The ARRF II Model

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ARRF-II
Overview of Presentation

- Introduction to the Aggregate Rail Ridership Forecasting Model (ARRF)
- Application issues with ARRF-I
- Goals for ARRF-II
- ARRF-II Calibration
- ARRF-II Forecasts
  - Charlotte
  - Phoenix

Introduction to ARRF

- New generation of rail projects offers opportunity to understand markets and ridership experience outside very largest metropolitan areas
- Forecasting for new projects could usefully tap this experience, if done carefully:
  - Relatively simple, robust approach
  - Transferable using consistently available data
- Idea grew out of Charlotte aggregate forecasts based on model developed by the Phoenix MPO

ARRF
Purpose and Basic Approach

- Purpose: Supplement conventional forecasting models with:
  - Insights into reasonableness of forecasts
  - Understanding of potential markets
  - ***TARGETS*** for model calibration in starter-line cases
  - ***BASIS FOR QC*** comparisons in system-expansion cases

- Aggregate Rail Ridership Forecasting (ARRF) Model relates:
  - Y2000 CTPP JTW

    - to -
  - NTD ~Y2000 rail ridership

ARRF-I

LRT Systems Used to Calibrate Model

- Excluded very largest metro areas
- Year 2000 unless more recent data matches survey that provides insights into travel patterns
- Snapshot of ridership and system extent at a single point in time

City	Year	Weekday Unlinked Trips
Baltimore	2000	27,415
Buffalo	2000	23,155
Cleveland	2000	14,062
Dallas	2000	37,682
Denver	2001	31,423
Portland	2000	73,562
Sacramento	2000	29,102
Salt Lake City	2002	33,615
San Diego	2000	83,474
San Jose	2001	30,295
St. Louis	2002	37,281

Source: National Transit Database

ARRF-I

Commuter Rail Systems Used to Calibrate Model

- Excluded very largest metro areas
- National Transit Database used except for ACE where 2000 appeared to be an outlier
- Snapshot of ridership and system extent at a single point in time

City	Year	Weekday Unlinked Trips
Baltimore-DC MARC	2000	20,851
Dallas-Ft. Worth TRE	2000	4,229
LA Metrolink	2000	26,300
Miami Tri-Rail	2000	7,381
San Diego Coaster	2000	4,327
San Francisco Caltrain	2000	30,616
San Jose ACE	2000	3,500
Seattle Sounder	2000	1,120
Washington DC VRE	2000	8,057

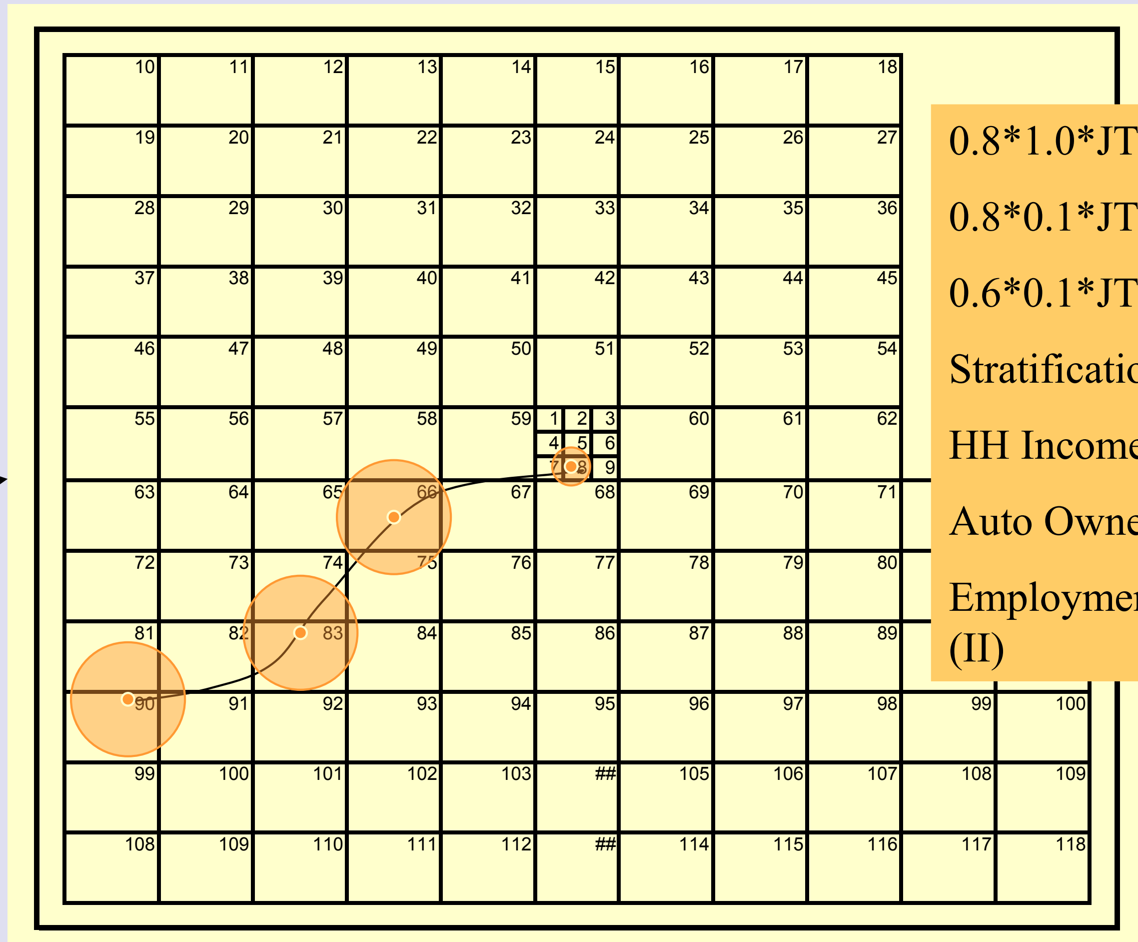
Source: National Transit Database (APTA for ACE)

ARRF-I
Model Structure

- Separate models for LRT and commuter rail
- LRT model:
  - CTPP Flows stratified by employment density
- Commuter rail model:
  - CTPP Flows stratified by employment density and income
  - Level-of-Service variables:
    - Speed (NTD vehicle miles/vehicle hours)
    - Train miles per direction route mile
    - Connection to rail distributor (only Seattle has none)

ARRF-I

Sample Computation of CTPP JTW Inputs



0.8*1.0*JTW(90 to 8)

0.8*0.1*JTW(90-to-7)

0.6*0.1*JTW(81-to-7)

Stratifications:

HH Income (Part I)

Auto Ownership (III)

Employment Density (II)

