greater ridership reduction than the same size fare reduction will increase ridership. We therefore choose asymmetric elasticities. For the *time period*, we consider the price impacts to be short-run (<2 years), as opposed to medium run (2–5 years) or long-run (5+ years). Short-run impacts are usually estimated to half as severe as long-run impacts.

A wide range of elasticity values are used in transit planning and academic studies to quantify the impact of price changes on transit. A comprehensive review of the literature is provided by Litman (2019)[4], whose recommendations are summarised by market segment and time period in Table A3.

Table A3. Elasticity values recommended by Litman (2019) for modelling response to transit fare changes.

Market segment	Short-term	Long-term
Overall	–0.2 to –0.5	–0.6 to –0.9
Peak	–0.15 to –0.3	–0.4 to –0.6
Off-peak	–0.3 to –0.6	–0.8 to –1.0
Suburban commuters	–0.3 to –0.6	–0.8 to –1.0

For our model, we chose an elasticity value of -0.35 for trip categories that will experience an *increase* in fare price, and a value of 0.25 for trip categories that will experience a *decrease* in fare price. This assumes short-term impacts, and balances the fact that many different trip types are taken on CCT, from commuting to recreation and socialising. This also closely matches a frequently-used rule-of-thumb, known as the Simpson–Curtin rule, which states that each 3% fare increase reduces ridership by 1%.

To calculate the impact of a fare change in ridership, we first consider the average trip price in each price category as the 'old price' (e.g. any rides in the <$2 category are given an 'old price' of $1.40, as shown in Table 1). Special care is required when calculating the impacts of large price changes, because each subsequent change impacts a different base in a compound way. Since this effect becomes significant when price changes exceed 50% (which will occur often in CCT's case), we compute elasticities using the appropriate 'arc elasticity' method[5]. As an example, a rise in average fare from $1.40 to $2 equates to a 42% increase; given an elasticity of -0.35, the arc elasticity is calculated as 1.42^(-0.35), multiplied by the old ridership. This results in a 12.5% decrease in ridership.

[4] Litman, T. (2019). https://www.vtpi.org/elasticities.pdf
[5] Pratt, R. (2004). http://www.trb.org/TRBNet/ProjectDisplay.asp?ProjectID=1034

We do not assume a change in the average distances/prices taken in each trip category – we only calculate change in the number of trips taken in each category. In reality, lower prices may encourage riders to take slightly longer trips, which would push up the category averages. However, we assume this effect is relatively negligible to our overall results.

Appendix 4: Simulation run results

Door-to-door simulations

Demand	# of Duties	Requests	Simulation address	Booking success (%)	Max Vehicle Occup.	PPVH	Pooling Ratio (%)	Max Wait (mins)	Avg. Wait (mins)	< 15 Min Wait	Avg Trip Distance (km)
L	3	46	https://sparelabs-simulation-results.nyc3.digitaloceanspaces.com/03c9de9d-be03-4451-a8b0-e5ae1ef8d980.zip	89	2	1.2	53.00%	53	27	22.00%	19.00
L	3	45	https://sparelabs-simulation-results.nyc3.digitaloceanspaces.com/94b0e741-301d-4861-9570-75cd78c16c4d.zip	87	3	1.2	60.00%	58	26	27.00%	19.00
L	3	45	https://sparelabs-simulation-results.nyc3.digitaloceanspaces.com/b207b4d7-4379-4de4-aee9-6ec4a27fbdb9.zip	87	3	1.2	78.00%	60	32	18.00%	19.00
L	5	51	https://sparelabs-simulation-results.nyc3.digitaloceanspaces.com/0678bda9-686a-4143-93cd-08239ac196c9.zip	98	3	0.8	44.00%	42	19	45.00%	19.00
L	5	52	https://sparelabs-simulation-results.nyc3.digitaloceanspaces.com/1f06b506-600c-43bd-85f2-7a1497c3218b.zip	97	3	0.8	42.00%	59	23	30.00%	19.00
L	5	52	https://sparelabs-simulation-results.nyc3.digitaloceanspaces.com/d07335c7-c303-4a99-8ac0-cfbc4c0ce8f2.zip	100	2	0.8	56.00%	42	18	37.00%	19.00
M	4	60	https://sparelabs-simulation-results.nyc3.digitaloceanspaces.com/0f3a52d7-b855-4598-b91c-77bf3067e316.zip	92	4	1.2	27.00%	55	25	34.00%	19.00
M	4	63	https://sparelabs-simulation-results.nyc3.digitaloceanspaces.com/9b0eeed1-60a3-48e2-85dc-92c21361da9f.zip	97	3	1.2	61.00%	60	26	19.00%	19.00
M	4	61	https://sparelabs-simulation-results.nyc3.digitaloceanspaces.com/6114bc9c-aa5c-41b7-aafa-147f3376b7ad.zip	94	3	1.2	74.00%	60	28	22.00%	19.00
M	6	64	https://sparelabs-simulation-results.nyc3.digitaloceanspaces.com/025b6c61-1b37-408f-b852-0135c805f0b5.zip	99	3	0.8	50.00%	41	16	49.00%	19.00
M	6	62	https://sparelabs-simulation-results.nyc3.digitaloceanspaces.com/64b7ea32-fb57-499a-ab2b-fc363b239bff.zip	96	2	0.8	55.00%	47	16	52.00%	19.00
M	6	63	https://sparelabs-simulation-results.nyc3.digitaloceanspaces.com/efe3bfa0-b244-4221-9939-64fdd38f23b1.zip	97	3	0.8	56.00%	42	15	67.00%	19.00
H	4	69	https://sparelabs-simulation-results.nyc3.digitaloceanspaces	82	3	1.3	48.00%	61	29	25.00%	19.00

