Estimating Uncertainty and Misery (Index) of the Paratransit Experience TRB 103rd Annual Meeting, Washington DC, January 2024

BACKGROUND

- Transportation access has significant impacts on inclusion, well-being, and health.
- People with disabilities have additional challenges with transportation access as they cannot often use the fixed route transit systems.
- The 1990 Americans with Disabilities Act was enacted to require providers of fixed-route public transit service to provide "complementary paratransit" service to customers with disabilities.
- But transit agencies face challenges to providing paratransit services including staffing, constrained budgets, and competition of political priorities and election cycles.
- And people with disabilities face challenges with using paratransit services including scheduling difficulties, long wait times, untimely or missed pickups, long trip lengths and concern for physical and social safety while using paratransit.

RESEARCH QUESTION

What is the reliability and uncertainty associated with paratransit trips?

STUDY AREA CONTEXT

About the Regional Transit District (RTD)

- RTD serves eight counties in Colorado covering 2,342 square miles.
- Over 3 million people are served by RTD via bus, rail, shuttle, paratransit, FlexRide, and vanpool (34), with almost 3 million annual passenger miles.

RTD's Access-a-Ride Paratransit Services

- Pre-pandemic, RTD provided Access-a-Ride services to 17,000 people per week within the eight county service area.
- Paratransit users do not feel they can rely on RTD's Access-a-Ride services due to the time sink and uncertainty around scheduling trips.



Credit: Longmontleader.com

METHODOLOGY

Overview of Data Used

- We analyzed 1.16 million paratransit trips over a 30-month period (January 2019 -June 2021) in the RTD service area to calculate travel time reliability to assess the uncertainty that paratransit users experience.
- We used the FHWA guide for estimating trip reliability and used metrics of (i) travel time reliability, (ii) planning index, (iii) buffer index, (iv) misery index and skewness and kurtosis to understand spread of the trip rate:

trip rate = trip distanc

- We calculated trip duration for each trip using time stamp information associated with the start and end of a trip for each user.
- We calculated trip distance was calculated as Euclidean distance between pick up and drop off locations.
- We grouped trips into short (< 5 miles), medium (between 5 and 12 miles), and long (> 12 miles) and time of day AM Peak (6 AM - 9 AM), PM Peak (3 PM - 7 PM), Off Peak 1 (9 AM - 3 PM) or Off Peak 2 (7 PM - 6 AM).
- We compared the metrics to experiences shared by people with disabilities using RTD paratransit services.

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ANALYSIS

Table 1. Summary Statistics for Trip Rate, Trip Distance, and Trip Time for Different Trip Lengths

Trip Rate (1	miles/min)									
110 200	1111C5/11111)	Trip Rate (miles/min)								
118,322	304,194	272,717								
0.25 (0.19, 0.34)	0.21 (0.16, 0.27)	0.15 (0.10, 0.19)								
0.07, 60.70	0.03, 53.36	0.00, 38.45								
0.28 (0.38)	0.22(0.25)	0.15(0.17)								
1.36	1.14	1.13								
Trip Distan	ce (Miles)									
15.3 (13.4, 17.7)	7.7 (6.2, 9.5)	3.0 (1.9, 4.0)								
12.0, 46.5	5.0, 12.0	0.0, 5.0								
16.1(3.7)	7.9(2.0)	2.9(1.3)								
Trip Time (mins)										
62 (46, 80)	36 (27, 51)	19 (14, 25)								
0, 167	0, 165	0, 164								
65(24)	41(19)	22(13)								
	$118,322$ $0.25 (0.19, \\ 0.34)$ $0.07, 60.70$ $0.28 (0.38)$ 1.36 Trip Distan $15.3 (13.4, \\ 17.7)$ $12.0, 46.5$ $16.1(3.7)$ Trip Tim $62 (46, 80)$ $0, 167$ $65(24)$	1118,322 304,194 0.25 (0.19, 0.34) 0.21 (0.16, 0.27) 0.07, 60.70 0.03, 53.36 0.28 (0.38) 0.22(0.25) 1.36 1.14 Trip Distance (Miles) 15.3 (13.4, 17.7) 7.7 (6.2, 9.5) 12.0, 46.5 5.0, 12.0 16.1(3.7) 7.9(2.0) Trip Time (mins) 62 (46, 80) 36 (27, 51) 0, 167 0, 165 65(24) 41(19)								

Figure 1. Distribution of Trip Rate across Different Trip **Class and Trip Start Time**



Measuring Travel Time Reliability using Metrics Recommended by the FHWA

• **Travel Time Index:** Measure of how much worse travel is due to congestion compared to free flow.