Schematic zone map

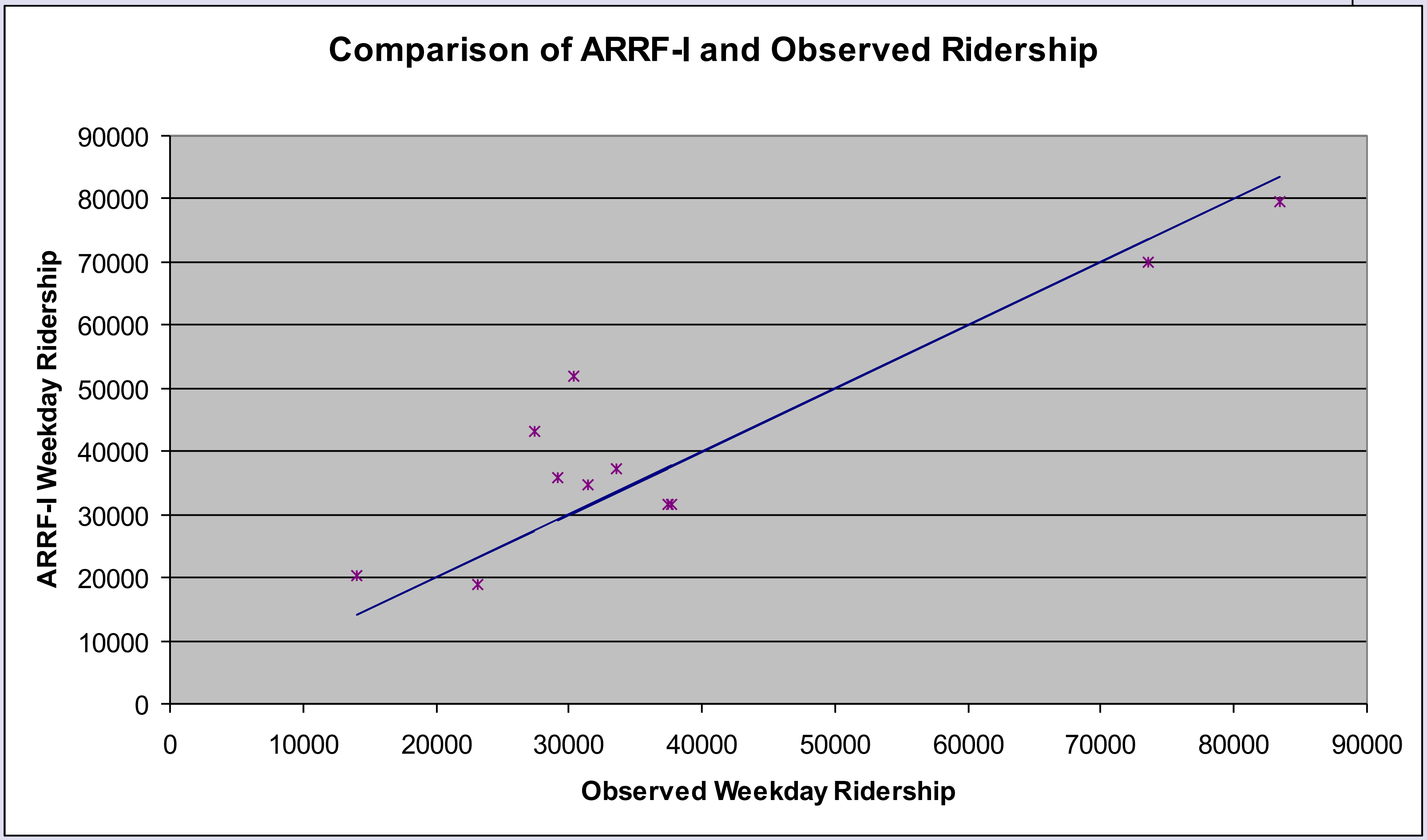
ARRF-I
LRT Model

Weekday Unlinked
Drive Access to Work
Rail Trips= 0.030 * CTPP PNR 6 -to-1 Mile JTW Flows (<50K Den) +
0.202 * CTPP PNR 6 -to-1 Mile JTW Flows (>50K Den)

Weekday Unlinked Other
(Non-Drive Access to Work)
Rail Trips= 0.395 * CTPP 2 -to-1 Mile JTW Flows (<50K Den) +
0.449 * CTPP 2 -to-1 Mile JTW Flows (>50K Den)

Total Weekday Unlinked
Rail Trips= Weekday Unlinked Drive Access to Work Rail Trips +
Weekday Unlinked Other Rail Trips

ARRF-I
LRT Predicted vs. Actual



$R^2 = 0.958$

ARRF-I

Commuter Rail Model

Commuter Rail Weekday
Unlinked Trips =Nominal Ridership x Demand Adjustment Factor

Nominal Ridership=

0.069*High Income CTPP Flows within 6 miles of a PNR station at the home end and 1 mile of any station at the work end of the trip +

0.041*Medium Income CTPP Flows within 6 miles of a PNR station at the home end and 1 mile of any station at the work end of the trip +

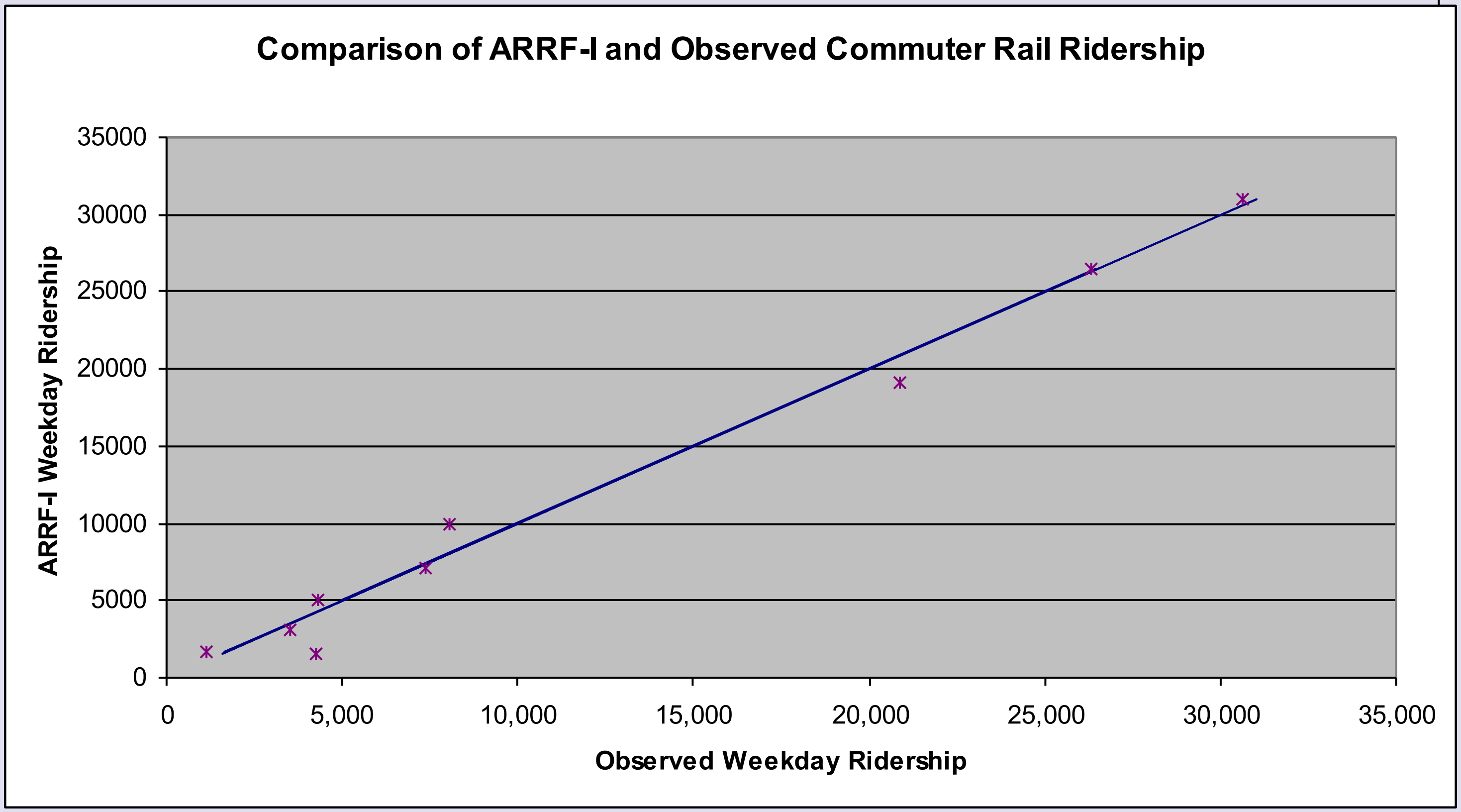
0.151*Low Income CTPP Flows within 2 miles of any station at the home end and 1 mile of any station at the work end of the trip

Demand Adjustment Factor=

(1+0.3*Percent Deviation in Average System Speed) x
(1+0.3*Percent Deviation in Train Miles per Mile) x Rail Connection Index

ARRF-I

Commuter Rail Predicted vs. Actual



$R^2 = 0.993$

Application of ARRF I to New Projects

City/Ridership Estimate	Market: Walk Access	Drive Access	Special Events	Total
Charlotte				
Observed (April 2008 Survey)	10,800	4,000	(note 1)	14,800
Observed (June 2008 Counts)				16,500
Forecast (Model: local calibration to bus ridership)	4,300	2,100		6,400
Forecast (Model with Houston PNR Constants)	4,400	3,100	1,700	9,200
ARRF-I	8,300	4,100		12,400
Phoenix				
Observed (January 2001 counts/1st Month of operation)				30,000
Forecasted (New Starts Report)				26,100
ARRF-I				26,400

Note 1: Significant special event ridership observed on an anecdotal basis

ARRF-II
Needs Identified from ARRF- I Application

- Unified commuter rail / LRT model
- Improved processing of CTPP input data to exclude trips that would use same station to board/alight
- More accurate characterization of trips by work/non-work and mode of access based on FTA survey data library
- More accurate selection of year consistent with survey data and mature markets