			.com/740f7f67-bb75-409a-ad54-63a68919dc82.zip								
H	4	77	https://sparelabs-simulation-results.nyc3.digitaloceanspaces.com/0f7479a8-cc9e-4db6-ac4a-34f1c53125d3.zip	91	3	1.5	92.00%	58	27	26.00%	19.00
H	4	74	https://sparelabs-simulation-results.nyc3.digitaloceanspaces.com/df0ee6d6-949b-44d5-88e5-3d1f19081fb3.zip	88	4	1.4	63.00%	68	29	29.00%	19.00
H	8	84	https://sparelabs-simulation-results.nyc3.digitaloceanspaces.com/90afca0d-609e-47d5-b829-adbb137e62c3.zip	99	4	0.8	47.00%	45	13	63.00%	19.00
H	8	80	https://sparelabs-simulation-results.nyc3.digitaloceanspaces.com/0343f4be-016b-4759-b173-4588bfc7bcaf.zip	94	4	0.8	47.00%	44	14	63.00%	19.00
H	8	84	https://sparelabs-simulation-results.nyc3.digitaloceanspaces.com/b858d459-eba4-4d95-aa1a-3e65cd23cbbc.zip	99	3	0.8	60.00%	59	21	48.00%	19.00

Stop-to-stop simulations

Demand	# of Duties	Requests	Simulation address	Booking success (%)	Max Vehicle Occup.	PPVH	Pooling Ratio (%)	Max Wait (mins)	Avg. Wait (mins)	< 15 Min Wait	Avg Trip Distance (km)
L	3	48	https://sparelabs-simulation-results.nyc3.digitaloceanspaces.com/fbae1820-1072-45ca-92a6-e6560bd45880.zip	94	3	1.2	85.00%	65	24	36.00%	19.00
L	3	45	https://sparelabs-simulation-results.nyc3.digitaloceanspaces.com/b1aee079-37a2-4743-b740-787bb8ccb864.zip	87	2	1.2	80.00%	75	25	40.00%	19.00
L	3	47	https://sparelabs-simulation-results.nyc3.digitaloceanspaces.com/cfdaa543-cdd8-406a-be45-fd48d74534af.zip	91	2	1.2	68.00%	58	21	39.00%	19.00
L	5	51	https://sparelabs-simulation-results.nyc3.digitaloceanspaces.com/35bc1c0e-2334-4add-a412-eabd9886518f.zip	98	3	0.8	65.00%	39	10	77.00%	19.00
L	5	47	https://sparelabs-simulation-results.nyc3.digitaloceanspaces.com/2b59810f-9f70-4f25-9110-707a32a38781.zip	91	2	0.7	68.00%	59	12	73.00%	19.00
L	5	51	https://sparelabs-simulation-results.nyc3.digitaloceanspaces.com/e48427a8-ee71-4a5b-add5-ed7b93b719e0.zip	98	3	0.8	49.00%	52	10	69.00%	19.00
M	4	65	https://sparelabs-simulation-results.nyc3.digitaloceanspaces.com/f454f1d8-a861-4585-be61-8d020ea55676.zip	100	3	1.3	74.00%	51	15	54.00%	19.00
M	4	58	https://sparelabs-simulation-results.nyc3.digitaloceanspaces.com/ed98fc4f-cc98-436e-ab8d-fe680823e723.zip	89	3	1.1	62.00%	59	21	52.00%	19.00
M	4	59	https://sparelabs-simulation-results.nyc3.digitaloceanspaces.com/e39842a1-18b9-4c8e-9474-5a32bec37d12.zip	91	2	1.1	88.00%	56	15	60.00%	19.00
M	6	63	https://sparelabs-simulation-r	97	2	0.8	43.00%	34	10	77.00%	19.00

			esults.nyc3.digitaloceanspaces.com/e0b0d86b-a402-471d-a09b-0d80e891f5a3.zip								
M	6	64	https://sparelabs-simulation-results.nyc3.digitaloceanspaces.com/9e10fa48-77d1-4084-97d6-673e0ce3bfa0.zip	98	2	0.8	43.00%	53	10	75.00%	19.00
M	6	64	https://sparelabs-simulation-results.nyc3.digitaloceanspaces.com/9859a03a-849a-43b9-b4fe-0752bdaaf7f9.zip	98	2	0.8	48.00%	41	10	65.00%	19.00
H	4	69	https://sparelabs-simulation-results.nyc3.digitaloceanspaces.com/3bedece2-8fe3-4b91-ac83-a8ec632ae008.zip	82	2	1.3	82.00%	67	29	35.00%	19.00
H	4	76	https://sparelabs-simulation-results.nyc3.digitaloceanspaces.com/9b27ba7c-a41c-47d3-a600-be8f0261fb38.zip	89	3	1.5	84.00%	60	24	27.00%	19.00
H	4	70	https://sparelabs-simulation-results.nyc3.digitaloceanspaces.com/51f0854d-fb32-4292-be9f-95eebb1dfa04.zip	83	4	1.4	85.00%	60	23	39.00%	19.00
H	8	80	https://sparelabs-simulation-results.nyc3.digitaloceanspaces.com/0c5e34d8-4c69-45d3-b919-63b8f6f197e4.zip	94	2	0.8	32.00%	33	7	83.00%	19.00
H	8	83	https://sparelabs-simulation-results.nyc3.digitaloceanspaces.com/37a74a2e-1f4b-4c7c-9114-d176fe8be856.zip	98	3	0.8	47.00%	42	6	91.00%	19.00
H	8	83	https://sparelabs-simulation-results.nyc3.digitaloceanspaces.com/177c066b-95ae-4068-ae31-6d094b20b05c.zip	98	3	0.8	79.00%	33	7	84.00%	19.00