

# Estimating Transit Fares for Travel Demand Models Using On-Board Surveys



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TRB National Transportation Planning Applications Conference (Atlantic City, NJ)

May 19, 2015

**AECOM**

# Transit Fares in Demand Models

- Modeled fare is usually either full cash fare or some approximation based on the monthly pass and other fare types
- Issue: Inaccurate representation of the fare paid by an average rider
  - Key travel markets could be under- or over-estimated
  - Forecasts made by the model can be potentially distorted
- Solution: Use on-board transit surveys that ask questions related to the fare type and fare medium used by riders to estimate transit fare

# On-board Surveys

- Questions related to origin/destination locations, access/egress modes, on/off stops, trip purpose etc. are asked
- Primarily used to understand travel patterns and characteristics of existing riders
- Play a critical role in the calibration and validation of models

**1. I ORIGINALLY STARTED THIS ONE-WAY TRIP AT:**  
 Work  Home  Shopping  Social/Recreational  Airport  
 School(K-12)  College/University  Other \_\_\_\_\_  
*(ex. Hotel, doctor, etc.)*

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**2. WHICH IS LOCATED AT (IMPORTANT!):**  
 \_\_\_\_\_  
*(Please provide the nearest cross-street or intersection and City)*

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**3. TO GET TO TRI-RAIL I ARRIVED BY:**  
 Walking  Taxi  
 School Bus  Metrorail  
 Bike, and used:  Bike Locker  Bike Rack  Bike on Train  
 Transit Bus (Agency/Route #) \_\_\_\_\_  
 Tri-Rail Shuttle Bus (Route Name) \_\_\_\_\_  
 Drove and Parked (How many people in car) \_\_\_\_\_  
 Dropped Off  
 Other (Please specify) \_\_\_\_\_

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**4. I GOT ON THIS TRAIN AT:** \_\_\_\_\_ Station  
*Station Name*

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**5. I WILL GET OFF THIS TRAIN AT:** \_\_\_\_\_ Station  
*Station Name*

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**6. I WILL LEAVE THE TRI-RAIL STATION BY:**  
 Walking  Taxi  
 School Bus  Metrorail  
 Biking  
 Transit Bus (Agency/Route #) \_\_\_\_\_  
 Tri-Rail Shuttle Bus (Route Name) \_\_\_\_\_  
 Parked Car (How many people in car) \_\_\_\_\_  
 Picked up  
 Other (Please specify) \_\_\_\_\_

# CASE STUDY



# Tri-Rail Overview

72-mile commuter rail system in Southeast Florida

17 stations across 3 counties

1hr 45min traveling time

50 trains/day service

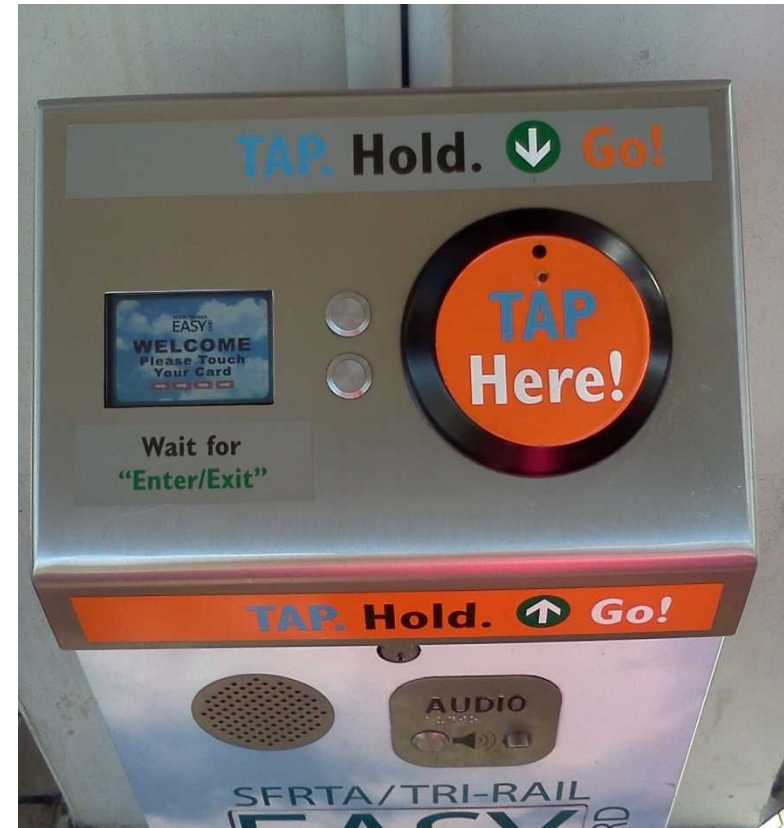
14,300 average daily riders (2013)