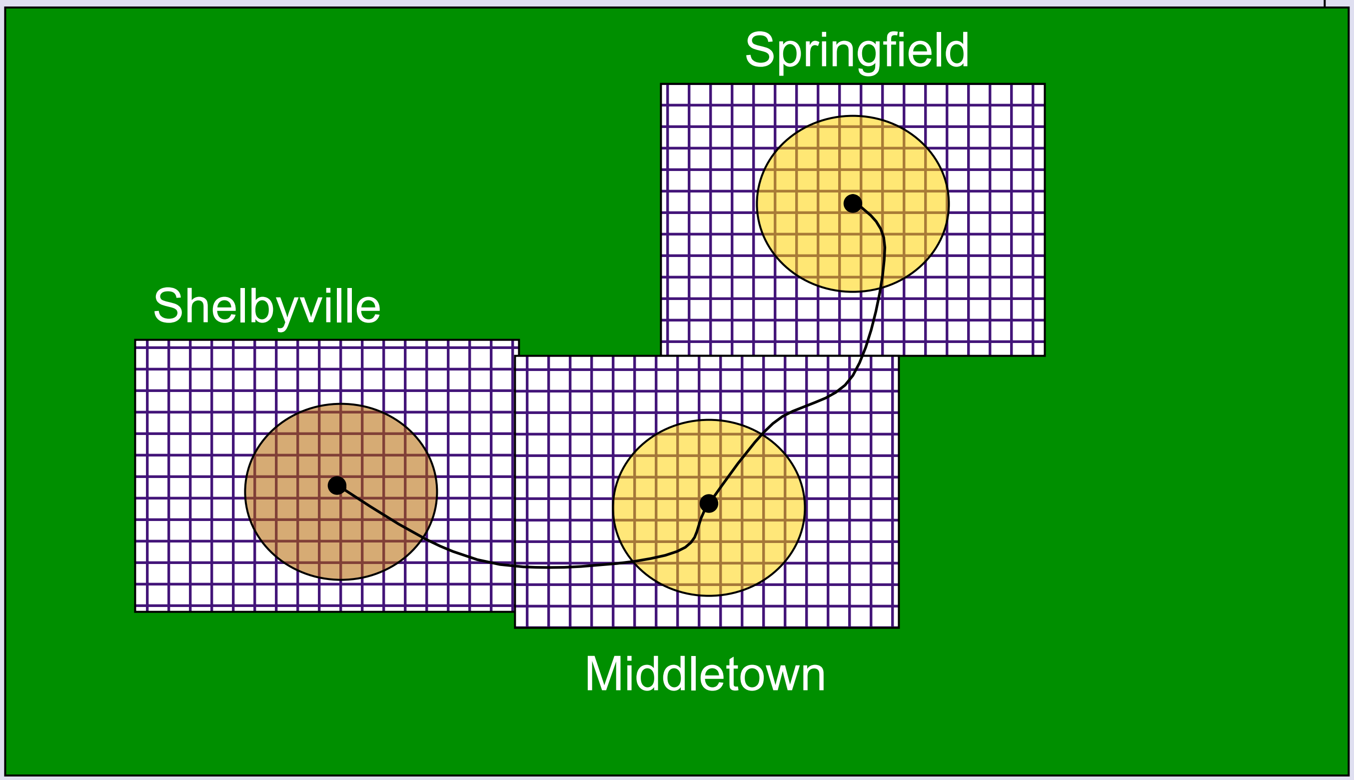
ARRF-II
Unified LRT/Commuter Rail Model

- Problem arises with hybrid projects that use commuter rail equipment but operate in urban environments with frequent, all day service
- Different LRT and commuter rail structures generate significantly different answers for the same project

ARRF-II

Improved CTPP Processing to exclude trips using same station

Schematic Zone Map



ARRF-I	Springfield	Middletown	Shelbyville	Total
Springfield	15,000	7,500	2,500	25,000
Middletown	7,500	15,000	2,500	25,000
Shelbyville	2,500	2,500	20,000	25,000
Total	25,000	25,000	25,000	75,000

Springfield-Middletown LRT 45,000
Middletown-Shelbyville LRT 40,000

ARRF-II	Springfield	Middletown	Shelbyville	Total
Springfield		7,500	2,500	10,000
Middletown	7,500		2,500	10,000
Shelbyville	2,500	2,500		5,000
Total	10,000	10,000	5,000	25,000

Springfield-Middletown LRT 15,000
Middletown-Shelbyville LRT 5,000

ARRF-II

Calibration Approach

- Separately estimate models (where survey data exists) for:
  - Walk Access, Home-Based Work
  - Drive Access, Home-Based Work
  - Walk Access, Other purposes
  - Drive Access, Other purposes
- Combine into a single model and normalize to match total ridership for all modes

ARRF-II

CTPP Trip Rates (Before LOS Adjustment)

Trip Purpose/Employment Density	Walk Access	Drive Access
Home-Based Work		
- to destinations with <50,000 emp/sq mile	0.103631	0.038882
- to destinations with >50,000 emp/sq mile	0.146814	0.135892
Non-Work		
- to destinations with <50,000 emp/sq mile	0.181801	0.013572
- to destinations with >50,000 emp/sq mile	0.184666	0.038878

- Walk access trips:
  - CTPP Buffer: 2 miles on production end / 1 miles on attraction end
  - Higher for non-work than for work trips
  - Slightly higher for CBD than non-CBD
- Drive access trips:
  - CTPP Buffer: 6 miles on production end / 1 miles on attraction end
  - Much higher for work than for work trips
  - Much higher for CBD than non-CBD

ARRF-II
Level of Service

- Ridership = {CTPP JTW x CTPP Rates} x Level-of Service Factor
- Level-of-Service Factor= Speed Factor x Frequency Factor
- Speed=NTD Vehicle Miles/NTD Vehicle Hours (includes layover)
- Speed and Frequency Factors computed using ARC elasticity:

$$FreqFactor = \frac{Frequency - AvgFreq}{(Frequency + AvgFreq)/2} \times e_{Frequency}$$

