WAV ON DEMAND PILOT
PROJECT ID: CEEN_2018CPST_015

by

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A Capstone Project Final Report

Submitted to

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Executive Summary

PROJECT TITLE: UTA ON-DEMAND WHEELCHAIR ACCESSIBLE VEHICLE (WAV) PILOT
PROJECT ID: CEEn_2018CPST_015
PROJECT SPONSOR: Utah Transit Authority
TEAM NAME: Enginuity

The Utah Transit Authority (UTA) has partnered with the Utah Developmental Disabilities Council (UDDC) and with Lyft to test a new solution to enhance wheelchair accessible transportation in Salt Lake County in order to provide equal opportunity for all users in Salt Lake County. The pilot is scheduled to run through September of 2019 and aims to deploy four wheelchair accessible vehicles (WAVs) on Lyft's on demand ride-hailing platform within the Salt Lake Valley. This service will not replace the current UTA Paratransit buses, but rather it will introduce a new mode for persons with disabilities in Salt Lake County. During this pilot, UTA will test the functionality of a WAV on demand program, understand the WAV supply and ridership demand in Salt Lake County, gain operational experience with an on-demand WAV service, and understand the costs associated with implementing this solution. If successful, the pilot partners will work to identify future funding opportunities for expansion as part of future UTA innovative services. The pilot is expected to operate 24-7, every day of the month. Hours of operation will be determined by drivers contracted by Lyft, and the vehicles will be leased from UTA at zero cost to the drivers. Drivers will be expected to meet the qualifications set by UTA and the Lyft. In preparation to launch the pilot, the BYU capstone team assisted UTA on three main tasks: 1) Site Selection, 2) Cost Analysis, and 3) Creating an RFP.

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Introduction

To provide equal opportunity for all users in Salt Lake County, the UTA Innovative Mobility Solutions Office and Coordinated Mobility Department are exploring a public/private partnership to pilot the introduction of wheel chair accessible vehicles (WAVs) into an on-demand ride-hailing network. Currently, there are no providers of on-demand WAVs in the UTA service area or on any TNC platform in the Greater Salt Lake Area.

The goal of this pilot is to test a new solution to enhance wheelchair accessible transportation and to improve transit for people with disabilities. UTA aims to test the functionality of a WAV on-demand program, to understand the WAV ridership demand in Salt Lake County, to gain operational experience with an on-demand WAV service, and to understand the costs associated with implementing this solution. If successful, the project team will work to identify future funding opportunities for expansion as part of future UTA innovative services.

The WAV on-demand mobility pilot will run from March 1st to August 31st. UTA will provide four, non-branded 2017 Ford Transit vans with wheelchair lifts, where each vehicle seats six passengers and securement for one power size wheelchair. These vehicles will operate as part of an on-demand service to the entire public; prioritizing rides to individuals needing wheelchair accessibility. Non-WAV rides may be provided, but not to the exclusion or priority of WAV rides. The pilot should be a geofenced pilot zone limited to Salt Lake County (807 sq. miles). UTA prefers the pilot to operate all hours and every day of the week or by market demand. UTA will lease the vehicles to drivers at zero cost with the expectation of minimum operational hours per week as determined by UTA. Drivers are required to meet the qualifications set by UTA and the TNC partner.

UTA Responsibilities

Vehicles

- UTA will provide four, non-branded, 2017 Ford Transit vans.
- UTA will lease the vehicles at no cost to the drivers. A deposit by the driver may apply.
- UTA will provide basic insurance coverage. A deductible will apply to the driver.
- UTA will provide vehicle maintenance.

Drivers

- UTA will provide drivers with proper training on vehicle operations, wheelchair lift operations, passenger securement, and all other applicable training requirements.
- UTA will provide a fuel card to drivers with weekly limits of $100 explicitly for the purposes of this pilot.

Marketing

- UTA will support and contribute to marketing efforts with the TNC partner.

TNC Partner Responsibilities

Technology

- The application interface must include a WAV option.
- Operation of the WAV option should be limited to the geofenced pilot zone.

- Give priority to WAV requests in the rider queue.