> travel time during peak periods Travel Time Index $(tti) = \frac{dtave}{dtave}$ travel time during freeflow

• **Buffer Index:** Measure of measure of how much extra time a person should budget to ensure that they reach their destination on time 95% of the time.

Additional time budget for ontime arrival 95% of the time Buffer Index (bi) =

• **Planning Index:** The total time needed to be planned for the trip to ensure that the person reaches the destination on time 95% of the time. The difference between planning index and buffer index is that while buffer index is the additional time needed for on time arrival 95% of the time, planning index is the total time needed for the trip to ensure on time arrival 95% of the time. For our analysis, noting that when a paratransit trip is requested, the requester is given a 2-hour window for pickup, we include that time in the estimation of the planning index, along with the buffer time.

Planning Index (pi) = Total time allocated for the trip to be ontime 95% of the time

Table 3. Summary of Reliability Metrics for Different Trip Class

Metrics

Travel time Buffer Index Planning In Misery Inde

Variable	AM Peak	PM Peak	Off Peak 1	Off Peak 2			
Short Distance Trip Rate (miles/min)							
Ν	55,671	54,949	137,864	24,233			
Median	0.15 (0.10,	0.13 (0.09,	0.15 (0.10,	0.16 (0.11,			
(IQR)	0.20)	0.18)	0.20)	0.21)			
Range	0.00, 20.75	0.00, 12.46	0.00, 38.45	0.00, 22.95			
Mean	0.15	0.14	0.15	0.16			
	Medium Dista	nce Trip Rate ((miles/min)				
Ν	80,763	65,014	133,163	25,254			
Median	0.19 (0.14,	0.20 (0.15,	0.22 (0.17,	0.26 (0.20,			
(IQR)	0.25)	0.25)	0.28)	0.32)			
Range	0.03, 22.50	0.03, 52.60	0.04, 49.99	0.05, 53.36			
Mean	0.2	0.21	0.23	0.27			
	Long Distance	e Trip Rate (m	niles/min)	_			
Ν	36,975	26,890	43,214	11,243			
Median	0.21 (0.18,	0.27 (0.21,	0.28 (0.21,	0.30 (0.21,			
(IQR)	0.28)	0.34)	0.38)	0.41)			
Range	0.08, 57.87	0.07, 60.70	0.08, 32.64	0.08, 6.42			
Mean	0.24	0.29	0.3	0.32			

Off Peak 1

- associated with it.
- person on the trip. Misery Index =

Table 2. Summary Statistics for Trip Rate for Different Trip Lengths and Peak and Off-Peak Hours

• Table 1 shows the average trip rate for short distance trips is 0.15 miles/min or **9 miles/hour**, for medium distance trips 0.22 miles/hour or **12.2 miles/hour,** and for long distance trips 0.28 miles/min or **16.8 miles/hour**, which are close to the average speed at which bicyclists travel (~12 miles/hour) and about half of average car speed on an arterial (~25 miles/hour).

 Table 1 and Figure 1 show the trip rate is significantly lower for short distance trips than for long distance trips. However, the variability associated with trip rate is much higher for longer and medium long trips than for shorter trips as shown in the range statistic for trip rate.

• For all three trip types, the standard deviation (SD) is higher than the mean and hence the coefficient of variation (COV) which is measured as a ratio of population SD to population mean, is greater than 1.

• As shown in Table 1, COV for trip rate is greater than 1 for long, medium and short distance trips, indicating high variability for all three trip types.

• It appears that short distance trips are time consuming but slightly more reliable while longer distance trips are sometimes time efficient but have a large amount of uncertainty

• **Misery Index:** Measure of how much worse the longest trips are as compared to average trips. It is measured as the ratio of the difference of the average trip time for the worst 20% trips and the average trip time of all trips to the average trip time of all trips. The misery index is particularly relevant for the paratransit trips as people in the same trip may experience different travel time depending on if they are picked up as the first person or the last

> travel time for worst 20% trips) – (Average travel time) Average travel time

Table 3 shows the metrics of travel time index, buffer index, planning index and misery index for each of short distance trips, medium distance trips and longer distance trips.