$$SpeedFactor = \frac{Speed - AvgSpeed}{(Speed + AvgSpeed)/2} \times e_{Speed}$$

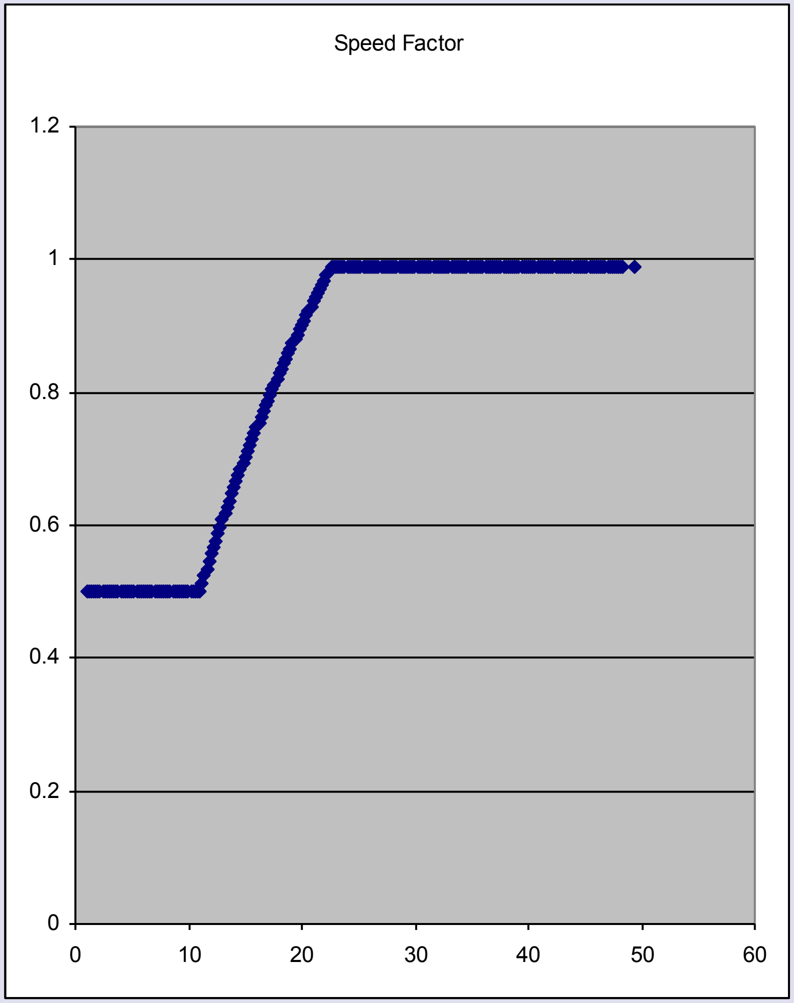
Frequency in trains/day per direction

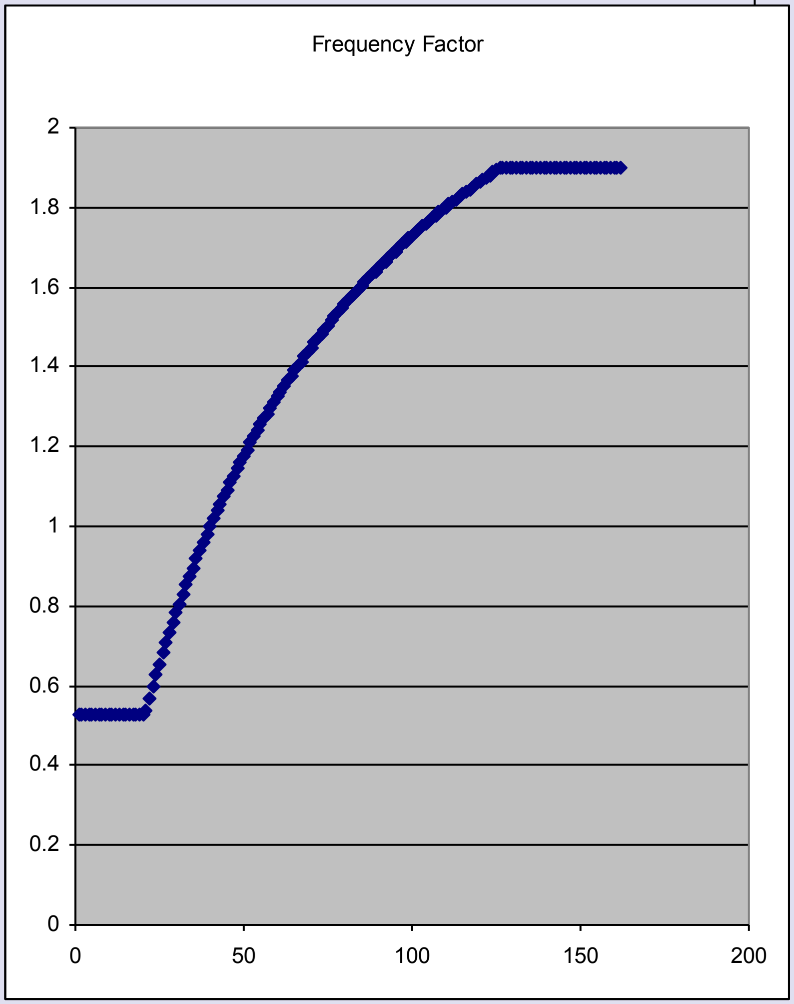
Speed in mph

- Normalized so that the average multiplier for all systems is 1.0
- Limited to prevent large factors out of range of calibration experience

ARRF-II

Speed and Frequency Factors





Demand Adjustment Parameters

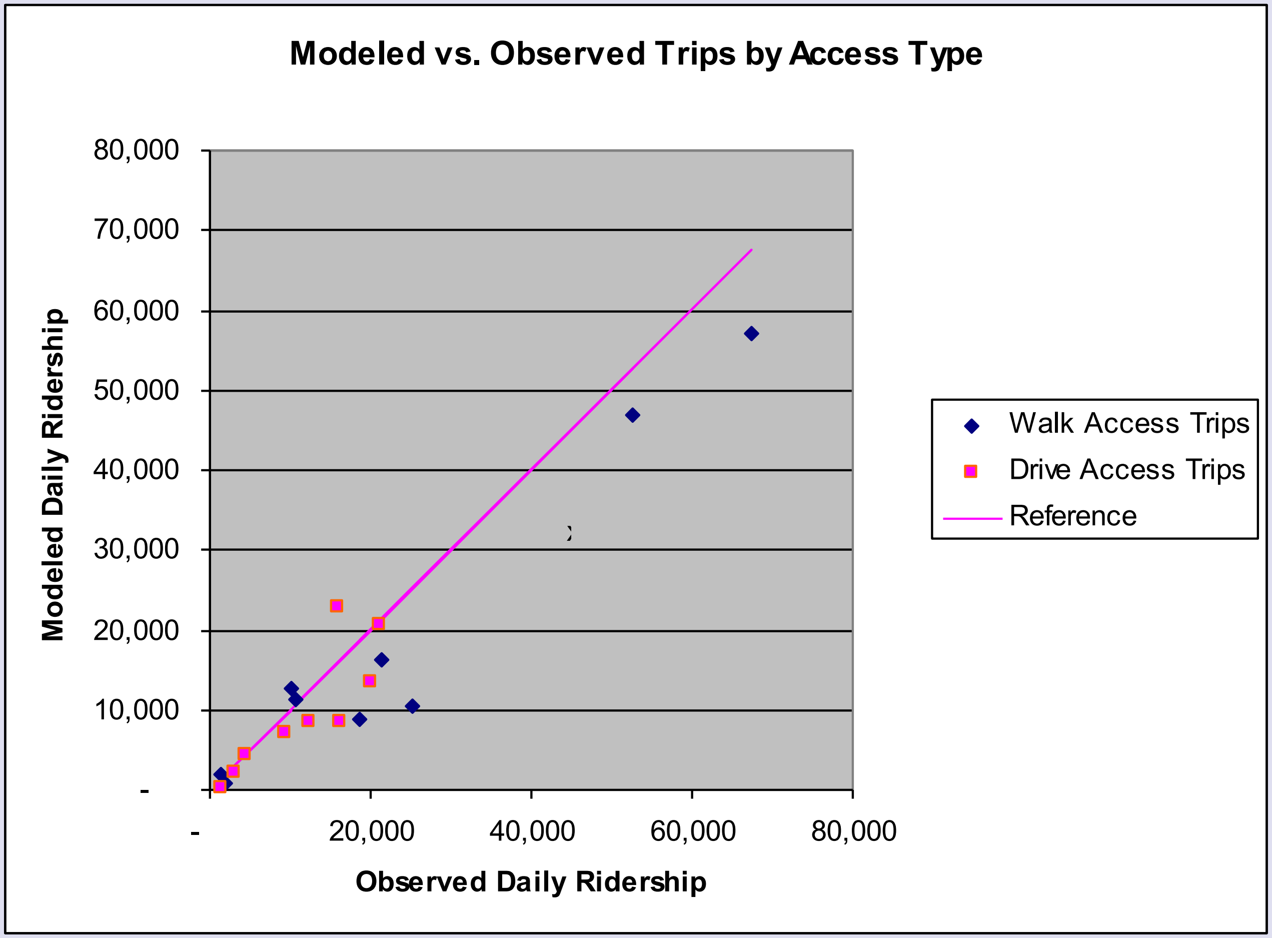
	Arc Elasticity	Elasticity Mid-point	Normalization Divider	Minimum	Maximum
Speed Factor	0.70	23.38	0.9879	0.50	0.99
Frequency Factor	0.62	58.78	0.7644	0.53	1.90

$$FinalFreqFactor = Max\left[Min\left(\frac{FreqFactor}{NormalizationDivider_{Frequency}}, FreqFactor_{Max}\right), FreqFactor_{Min}\right]$$

$$FinalSpeedFactor = Max\left[Min\left(\frac{SpeedFactor}{NormalizationDivider_{Speed}}, SpeedFactor_{Max}\right), SpeedFactor_{Min}\right]$$