Driver Management

- Financially incentivize drivers to maintain ideal hours of operation and service within the geofenced pilot zone.
- Maintain the standard responsibility for insurance, driver recruitment, driver training, and driver compensation, etc.

Data and Measures of Effectiveness

- Collaborate with UTA to determine pilot metrics, review program data, determine pilot effectiveness, identify opportunities for improvement, and evaluate long-term sustainability.
- UTA anticipates these types of data points would assist in program evaluation:
  - Total number of WAV and non-WAV trips requested and provided.
  - Wait time distribution of WAV and non-WAV users.
  - Origin and destinations.

Marketing

- The TNC partner will contribute to marketing efforts, in collaboration with UTA.
- The TNC partner and UTA will explore the use of promotion codes to focus the WAV user demand in concentrated areas and to increase ridership.

Site Selection

The Brigham Young University (BYU) capstone team has identified six potential sites for UTA to test the on-demand wheelchair accessible vehicle (WAV) pilot. Of the six sites, **the BYU team recommends Site 2. South Salt Lake.** The most important factor in the pilot will be volume (i.e. number of pick-ups and drop-offs), and the main goals are to identify where the users are coming from and where they are going: trip productions and attractions. The data used in this analysis are displayed in the Appendix.

Using data from UTA Paratransit Services, the students selected the following six sites based on criteria that includes square mileage of the pilot area, number of addresses of eligible paratransit users, number of paratransit pick-ups/drop-offs (during the week of Sept. 17-21, 2018), and number of bus ramp activations within the month of August 2018 (see Table 1).

The team identified four static sites and two dynamic zones. Static sites are smaller and would assume that the four UTA WAVs are not connected and would not coordinate spacing. A dynamic zone covers a larger area and assumes the vehicles space themselves intelligently to cover more area and avoid "bunching".
A static site was selected based on the assumption that vehicles will not be connected (i.e. aware of spacing) and a smaller area will reduce user wait times.

- Site 1. Salt Lake City Downtown. 300 N to 900 S and 600 W to the U of U
- **Site 2. South Salt Lake. 1700 S to 4500 S and 300 W to 1300 E**
- Site 3. West Jordan. 6200 S to 9000 S and 4000 W to Redwood Rd.
- Site 4. Sandy. 8600 S to 10600 S and 500 W to Mt Jordan Rd.
- Dynamic Zone 1. Salt Lake City. 1700 N to I-80 and I-215 (north of I-80) to the U of U
- Dynamic Zone 2. Murray. I-80 to I-215 and I-15 to 1300 E

Table 1 Comparison of the Six Sites Based on Area, Travel Time, Number of Addresses, and Number of Pick-ups/Drop-offs

	Area (mi^2)	Travel Time (min)		Addresses	Pick-Ups	Bus Ramps
Static Sites		East-West	North-South			
SLC Downtown	9	30	18	178	94	3820
South Salt Lake	10.2	15	25	302	98	4883
West Jordan	9.5	15	15	267	74	450
Sandy	14.25	22	15	131	22	123
Dynamic Zones		East-West	North-South			
Salt Lake City	17	30	25	388	186	6669
Murray	16.25	25	25	338	79	4649

Cost Analysis

The Brigham Young University (BYU) capstone team calculated the total monthly cost to operate four wheelchair accessible vehicles for 10 hours per day for 31 days to be between **$9,000 and $11,200**, as shown in Table 1. **This value assumes that cost of labor is $0/hour**. This assumption is sensitive to the variables held constant (i.e. insurance, depreciation, gas price and maintenance costs) and compares monthly cost based on vehicle miles traveled (VMT). This price can be reduced by changing number of hours and days of operation. Further cost comparisons are shown in the Appendix.