Six zones used to determine weekday fare



# Tri-Rail Fare Types and Discounts

- Fare Types
  - One-way
  - Round-trip
  - 12-trip
  - Monthly
  - Regional Monthly
- Fare Medium
  - Easy Card
  - Paper Ticket
- Discounts
  - Employee Discount Program (EDP) – 25% discount on monthly and 12-trip passes to participating businesses
  - 50% discount on one-way, round-trip and monthly passes for students, children ages 5-12 and seniors



# Tri-Rail Fares

No. of zones traveled	One-way	Round-trip	12-Trip	Monthly	Regional Monthly
1	\$2.50	\$4.40	\$21.25	\$100.00	\$145.00
2	\$3.75	\$6.25	\$31.25		
3	\$5.00	\$8.45	\$41.90		
4	\$5.65	\$9.70	\$47.50		
5	\$6.25	\$10.65	\$52.50		
6	\$6.90	\$11.55	\$57.50		



# Survey Data

- Survey conducted in February 2013
- 28 trains surveyed (14 in each direction)
- Station level door counts on all 50 trains on the survey date
- 3,739 useable records – 26% sample rate
- Expansion method – Iterative Proportional Fitting (IPF) by time of day and direction
  - Six seed matrices (3 time periods x 2 directions)
  - Expanded to 14,300 average daily trips



# Fare Related Questions

**10. THE FARE I USED FOR THIS ONE-WAY TRIP WAS:**

Fare Type:     Full Fare     EDP     Discount

Fare Medium:     Easy Card     Paper Ticket

Fare:     One-way     Round-trip     12 Trip     Monthly  
 Regional Monthly

- 70% of the final expanded trips had responses for the fare question

Fare	Total	Total %
Monthly	3,944	40%
Regional Monthly	1,266	13%
12 Trip	963	10%
Round-trip	2,089	21%
One-way	1,688	17%
<b>Grand Total</b>	<b>9,950</b>	<b>100%</b>

# Average Fare Estimation (1 of 6)

- Generate station-to-station flow matrices for each of the five fare types from the survey

Monthly Trips	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Grand Total
1-Mangonia Park			13		3	68	17	16	34	23	41	13	13	10	13	7	9	280
2-West Palm Beach	39				6	120	30	23	37	15	23	5	14	6	3	8	21	351
3-Lake Worth	54					116	13	24	44	40	39	25	24	31	23	15	16	464
4-Boynton Beach	36	33				51	7		109	28	68	9	11		12		13	375
5-Delray Beach		13				4		4	40	50	4	13				12	7	148
6-Boca Raton	36	46	15	2				12	15	10		17	17	15	4	10	9	208
7-Deerfield Beach	49	49	14		3					12	30			27	9	20	26	239
8-Pompano Beach	61	25	11		24	6				3	7	8		5		37	24	212
9-Cypress Creek	18	57	15	12	5	17				9	9	7			15	31	46	240
10-Ft. Lauderdale	18	40	9	12	28	81	11				3			4	10	3	14	233
11-Ft. Lauderdale Airport	8	52	19	7		60	16		6							18	23	211
12-Sheridan	27	10		13	7	72	16	27	24							12		209
13-Hollywood	9	23	12	17	29	84	9		13							9	21	227
14-Golden Glades	8		13	3	4	106	35	17	16	9								211
15-Opa-Locka	3		5	9	3	10	15	21	3	2							4	74
16-Metro-rail transfer			2		4	8			10	13	5	14					4	60
17-Hialeah Market		19	11	5	9	17	35		67	12	14	3	3			7		201
<b>Grand Total</b>	<b>367</b>	<b>367</b>	<b>139</b>	<b>80</b>	<b>125</b>	<b>820</b>	<b>204</b>	<b>144</b>	<b>419</b>	<b>226</b>	<b>243</b>	<b>114</b>	<b>81</b>	<b>99</b>	<b>89</b>	<b>189</b>	<b>238</b>	<b>3,944</b>

## Average Fare Estimation (2 of 6)

- Generate corresponding station-to-station “average one-way fare” matrices for each of five fare types

No. of zones traveled	One-way	Round-trip	12-trip	Monthly	Regional Monthly
1	\$2.50	\$4.40	\$21.25	\$100.00	\$145.00
2	\$3.75	\$6.25	\$31.25		
3	\$5.00	\$8.45	\$41.90		
4	\$5.65	\$9.70	\$47.50		
5	\$6.25	\$10.65	\$52.50		
6	\$6.90	\$11.55	\$57.50		