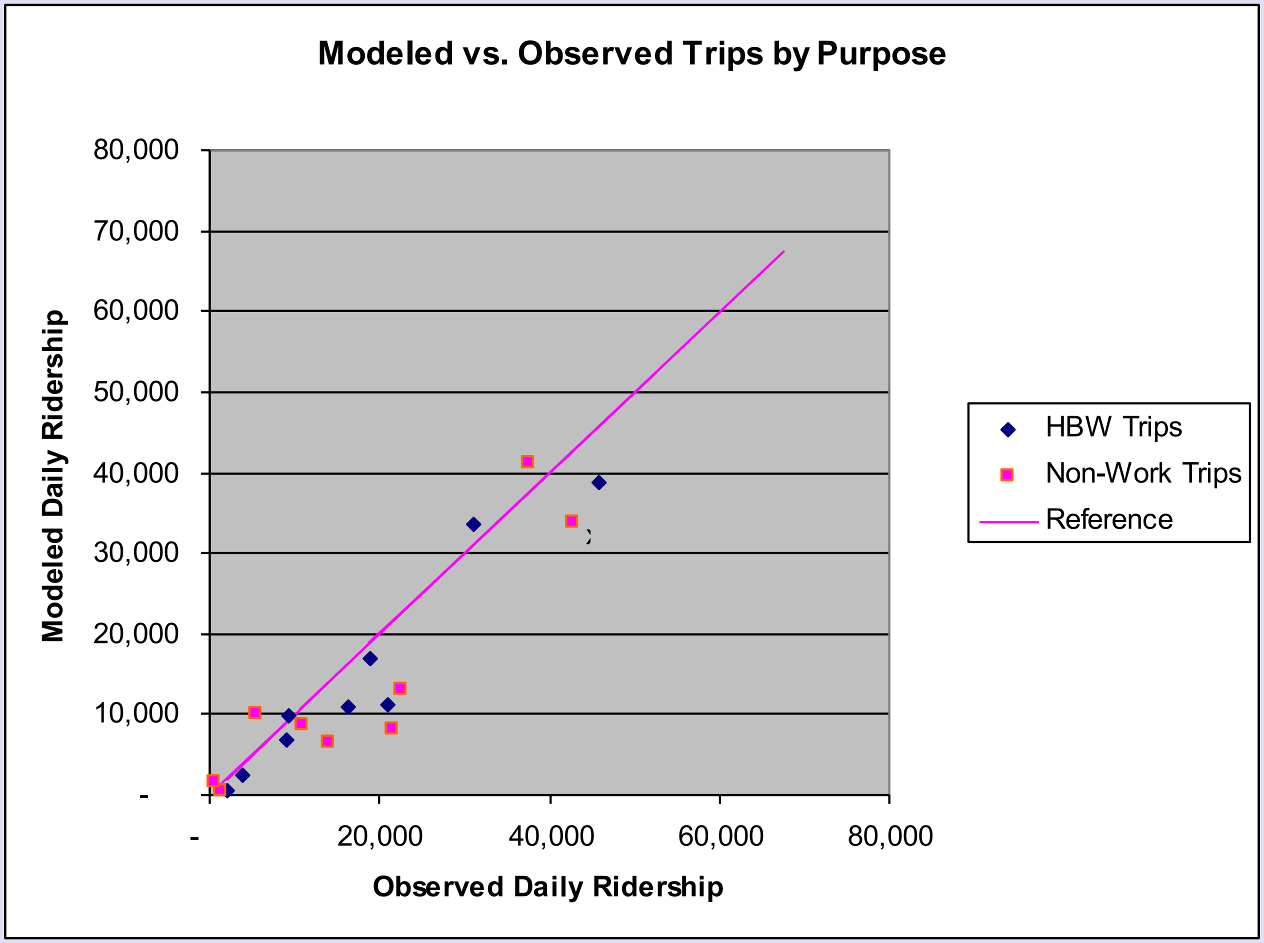
ARRF-II

Calibration Results by Access Type

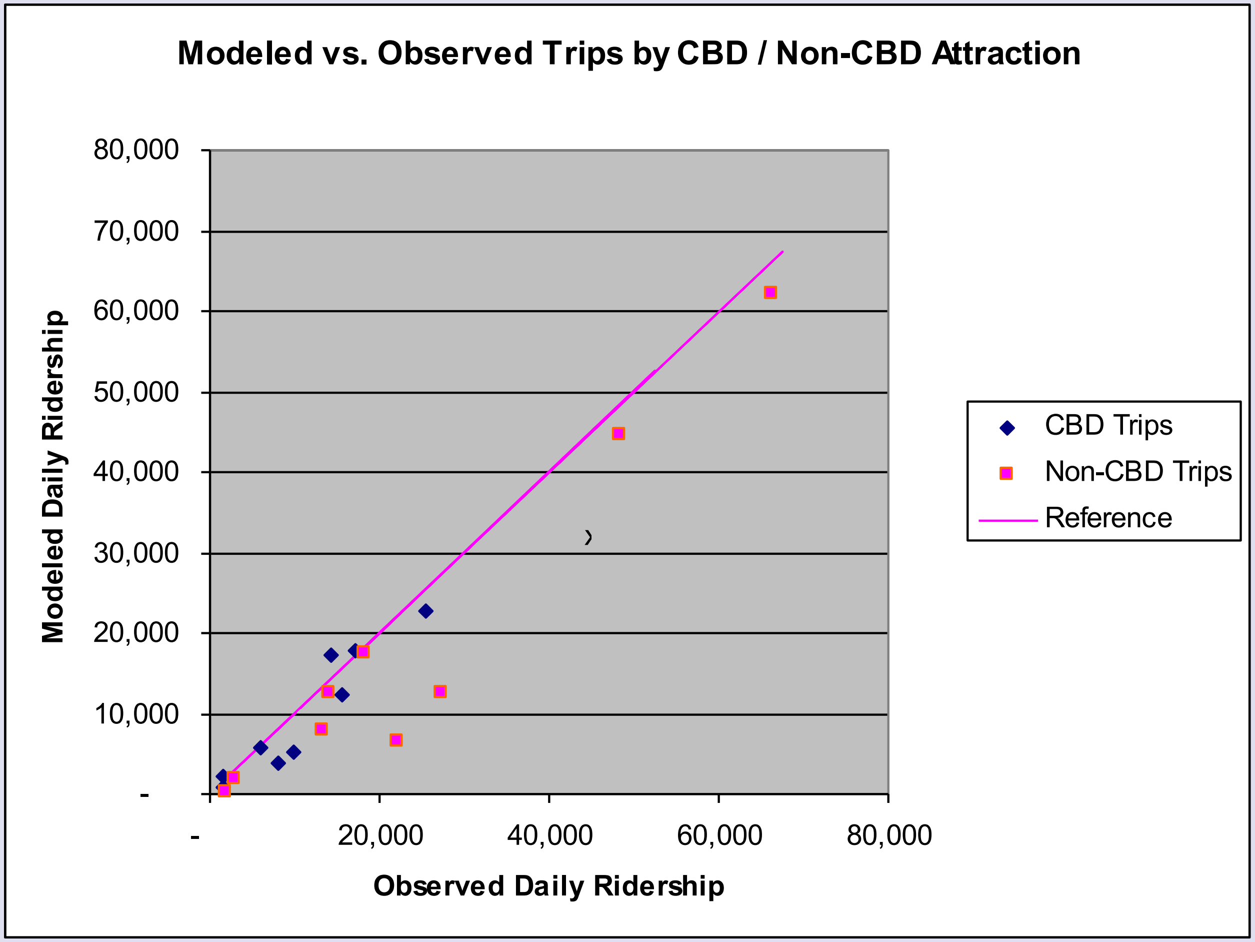


ARRF-II

Calibration by Purpose

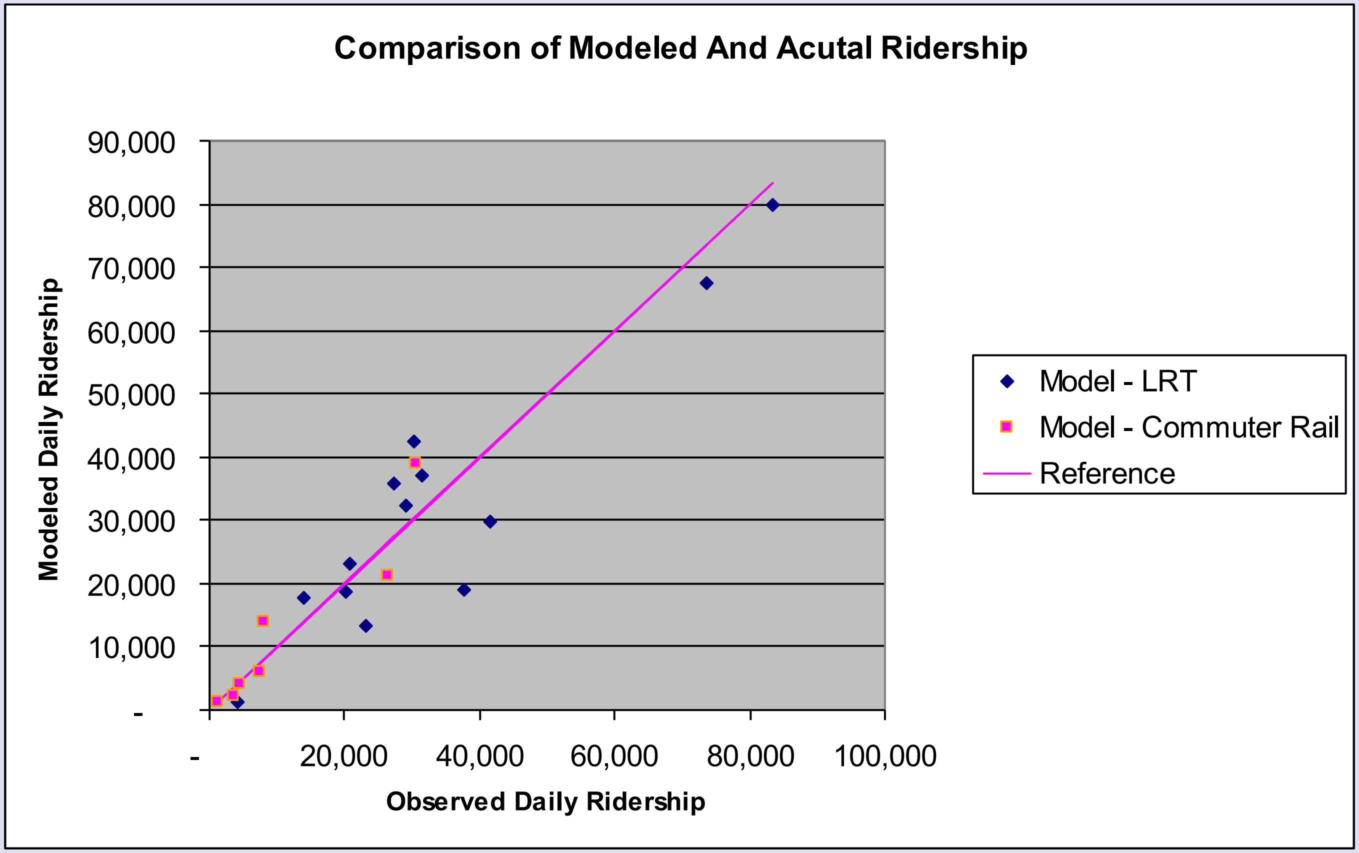


ARRF-II
Calibration by CBD/Non-CBD Attraction



ARRF-II

Calibration Results Total Ridership



R^2 = 0.952. Good match for both LRT and Commuter Rail Systems

ARRF-II

Application to New LRT Cities

City/Ridership Estimate	Market: Walk Access	Drive Access	Special Events	Total
Charlotte				
Observed (April 2008 Survey)	10,800	4,000	(note 1)	14,800
Observed (June 2008 Counts)				16,500
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Forecast (Model with Houston PNR Constants)	4,400	3,100	1,700	9,200
ARRF-I	8,300	4,100		12,400
ARRF-II	8,700	6,800		15,500
Phoenix				
Observed (January 2001 counts/1st Month of operation)				30,000
Forecasted (New Starts Report)				26,100
ARRF-I				26,400
ARRF-II	15,500	9,300		24,800

Note 1: Significant special event ridership observed on an anecdotal basis

FTA Conclusions, Next Steps

- Conclusions
  - FTA likes QC with ARRF
  - FTA likes starter-line information from ARRF
  - FTA thinks II is better than I -- robustness
- Next steps
  - Additional variables (income, others?)
  - Application package
  - Documentation

Distribution of ARRF II

- Short term (while next steps are underway)
  - Request to Nazrul Islam, FTA
  - FTP-site transfer of application files from AECOM
  - Start-up coaching from AECOM
- Long term
  - Request to Nazrul Islam, FTA
  - E-mail delivery of application files, documentation

Model Testing – Methods

Session 7

- Conventional approach
- FTA recommendations
- Thoughts on good practice

Conventional Approach

- Observed data for some recent year(s)
- Aggregate checks
- Lots of factoring
- Model deemed “validated” and ready to use

Conventional Approach

- Base year estimation (and assertion)
  - Trip rates, mode choice coefficients, distribution parameters
- Base year calibration
  - Modal constants, K-factors
- Base year validation
  - Checks against traffic volumes, transit line boardings
  - Last-minute factors, as needed, to “validate”

FTA Recommendations

- Data matching → “calibrated” model
- Model assessment → “plausible” model
- Forecast testing → “tested” model
- Documentation → “ready-for-forecasters” model

FTA Recommendations
Data Matching

- Central focus on transit components
  - Transit network, access representations
  - Transit pathbuilding
  - Mode choice
- Unavoidable focus on upstream components
  - Socio-economic models
  - Trip generation and distribution
  - Highway network and highway speed prediction

FTA Recommendations
Model Assessment

- Specific behavioral explanations for:
  - Trip rates and distribution parameters
  - Mode choice coefficients and constants
- <u>Relative</u> values of parameters across:
  - Socio-economic classes
  - Travel modes
  - Other segmentations
- Adjustments
  - Intelligent and iterative – find and fix the errors
  - Needs a formal conclusion in model testing

FTA Recommendations

Testing of Forecasting Capability

- Meaningful tests
  - Not parametric "sensitivity testing"
  - Not forecasts for the calibration-data year
  - Application of the entire model for very different conditions
- Best: forecast for some recent year with data
  - Back-cast
  - Fore-cast from the validation year to a base year
  - Most powerful if it spans a major transit improvement
- Next-best: forecasts for conditions without data
  - Horizon-year forecast
  - Forecast for a major transit alternative

FTA Recommendations