Table 2 Calculation of Monthly Cost Comparing VMT

Variable	Min Value	Max Value	
Number of Vans	4	4	
Wage (per driver per hour)	$ -	$ -	
Hours of Operation (per day)	10	10	
Days of Operation (per month)	31	31	
Insurance (per month)	$ 1,200.00	$ 1,200.00	
Maintenance (per mile)	$ 0.09	$ 0.09	
Vehicle Miles Traveled (VMT) (per van per day)	25	75	
MPG	15	15	
Gas Price	$ 3.50	$ 3.50	
Depreciation (per month)	$ 855.00	$ 855.00	
Cost of Operation	$ 2.97	$ 1.20	Per mile
	$ 296.99	$ 360.66	Per day
	$ 2,301.71	$ 2,795.13	Per week
	$ 9,206.83	$ 11,180.50	Per month
	$ 2,301.71	$ 2,795.13	Per van per month

The team used the following equation to estimate total monthly cost. From this equation the team calculated the derivative with respect to each variable to measure the sensitivity of each variable (see Appendix).

$$Total\ Monthly\ Cost = \#vans * [\frac{fuel\ cost}{month} + \frac{insurance\ cost}{month} + \frac{maintenance\ cost}{month} + \frac{labor\ cost}{month} + \frac{depreciation\ cost}{month}]$$

The *BYU Cost Analysis Final* spreadsheet is a tool built to analyze monthly cost based on changes in assumptions of several variables. As multiple variables are uncertain, *BYU Cost Analysis Final* provides an adaptive solution to accurately estimate price as data becomes more available (i.e. variance in gas price, ridership demand, wage, and hours and days of operation).

The estimate used for vehicle miles traveled (VMT) was NOT calculated mathematically. A travel demand estimate is still to be done by the BYU student team; this will provide more accurate estimates of VMT. However, the above range is sufficiently broad to cover a minimum and maximum VMT.

VMT Analysis

The Brigham Young University (BYU) capstone team estimated that the demand in vehicle miles traveled (VMT) should be at most **70 miles per day**, as shown in Table 1 (according to the specified assumptions). These results are based on the number of activations from bus ramps during the month of August and only include wheelchair users (not regular public using the service).

The team used the following equation and following assumptions to determine these results. Each variable in the equation has a high level of uncertainty.

$$VMT = (\#\ of\ trips) * (avg.trip\ distance) * (usage\ factor)$$

Table 3 Vehicle Miles Traveled in Each Site

Site	Bus Ramp Activations	# of Trips	Avg. Trip Distance (miles)	Usage Factor	VMT (per month)	VMT (per day)
SLC Downtown	3820	1910	2.06	0.2	785.01	26.17
South Salt Lake	4883	2442	2.56	0.2	1250.05	41.67
West Jordan	450	225	2.36	0.2	106.09	3.54
Sandy	123	62	2.73	0.2	33.58	1.12
Salt Lake City	6669	3335	3.14	0.2	2095.73	69.86
Murray	4649	2325	2.56	0.2	1190.14	39.67

Number of Trips

The total number of trips (in this analysis) is limited to wheelchair users that currently take the bus. We assume that the main population piloting the on-demand service will be those who currently use the bus system. According to the number of bus ramp activation provided by UTA, we assume that two activations equals one trip in each area.

Average Trip Distance

Average trip distance is an average of four arbitrary, conservative trip lengths selected in the site.

Usage Factor

Usage factor is the percentage of users that will use the on-demand service instead of public transit. This value varies from 6% to 20%. We assume that on-demand ridership in Salt Lake would be below average, and that paratransit demand would be even lower. But to show conservative results we used 20% (http://prospect.org/article/ridesharing-versus-public-transit).

VMT (per day)

The total vehicle miles traveled in one day is independent of number of vans. This is the total demand estimated per day.

Project Evaluation

The goal in collecting data during the pilot is to determine the overall productivity of the program. Table 4 shows a list of all of the goals, targets and data sources of the pilot. The BYU student capstone team recommends the pilot program focus on identifying demand. How many rides will be generated, and where are they coming from/going to? These questions will be key to matching supply (vehicles and drivers) to demand (riders with wheelchairs) and ultimately determining the cost. We recommend that fares are held constant to accurately measure productivity. That analysis could be done later. Productivity should be measured by number of WAV trips divided by the total number of expected WAV trips. This number can be estimated by following trends of typical Uber and Lyft usage divided by total populations.