Actual cost of each fare type



No. of zones traveled	One-way	Average for Round-trip	Average for 12-trip	Average for Monthly	Average for Regional Monthly
1	\$2.50	\$2.20	\$1.77	\$2.27	\$3.30
2	\$3.75	\$3.13	\$2.60	\$2.27	\$3.30
3	\$5.00	\$4.23	\$3.49	\$2.27	\$3.30
4	\$5.65	\$4.85	\$3.96	\$2.27	\$3.30
5	\$6.25	\$5.33	\$4.38	\$2.27	\$3.30
6	\$6.90	\$5.78	\$4.79	\$2.27	\$3.30

Average one-way fare

# Average Fare Estimation (3 of 6)

Sample “average one-way fare” matrices

12 Trip Fare	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1-Mangonia Park	0.00	1.77	1.77	2.60	2.60	3.49	3.49	3.49	3.96	3.96	4.38	4.38	4.38	4.79	4.79	4.79	4.79
2-West Palm Beach	1.77	0.00	1.77	2.60	2.60	3.49	3.49	3.49	3.96	3.96	4.38	4.38	4.38	4.79	4.79	4.79	4.79
3-Lake Worth	1.77	1.77	0.00	2.60	2.60	3.49	3.49	3.49	3.96	3.96	4.38	4.38	4.38	4.79	4.79	4.79	4.79
4-Boynton Beach	2.60	2.60	2.60	0.00	1.77	2.60	2.60	2.60	3.49	3.49	3.96	3.96	3.96	4.38	4.38	4.38	4.38
5-Delray Beach	2.60	2.60	2.60	1.77	0.00	2.60	2.60	2.60	3.49	3.49	3.96	3.96	3.96	4.38	4.38	4.38	4.38
6-Boca Raton	3.49	3.49	3.49	2.60	2.60	0.00	1.77	1.77	2.60	2.60	3.49	3.49	3.49	3.96	3.96	3.96	3.96
7-Deerfield Beach	3.49	3.49	3.49	2.60	2.60	1.77	0.00	1.77	2.60	2.60	3.49	3.49	3.49	3.96	3.96	3.96	3.96
8-Pompano Beach	3.49	3.49	3.49	2.60	2.60	1.77	1.77	0.00	2.60	2.60	3.49	3.49	3.49	3.96	3.96	3.96	3.96
9-Cypress Creek	3.96	3.96	3.96	3.49	3.49	2.60	2.60	2.60	0.00	1.77	2.60	2.60	2.60	3.49	3.49	3.49	3.49
10-Ft. Lauderdale	3.96	3.96	3.96	3.49	3.49	2.60	2.60	2.60	1.77	0.00	2.60	2.60	2.60	3.49	3.49	3.49	3.49
11-Ft. Lauderdale Airport	4.38	4.38	4.38	3.96	3.96	3.49	3.49	3.49	2.60	2.60	0.00	1.77	1.77	2.60	2.60	2.60	2.60
12-Sheridan	4.38	4.38	4.38	3.96	3.96	3.49	3.49	3.49	2.60	2.60	1.77	0.00	1.77	2.60	2.60	2.60	2.60
13-Hollywood	4.38	4.38	4.38	3.96	3.96	3.49	3.49	3.49	2.60	2.60	1.77	1.77	0.00	2.60	2.60	2.60	2.60
14-Golden Glades	4.79	4.79	4.79	4.38	4.38	3.96	3.96	3.96	3.49	3.49	2.60	2.60	2.60	0.00	1.77	1.77	1.77
15-Opa-Locka	4.79	4.79	4.79	4.38	4.38	3.96	3.96	3.96	3.49	3.49	2.60	2.60	2.60	1.77	0.00	1.77	1.77
16-Metro-rail transfer	4.79	4.79	4.79	4.38	4.38	3.96	3.96	3.96	3.49	3.49	2.60	2.60	2.60	1.77	1.77	0.00	1.77
17-Hialeah Market	4.79	4.79	4.79	4.38	4.38	3.96	3.96	3.96	3.49	3.49	2.60	2.60	2.60	1.77	1.77	1.77	0.00

# Average Fare Estimation (4 of 6)

- For each of the fare types:
  - “station-to-station flow” matrix
  - X
  - “average one-way fare” matrix
  - =
  - “revenue” matrix
- Three matrices to estimate the average zonal fare
  - Sum of all the “station-to-station flow” matrices: **total trips**
  - Sum of all the “revenue” matrices: **total revenue**
  - Fare zone matrix which shows the number of zones traveled between any two stations: **zones**