Documentation

- The usual stuff, of course
  - Model development
  - Users' guide
- But also
  - Formal assessment of model plausibility
  - Results of forecast testing
  - Purview of the model for transit forecasting
    - What it knows about
    - What it does not know about

} markets, modes, behaviors

Thoughts on Good Practice
Model Tests

- Performance rather than validation standards
- Lots of important topics
  - Person trip tables
  - Roadway skims
  - Changes over time and across alternatives
  - Quality of data
- Today's focus: transit rider data and transit model components

Thoughts on Good Practice
Transit Model Tests

- Transit rider travel patterns
  - Trip tables: the expanded survey and the model
  - Mode choice focus
- Transit paths
  - Aggregate
    - Assignment of expanded survey trip tables
    - Comparison of line boardings and other aggregations
  - Disaggregate
    - Individual records from the survey
    - Path-choice focus

Thoughts on Good Practice
Transit Travel Patterns

- An understanding of the big picture
- District-to-district flows
  - By mode and market segment
  - Production and attraction totals
  - Transfer rates
- Mode shares
  - Area-to-area
  - Zone-to-zone differences

Thoughts on Good Practice
Transit Paths - Aggregate

- Assignment results
  - Expanded transit rider tables
    - Boardings by mode, route, route segment, station, other
    - Reasons for differences from observed
  - Modeled transit rider tables
    - Load volumes, on/off distributions, time-of-day
    - Modes of access and egress
    - Park-ride usage
    - Distribution of walk trip distances
    - Major under/over patterns
    - Documentation of differences from observed

Thoughts on Good Practice

Transit Paths - Disaggregate

- Prediction-success tables
  - Consistency between pathbuilder and observed
    - The same sequence of modes (bus-rail-bus, etc.)
    - The same number of transfers
    - Park-ride location, other checks
  - Insights gained from matches
    - Lack of real-world path choices
    - Impact of small origin and destination zones

Thoughts on Good Practice

Prediction-Success Tables

- Insights gained from misses
  - Reasonability of “observed” trip data
  - Reasonability of coded network
  - Zone size: centroids versus points
  - Initial wait and transfer wait times
  - Park-ride or kiss-ride location
  - Unmeasured attributes of better service
  - Other

Model Testing – Some Examples

Session 8

- Model Testing with 2007 Tri-Rail On-Board Survey Data
  - David Schmitt, AECOM
- Pathbuilder Tests using 2007 DART On-Board Survey
  - Arash Mirzaei, NCTCOG

Model Testing with 2007 Tri-Rail On-Board Survey Data

David Schmitt
AECOM

Tri-Rail On-Board Survey

March 2007

- First major data collection effort of Tri-Rail riders since 1999
- The 2007 survey underwent a comparison with limited count data
- The expanded 2007 dataset was used to verify the model's reflection of current transit rider patterns; the model previously underwent a traditional calibration and validation in 2006

Tri-Rail

- 72-mile commuter rail system
- 18 stations across 3 counties
- 1:45 traveling time
- About 50 trains/day
- Not easily accessible to any major attraction by walking
- Daily ridership
  - ~8,000 (2000)
  - ~11,000 (March 2007)

Verify Estimated Ridership Patterns

Purpose & Period

EXPANDED 2007 SURVEY

	Absolute			Relative		
	Peak	Off-peak	Total	Peak	Off-peak	Total
HBW	4,807	1,073	5,880	43%	10%	53%
HBNW	2,646	1,008	3,654	24%	9%	33%
NHB	1,024	525	1,549	9%	5%	14%
Total	8,477	2,606	11,083	76%	24%	100%