#	Goal	Target	Primary Data Source from WAVs
1	Provide WAVs on-demand	# of WAV trips per day per vehicle	Pick-ups, vehicle option, vehicle ID, time stamps,
2	Proper utilization of WAVs	% of WAV requests on WAVs	Pick-ups, vehicle option, vehicle ID, time stamps
3	Prioritize WAV trips	100% of all WAV requests are WAV rides	Requests, cancellations, pick-ups, vehicle option, time stamps
4	Equivalent service	Wait time < 10 min + conventional	Requests, pick-ups, vehicle option, time stamps (+ conventional vehicles too)
5	Understand WAV on-demand travel patterns	TBD; identify traffic generators, customer segments, etc.	Pick-ups, drop-offs, GPS locations, vehicle option, time stamps
6	Meet WAV demand by day and time of day	>98%	Requests, pick-ups, cancellations, time stamps
7	Productive driver time	100% of drivers comply with hours of operation	Driver online status, driver user ID, time stamps
8	Customer satisfaction	>4.8 rating	Customer feedback, driver user ID, time stamps
9	Affordable pricing	TBD; how does ride cost compare to other options?	Pick-ups, drop-offs, GPS locations, cost of ride, time stamps
10	Listen to customer feedback	TBD; use as leading indicators related to safety, ease of use, etc.	Customer feedback as appropriate

Public-Private Partnership

The greatest challenge of this project was also the most valuable learning experience for the students of the BYU student capstone team. The team at UTA spent their efforts in negation of contracts with lawyers from both UTA and Lyft from mid-January to mid-April (and possibly longer). It was surprising that so much delay came from the legal negotiations. The largest factor to be discussed is liability. This involves the insurance coverage for the vehicles owned by UTA, leased to independently contracted drivers from Lyft, and funded by UDDC.

These challenges are typical in projects that involve the state, a public agency, and private providers that independently contract employees (i.e. drivers). It was obvious it would be a challenge but surprising that it was as time consuming as it was.

The team got to see firsthand how partnerships are handled and dealt with, where the project moves quickly and slowly, and why the necessary negotiations need to take place. For the student team, the capstone project was a mix of policy, engineering, and business—an excellent multidisciplinary blend of skills for career preparation.

Conclusions

The BYU capstone team worked alongside the UTA in an effort to provide equal transportation opportunities to users with disabilities, specifically users with wheelchairs. Currently, there are no on-demand services available to accommodate for the required needs of wheelchair users in Salt Lake County. The UTA has partnered with the UDDC and Lyft, to launch a pilot program that will enhance wheelchair accessible transportation. This pilot will consist of four wheelchair accessible vehicles provided by the UTA and will be deployed under Lyft's on-demand ride-hailing platform. During the pilot, tests will be performed to help understand demand, functionality and the program's associated costs.

The role of the BYU Capstone Team in the pilot program consisted of: Site selection, cost analysis, a VMT analysis, and a request for proposal that the UTA used to submit to all potential partners. All assumptions made over the course of the project were researched and justified based on the studies performed in the results of this pilot. Six potential sites were found by the BYU team in the site selection process. A combination of the UTA Paratransit Service data, pick-ups and drop-offs locations and the addresses of current paratransit users were used to identify pilot launch locations. The cost analysis presented by the BYU team included an equation to calculate the total monthly cost required to operate all four vehicles, and an analysis of which costs were most sensitive. Assumptions were made to account for all variables effecting the cost and was later compared to the monthly cost based on vehicles miles traveled.

Moving forward, we recommend that UTA uses the data provided by Lyft to determine the overall productivity of the pilot. The key will be to understand the demand of the users. Demand can be affected by fares, wait times, and overall awareness of the opportunity. We recommend that fares are held constant to accurately measure productivity. That analysis could be done later. Productivity should be measured by number of WAV trips divided by the total number of expected WAV trips. This number can be estimated by following trends of typical Uber and Lyft usage divided by total populations.

The pilot is productive if demand is met by supply and if costs of maintenance are balanced by income (or a decrease of expenses on paratransit). By identifying all WAV requests, productivity could be evaluated by wait times. It is also important that UTA seeks to understand the variables that can increase or decrease demand (i.e. fares and/or availability of WAVs).