# Average Fare Estimation (5 of 6)

Total Trips	1	2	3	4	5	6	7
1-Mangonia Park	0	20	22	33	35	114	32
2-West Palm Beach	66	0	26	26	41	187	37
3-Lake Worth	110	17	0	6	29	191	61
4-Boynton Beach	67	63	0	0	7	90	34
5-Delray Beach	41	42	31	13	0	8	7
6-Boca Raton	58	92	42	6	0	0	3
7-Deerfield Beach	78	71	27	10	10	0	0

Sample "Total Trips" matrix

Total Revenue (\$)	1	2	3	4	5	6	7
1-Mangonia Park	0	49	52	102	113	347	88
2-West Palm Beach	154	0	64	87	128	555	99
3-Lake Worth	251	43	0	22	86	575	250
4-Boynton Beach	181	183	0	0	14	249	114
5-Delray Beach	131	122	101	24	0	23	28
6-Boca Raton	167	295	149	15	0	0	7
7-Deerfield Beach	221	195	84	35	26	0	0

Sample "Total Revenue" matrix

Sample "Fare Zone" matrix

Fare Zone	1	2	3	4	5	6	7
1-Mangonia Park	0	1	1	2	2	3	3
2-West Palm Beach	1	0	1	2	2	3	3
3-Lake Worth	1	1	0	2	2	3	3
4-Boynton Beach	2	2	2	0	1	2	2
5-Delray Beach	2	2	2	1	0	2	2
6-Boca Raton	3	3	3	2	2	0	1
7-Deerfield Beach	3	3	3	2	2	1	0

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# Average Fare Estimation (6 of 6)

Average zonal fare:

No. of zones traveled	Trips	Revenue	Average Fare
1	566	\$ 1,305	\$ 2.30
2	2,327	\$ 7,045	\$ 3.03
3	3,401	\$ 10,854	\$ 3.19
4	2,127	\$ 7,392	\$ 3.47
5	870	\$ 3,170	\$ 3.64
6	659	\$ 2,740	\$ 4.16
<b>Total</b>	<b>9,950</b>	<b>\$ 32,506</b>	<b>\$ 3.27</b>

<i>One-way</i>	<i>Average for Round-trip</i>	<i>Average for 12-trip</i>
\$2.50	\$2.20	\$1.77
\$3.75	\$3.13	\$2.60
\$5.00	\$4.23	\$3.49
\$5.65	\$4.85	\$3.96
\$6.25	\$5.33	\$4.38
\$6.90	\$5.78	\$4.79

# Adjustments for Work and Non-Work Trips

- 60% of the work trips use ‘regional monthly’ or ‘monthly’ passes, whereas only 25% of non-work trips use these passes
  - Workers are eligible for employee discount programs, making these passes very attractive
- Adjustments to account for these characteristics
  - Re-estimate average fare separately for work and non-work trips
  - Develop adjustment factors

<b>Trip Purpose</b>	<b>Average Fare</b>	<b>Adjustment Factor</b>
<b>All purposes</b>	<b>\$ 3.27</b>	<b>-</b>
Home-based Work	\$ 3.05	0.9
Home-based Non-Work and Non-Home Based	\$ 3.95	1.2



## Impacts on the Model

- Compared 'before' and 'after' model results
  - 'Before': using a 12-trip zonal fare on Tri-Rail
  - 'After': using the new fare estimated from the survey

	No. of stations traveled	Before	After	Delta
<u>Work Trips</u>	1	541	483	-58
	2	603	581	-22
	3	783	795	12
	3+	4,767	5,413	646
	<b>Total</b>	<b>6,694</b>	<b>7,272</b>	<b>578</b>

- Increase in overall magnitude of long distance work trips
  - Aligns with findings from survey
- Decrease in overall magnitude of non-work trips
  - Aligns with findings from survey

# Conclusions

- Better and more accurate representation of average transit fare in demand models
  - Very useful for transit systems using a zonal fare structure
  - Adjustments to fare can be done by trip purpose
- Better estimates from the model
  - Results directly tied to observable behavior of users
- Similar methodology can be used to estimate bus fares
- Beneficial to have questions related to fare type and fare medium in on-board transit surveys

# Acknowledgments

- South Florida Regional Transportation Authority (SFRTA)
- Florida Department of Transportation (FDOT)

# THANK YOU!