ESTIMATED

	Absolute			Relative		
	Peak	Off-peak	Total	Peak	Off-peak	Total
HBW	5,131	1,703	6,834	45%	15%	60%
HBNW	1,277	1,567	2,844	11%	14%	25%
NHB	941	769	1,710	8%	7%	15%
Total	7,349	4,039	11,388	65%	35%	100%

The model estimates trip purposes in generally the correct proportions but over-estimates off-peak trips

Figures are in P/A format

Verify Estimated Ridership Patterns
Purpose & Market Segment

EXPANDED 2007 SURVEY								
	0-car	**1-car**	**2+-car**	**Total**	**0-car**	**1-car**	**2+-car**	**Total**
HBW	452	1,906	3,522	5,880	4%	17%	32%	53%
HBNW	206	875	2,574	3,655	2%	8%	23%	33%
NHB	181	471	897	1,549	2%	4%	8%	14%
Total	839	3,252	6,993	11,084	8%	29%	63%	100%

ESTIMATED								
	0-car	**1-car**	**2+-car**	**Total**	**0-car**	**1-car**	**2+-car**	**Total**
HBW	2,483	2,611	1,744	6,838	22%	23%	15%	60%
HBNW	1,126	1,053	665	2,844	10%	9%	6%	25%
NHB	72	332	1,306	1,710	1%	3%	11%	15%
Total	3,681	3,996	3,715	11,392	32%	35%	33%	100%

The model over-estimates captive riders & under-estimates choice riders

Figures are in P/A format

Verify Estimated Ridership Patterns

Access Mode & Period

EXPANDED 2007 SURVEY

Access Mode	Absolute			Relative		
	Peak	Off-peak	Total	Peak	Off-peak	Total
Walk	833	324	1,157	8%	3%	10%
Park-ride	3,158	641	3,799	28%	6%	34%
Drop-off	3,106	890	3,996	28%	8%	36%
Bus/rail	1,379	752	2,131	12%	7%	19%
Total	8,476	2,607	11,083	76%	24%	100%

ESTIMATED

	Absolute			Relative		
	Peak	Off-peak	Total	Peak	Off-peak	Total
Walk	3,220	1,616	4,836	28%	14%	42%
Park-ride	2,391	1,262	3,653	21%	11%	32%
Drop-off	1,296	862	2,158	11%	8%	19%
Bus/rail	447	299	746	4%	3%	7%
Total	7,354	4,039	11,393	65%	35%	100%

The model under-estimates drop-off and bus/rail access trips

Figures are in P/A format

Verify Estimated Ridership Patterns

Egress Modes

EXPANDED 2007 SURVEY

Egress Mode	Absolute	Relative
Walk	2,356	21%
Park-ride	964	9%
Drop-off	2,489	22%
Bus/rail	4,536	41%
School bus	569	5%
Other	170	2%
Total	11,084	100%

Figures are in P/A format

- High proportion of auto-egress riders (31%), which were confirmed by station egress observations
- Current pathbuilding procedures assume only walk- and transit-egress modes, so these will need to be updated to reflect auto-egress modes

Verify Estimated Ridership Patterns
Station-to-Station Movements (2007 Survey)

Survey	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total
1-Magnonia Park	7	4	38	59	35	89	43	41	34	54	60	16	29	24	18	109	-	57	717
2-West Palm Beach	2	-	29	23	33	86	44	21	59	78	56	22	18	13	8	124	6	100	722
3-Lake Worth	96	62	23	9	29	79	29	22	99	66	21	25	68	11	15	118	18	51	842
4-Boynton Beach	264	279	12	-	7	27	23	50	45	101	55	8	27	13	1	155	4	50	1,123
5-Delray Beach	82	97	24	3	3	4	32	36	54	41	24	-	20	16	-	83	12	32	563
6-Boca Raton	141	273	38	12	5	9	5	9	28	36	51	8	7	12	8	35	5	77	759
7-Deerfield Beach	80	129	33	-	4	12	6	3	24	65	32	32	6	22	2	142	15	146	754
8-Pompano Beach	42	74	12	15	18	36	10	-	3	26	12	7	7	13	7	187	28	111	606
9-Cypress Creek	37	68	19	23	17	69	18	-	-	7	10	5	19	10	-	213	8	105	628
10-Fort Lauderdale	57	101	28	21	35	154	67	12	6	7	2	2	4	36	10	381	12	90	1,026
11-FLL Airport	17	45	3	22	17	40	26	25	25	6	4	3	-	11	2	288	11	86	629
12-Sheridan Street	19	16	-	13	9	49	27	11	5	9	6	2	1	5	-	299	13	72	556
13-Hollywood	12	47	8	12	45	76	36	35	63	21	4	-	-	5	23	209	22	75	693
14-Golden Glades	28	65	14	10	34	52	45	42	55	44	26	2	18	3	-	45	-	32	513
15-Opa-locka	32	5	18	-	7	9	8	20	27	16	12	16	17	-	-	3	2	9	200
16-Metrorail Transfer	18	47	53	39	21	31	29	61	99	66	91	43	53	13	8	2	-	16	688
17-Hialeah Market	2	3	3	2	3	20	7	15	26	6	7	10	8	-	-	5	2	-	121
18-MIA	20	81	24	22	8	56	35	13	124	56	83	7	31	13	3	22	-	6	604
Total	956	1,396	380	285	331	899	489	417	776	704	555	207	332	221	105	2,419	158	1,116	11,745

Pink boxes show top 10 station-to-station movements
Survey shows a predominant north-to-south movement (63% of all trips)

Verify Estimated Ridership Patterns

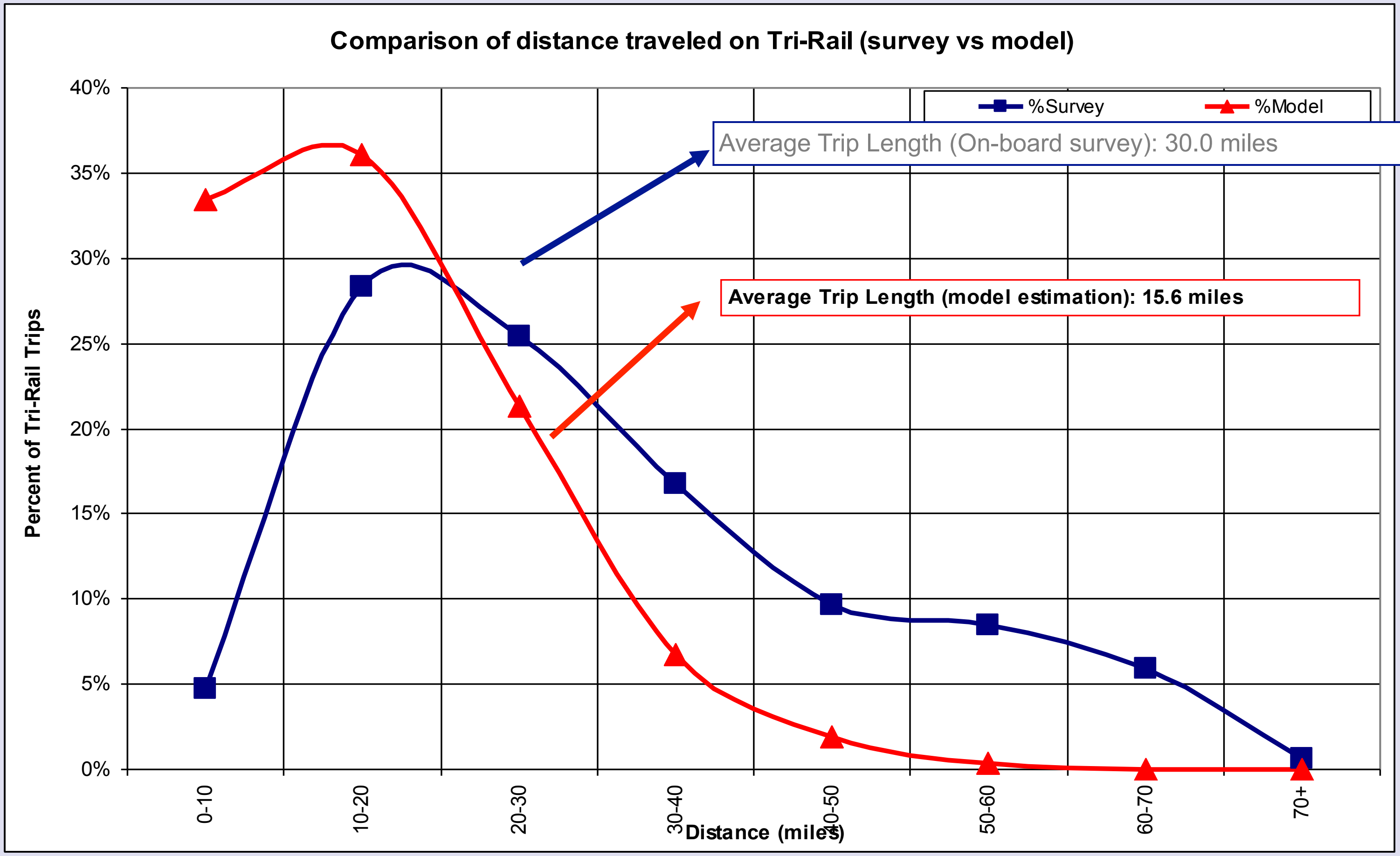
Station-to-Station Movements (Model)