Appendix

Appendix A

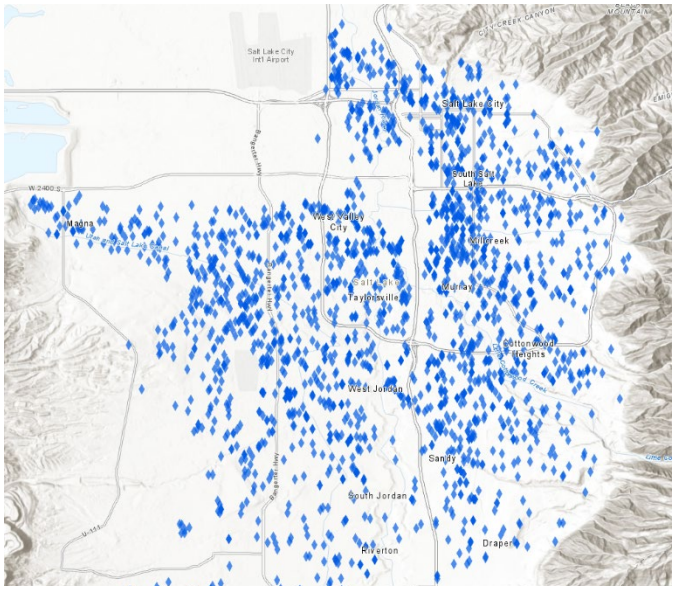

Figure 1 Addresses of qualified applicants for paratransit services (2,564 total). This data does not account for the unknown amount of wheelchair users that did not qualify for paratransit.

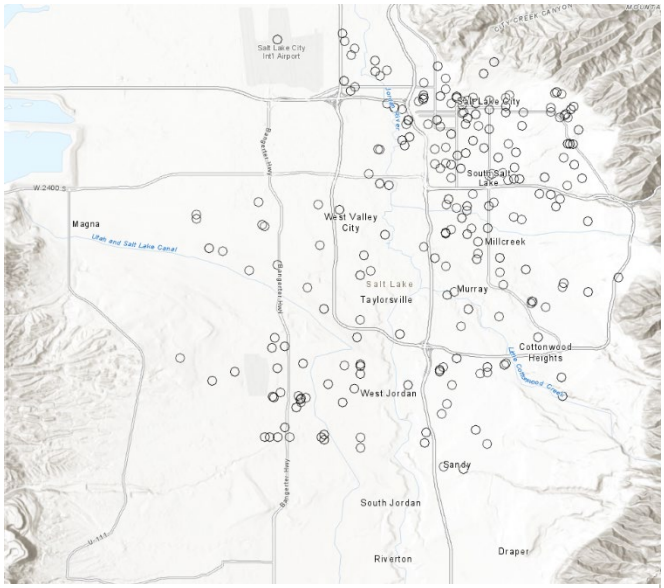

Figure 2 Locations of paratransit pick-ups from September 17-21, 2018 (554 total). Note that users must request a ride at least 24 hours in advance.

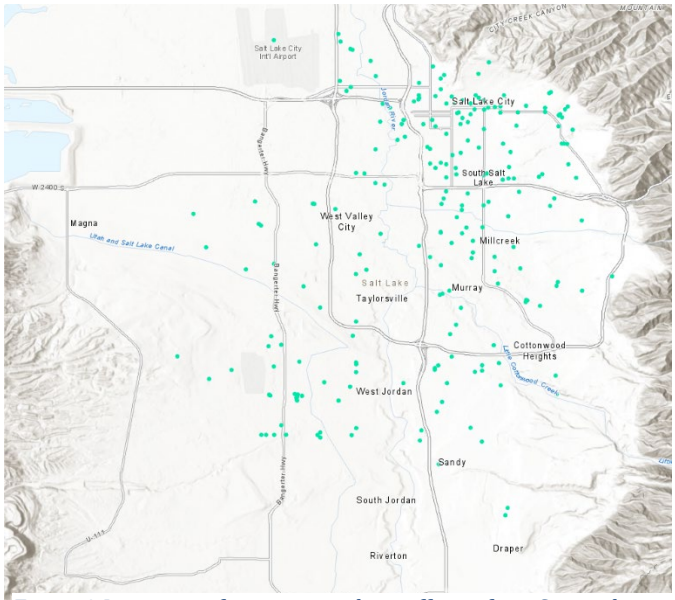

Figure 3 Locations of paratransit drop-offs ups from September 17-21, 2018 (554 total). Drop-offs occur within ¾ mile of route.