	Short Distance	Medium Distance	Long Distance
	AM:1.10,	AM:1.37,	AM:1.43,
index	PM:1.23	PM:1.30	PM:1.11
ex	0.6	0.31	0.32
ndex	170	175	200
ex	1.67	1.14	0.88

Short Distance Trips:

- at least 170 minutes (~3 hours) for a one-way 3-mile trip.

Medium Distance Trips:

- The median trip distance is 7.7 miles (Table 1)

Long Distance Trips:

- trip or ~6.5 hours for a 15 mile round trip

Validating User Experience

- with RTD paratransit services.
- unless necessary.

F The ride options such as Via and Access-a-ride are very good options, but the biggest problem with those is there's just too few of them going so the wait times are very long and you're forced to make reservations or appointments to reserve your ride days and sometimes longer in advance in order to get the day that you want.

– #17-I, Man with Wheelchair

- paratransit user.

- self-sufficiency.

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FINDINGS

• For short distance trips, a median trip distance is 3 miles (Table 1) • Buffer Index: For a median short distance trip length, a buffer time of **10 minutes is needed** • *Planning Index:* For a median short distance trip of average duration of 20 minutes, **150 minutes is needed** • *Misery Index:* The worst 20% of paratransit trips will have a planning index of 170 minutes or that they need to block off

• Buffer Index: For a median medium distance trip length, a buffer time of **11.43 minutes is needed** • Planning Index: For a median medium distance trip of average duration of 30 minutes, **168.13 minutes is needed** • *Misery Index:* The worst 20% of paratransit trips will have a planning index of 175 minutes or that they need to block off at least 175 minutes (~3 hours) or 6 hours for a 7.7-mile round trip.

• For long distance trips, the median trip distance is 15.30 miles (Table 1) • Buffer Index: For a median long distance trip length, a buffer time of **19.30 minutes is needed** • *Planning Index:* For a median long distance trip of average duration of 20 minutes, **200.52 minutes is needed** • *Misery Index:* The average trip rate for the worst 20% of long-distance trips is 0.16 miles/min, indicating the average travel time for a 15.3 mile trip is 95.63 minutes. The planning index for long distance trips is higher than the total trip time, indicating less overall trip budget variation. The average time budget needed is 200 minutes or 3.3 hours for one

• To validate our analysis, we reviewed transcripts from interviews with people with disabilities discussing experiences

• Interview participants shared that paratransit can be a good option for people with disabilities. However, having to schedule far in advance, long wait times, and long rides may add stress to people's daily life, making it not worth using

> **I** don't have my own vehicle, so I can't just jump in a car or go to the store and come back and I'm done in 15 minutes. I have to plan for and wait for a ride to go to the grocery store, get to an appointment, or anything else I want to do. Then I have to hope they show up on time. It's just tons and tons of planning to be able to take paratransit. I don't mind doing it because I'm used to it, but sometimes it's just so time consuming.

> > – #5-1, Woman with multiple disabilities

CONCLUSIONS

• We find that paratransit trip rates are 9-16 miles/hour as compared to an average 25 miles/hour for vehicular travel.

• There is significant uncertainty and variability associated with the trips depending on trip start time, as most paratransit trips end up starting at off peak hours likely to avoid that uncertainty.

• Our results suggest that if a paratransit user has, a medical appointment at noon located approximately 8 miles away, they would need to request a 10 AM paratransit ride in order to feel comfortable that they will arrive on time and be prepared for the ride to arrive from 9 AM. Assuming a 1-hour appointment and a similar turnaround time for the paratransit trip home, they can reasonably expect to be home by 4 PM.

• The sort of appointment that many people try to accomplish during their lunch break can take up the entire day for a

• While paratransit service has the benefit of providing low cost mobility solution to mobility impaired people, having to budget 6 hours and more of commute time for any trip is detrimental to anyone's willingness to travel.

• Paratransit has a huge deterrence to on-time arrival for work or any time-sensitive appointments like medical appointments and creates another handicap for the mobility impaired people in achieving self-sufficiency.

• There is a need to understand how this structural inefficiency can be reduced, including giving an unrealistic wait time window of 2 hours for any trip so that mobility impaired people can have an equitable chance to better life quality and

ACKNOWLEDGMENTS