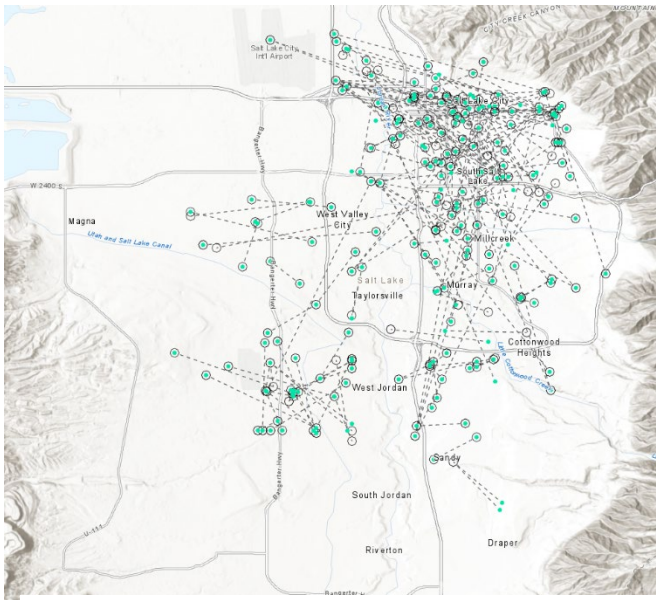

Figure 4 Connections between pick-up and drop-off ups from September 17-21, 2018. This data is highly correlated with routes that require more than one bus transfer.

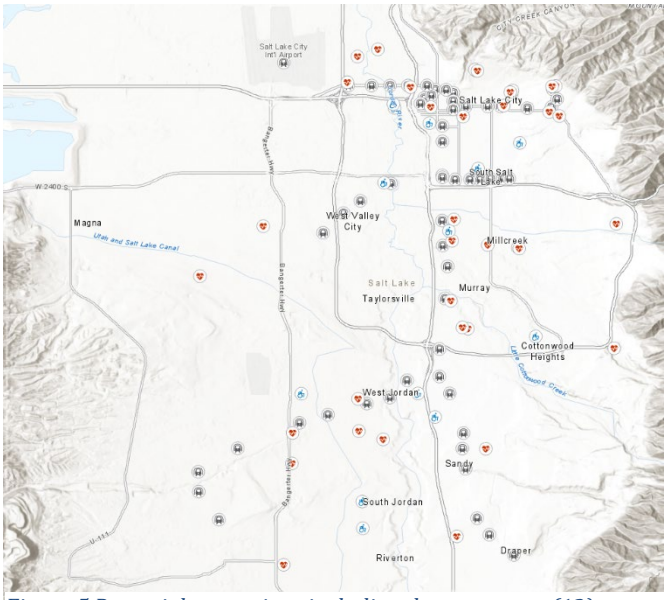

*Figure 5 Potential attractions including day programs (13), medical clinics (42), and commuter rail stations. **This data set does NOT include all day programs or medical clinics in the county. Other attractions discussed but not shown include grocery stores, shopping centers, restaurant, movie theaters, and other forms of entertainment.*

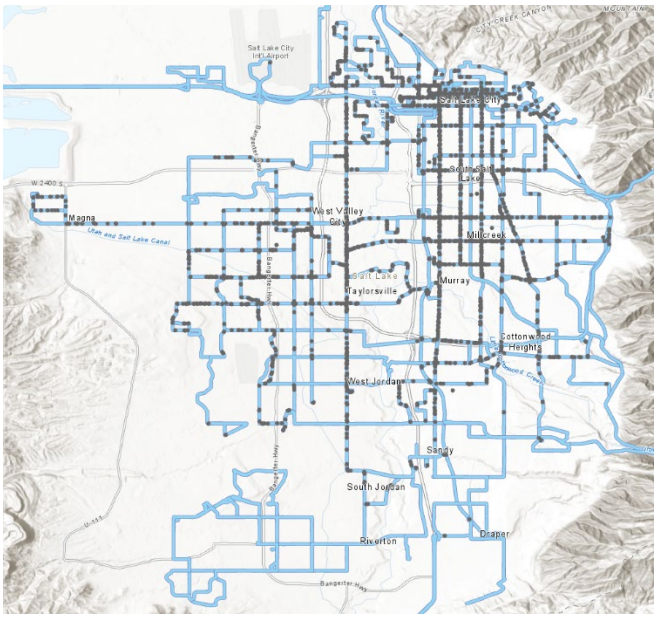

Figure 6 Bus routes and locations of ramp access activations from buses during the month of August 2018 (17,853 total). Note that every wheelchair user is to be properly strapped into the bus by the driver.

Appendix B

Variables

$\#vans$ = number of wheelchair accessible vehicles in operation
VMT = number of vehicle miles traveled per van per day
$\$gas$ = price of gas per gallon
$\#days$ = number of days of operation per month
MPG = miles per gallon of wheelchair accessible vehicle
$\$insurance$ = fixed monthly cost of insurance per vehicle
$\$maintenance/_{mile}$ = fixed cost of maintenance per vehicle per mile
$wage$ = hourly wage paid to driver
$\#hours$ = number of hours of operation per day
$\$depreciation$ = fixed monthly cost of depreciation per vehicle

General Equations

$$Total\ Monthly\ Cost = \#vans * [\frac{fuel\ cost}{month} + \frac{insurance\ cost}{month} + \frac{maintenance\ cost}{month} + \frac{labor\ cost}{month} + \frac{depreciation\ cost}{month}]$$

$$\frac{fuel\ cost}{month} = \frac{VMT * \$gas * \#days}{MPG}$$

$$\frac{insurance\ cost}{month} = \frac{\$insurance}{month}$$

$$\frac{maintenance\ cost}{month} = \frac{\$maintenance/_{mile} * VMT * \#days}{month}$$

$$\frac{labor\ cost}{month} = \frac{wage * \#hours/_{day} * \#days}{month}$$

$$\frac{depreciation\ cost}{month} = \frac{\$depreciation}{month}$$

Final Equation

$$MC = \left[\frac{VMT * \$gas * \#days * \#vans}{MPG}\right] + (\ \$insuarance * \#vans\ ) + \left[\frac{\$maintenance}{mile} * VMT * \#days * \#vans\right] + (\ wage * \#hours/_{day} * \#days * \#vans\ ) + (\ \$depreciation * \#vans\ )$$

Derivatives

$$\frac{\partial\, MC}{\partial\, \#vans} = \left[\frac{VMT * \$gas * \#days}{MPG}\right] + \$insurance + \left[\frac{\$maintenance}{mile} * VMT * \#days\right] + wage * {}^{\#hours}/_{day} * \#days + (\$depreciation)$$

$$\frac{\partial\, MC}{\partial\, wage} = \#hours * \#days * \#vans$$

$$\frac{\partial\, MC}{\partial\, \#hours} = wage * \#days * \#vans$$

$$\frac{\partial\, MC}{\partial\, \#days} = \left[\frac{VMT * \$gas * \#vans}{MPG}\right] + \left[\frac{\$maintenance}{mile} * VMT * \#vans\right] + wage * {}^{\#hours}/_{day} * \#vans$$

$$\frac{\partial\, MC}{\partial\, \$insurance} = \#vans$$

$$\frac{\partial\, MC}{\partial\, \$maintenance} = VMT * \#days * \#vans$$

$$\frac{\partial\, MC}{\partial\, \$depreciation} = \#vans$$

$$\frac{\partial\, MC}{\partial\, VMT} = \left[\frac{\#days * \$gas * \#vans}{MPG}\right] + \left[\frac{\$maintenance}{mile} * \#days * \#vans\right]$$

$$\frac{\partial\, MC}{\partial\, \$gas} = \left[\frac{\#days * VMT * \#vans}{MPG}\right]$$

$$\frac{\partial\, MC}{\partial\, MPG} = -\frac{VMT * \$gas * \#days * \#vans}{MPG^2}$$

Table 2 compares the change in cost based on VMT.

Table 2 Comparison of Monthly Cost Based on VMT

Variable	Min Value	Max Value	
Number of Vans	4	4	
Wage (per driver per hour)	$ -	$ -	
Hours of Operation (per day)	10	10	
Days of Operation (per month)	31	31	
Insurance (per month)	$ 1,200.00	$ 1,200.00	
Maintenance (per mile)	$ 0.09	$ 0.09	
Vehicle Miles Traveled (VMT) (per van per day)	25	75	
MPG	15	15	
Gas Price	$ 3.50	$ 3.50	
Depreciation (per month)	$ 855.00	$ 855.00	
Cost of Operation	$ 2.97	$ 1.20	Per mile
	$ 296.99	$ 360.66	Per day
	$ 2,301.71	$ 2,795.13	Per week
	$ 9,206.83	$ 11,180.50	Per month
	$ 2,301.71	$ 2,795.13	Per van per month

Table 3 compares change in cost based on wages, holding everything else constant (assumes $40/hour wage based on UTA standards given).

Table 3 Comparison of Monthly Cost Based on Wages

Variable	Min Value	Max Value	
Number of Vans	4	4	
Wage (per driver per hour)	$ -	$ 40.00	
Hours of Operation (per day)	10	10	
Days of Operation (per month)	31	31	
Insurance (per month)	$ 1,200.00	$ 1,200.00	
Maintenance (per mile)	$ 0.09	$ 0.09	
Vehicle Miles Traveled (VMT) (per van per day)	40	40	
MPG	15	15	
Gas Price	$ 3.50	$ 3.50	
Depreciation (per month)	$ 855.00	$ 855.00	
Cost of Operation	$ 1.98	$ 11.98	Per mile
	$ 316.09	$ 1,916.09	Per day
	$ 2,449.73	$ 14,849.73	Per week
	$ 9,798.93	$ 59,398.93	Per month
	$ 2,449.73	$ 14,849.73	Per van per month

Differently from Table 2 and Table 3, Table 4 reduces the daily and days hours of operations per month and compares change in cost based on number of vans.

Table 4 Comparison of Monthly Cost Based on Number of Vans with Reduced Hours and Days of Operation

Variable	Min Value	Max Value	
Number of Vans	2	4	
Wage (per driver per hour)	$ -	$ -	
Hours of Operation (per day)	5	5	
Days of Operation (per month)	20	20	
Insurance (per month)	$ 1,200.00	$ 1,200.00	
Maintenance (per mile)	$ 0.09	$ 0.09	
Vehicle Miles Traveled (VMT) (per van per day)	40	40	
MPG	15	15	
Gas Price	$ 3.50	$ 3.50	
Depreciation (per month)	$ 855.00	$ 855.00	
Cost of Operation	$ 2.89	$ 2.89	Per mile
	$ 230.97	$ 461.93	Per day
	$ 1,154.83	$ 2,309.67	Per week
	$ 4,619.33	$ 9,238.67	Per month
	$ 2,309.67	$ 2,309.67	Per van per month

Table 5 is the table of derivatives and shows the changes in monthly cost with respect to each variable. It calculates the slopes associated with the values from Table 4. The slope shows the amount of change in dollars per unit (i.e. maintenance slope represents the change in monthly cost increased for every dollar per mile increase, wage slope represents the change in monthly cost for every dollar per hour increase, and VMT slope represents

change in monthly price for every additional mile traveled per van per day). The steeper the slope of the variable, the more influence it has on the final monthly cost.

Table 5 Calculated Values of Derivatives of Monthly Cost with Respect to Each Variable

Variable	Slope (dollar per change in variable unit)	
	Min	Max
Number of Vans	2309.67	2309.67
Maintenance	1600.00	3200.00
Hours of Operation	0.00	0.00
Wage (Driver Rate)	200.00	400.00
Days of Operation	25.47	50.93
Gas Price	106.67	213.33
VMT	12.73	25.47
Insurance	2.00	4.00
Depreciation	2.00	4.00
MPG (negative)	24.89	49.78