Model	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total
1-Magnonia Park	-	77	24	17	19	12	3	4	3	2	0	0	0	0	0	0	-	0	165
2-West Palm Beach	4	-	30	45	73	36	13	12	10	6	1	0	0	1	0	1	0	0	233
3-Lake Worth	95	699	-	77	87	52	19	21	18	12	1	1	1	2	0	1	0	0	1,085
4-Boynton Beach	34	230	29	-	109	110	38	41	31	19	3	1	2	2	0	2	0	0	650
5-Delray Beach	27	152	26	33	-	34	63	74	52	31	5	2	2	4	1	4	0	1	510
6-Boca Raton	3	28	6	15	27	-	85	101	62	40	6	2	3	5	1	4	0	1	387
7-Deerfield Beach	12	73	8	21	68	243	-	189	124	79	12	5	7	13	2	13	1	2	873
8-Pompano Beach	16	89	11	22	63	194	85	-	54	48	11	5	7	13	3	17	1	3	642
9-Cypress Creek	12	92	10	17	50	139	65	15	-	22	35	21	20	38	10	63	4	12	626
10-Fort Lauderdale	7	102	12	25	63	186	84	23	75	-	49	36	34	86	24	139	10	30	984
11-FLL Airport	0	9	1	5	11	26	18	13	47	35	-	10	23	71	17	82	5	17	390
12-Sheridan Street	0	19	2	6	14	32	21	15	69	47	31	-	20	72	18	96	6	20	487
13-Hollywood	0	9	2	7	20	43	28	15	98	64	72	22	-	178	52	269	25	68	971
14-Golden Glades	0	1	0	1	11	48	52	52	251	105	170	54	36	-	17	106	22	125	1,051
15-Opa-locka	-	0	0	0	5	9	11	17	103	76	58	18	25	10	-	48	11	63	455
16-Metrorail Transfer	0	0	0	0	2	24	47	61	369	296	270	96	147	90	3	-	-	83	1,489
17-Hialeah Market	-	0	0	0	0	0	2	1	9	14	11	3	11	30	7	10	-	2	98
18-MIA	0	0	0	0	0	2	9	13	66	75	55	20	52	134	34	188	4	-	651
Total	210	1,580	160	290	622	1,191	645	667	1,439	972	788	294	389	749	189	1,043	90	427	11,745

Pink boxes show top 10 station-to-station movements
Model shows a predominant south-to-north movement (54% of all trips)

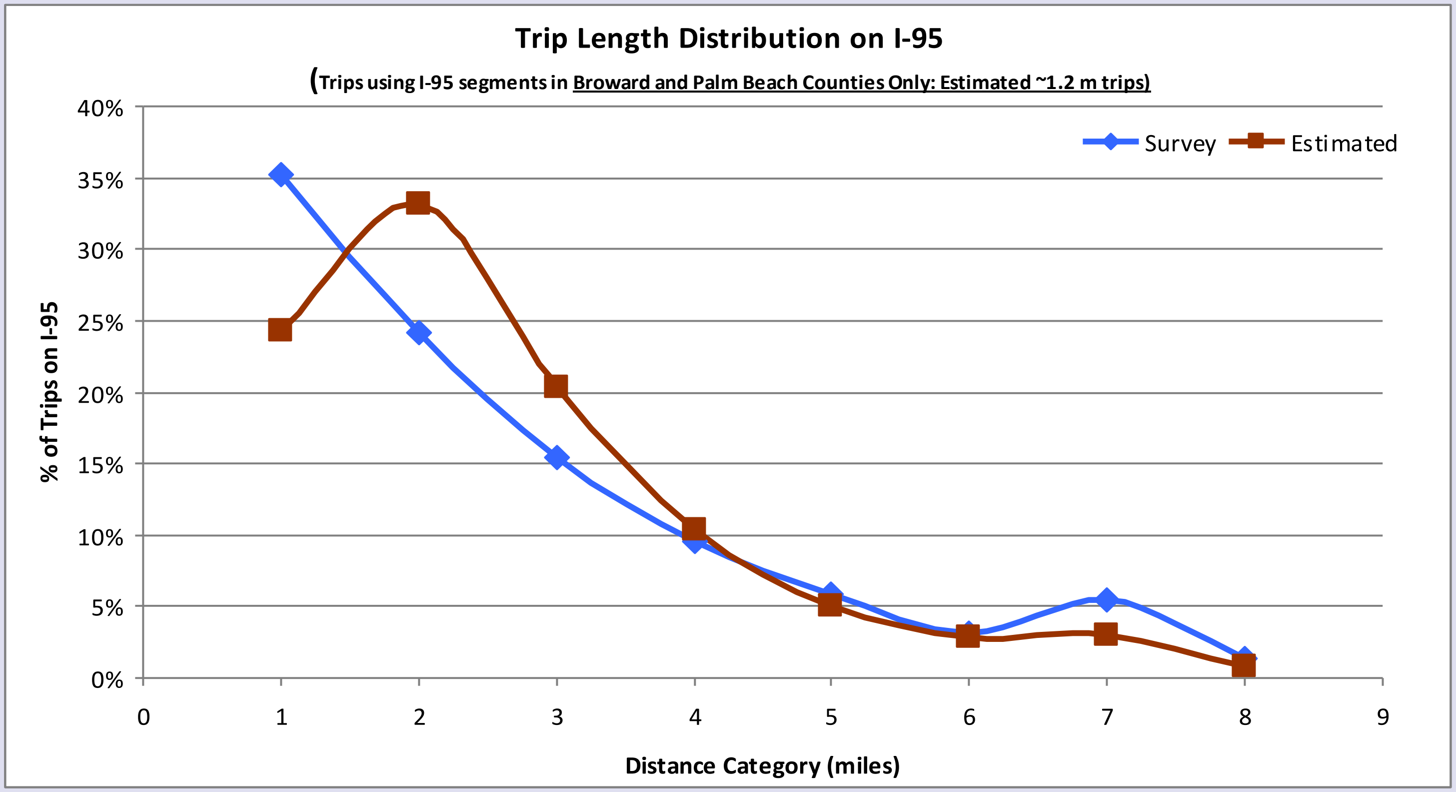
Understanding the Differences

Tri-Rail Trip Length (miles)



Understanding the Differences
I-95 vs. Tri-Rail Trip Lengths (miles)

Does the same disparity also reflected in the dominant freeway?



Answer: Not really

Note: I-95 survey data reflect unweighted records

Understanding the Differences

Tri-Rail HBW Trips (only geocodable records)

	P/A	1	2	3	4	5	6	Total
1	Miami CBD	.	.	2	.	10	2	14
2	Ft Lauderdale CBD	.	.	.	6	.	6	12
3	Palm Beach CBD	.	3	.	.	3	2	8
4	Miami-Dade Other	.	4	19	21	129	66	239
5	Broward Other	108	20	24	263	49	126	590
6	Palm Beach Other	24	50	14	118	168	95	469
	Total	132	77	59	408	359	297	1,332

Red boxes highlight major travel markets
Records are in P/A format

Understanding the Differences

Work Trip Comparison

Figures are in P/A format

Census (scaled)	1	2	3	4	5	6	Total
1-Miami CBD	7,735	95	50	17,398	1,139	236	**26,652**
2-Ft. Lauderdale CBD	75	1,351	0	459	3,839	89	**5,813**
3-Palm Beach CBD	17	0	1,437	31	77	5,120	**6,683**
4-Miami-Dade Other	173,030	4,319	247	1,338,658	110,408	6,886	**1,633,547**
5-Broward Other	25,190	49,171	1,280	196,259	996,362	100,384	**1,368,646**
6-Palm Beach Other	1,317	3,665	30,708	9,358	69,001	739,440	**853,488**
Total	**207,364**	**58,600**	**33,722**	**1,562,162**	**1,180,826**	**852,154**	**3,894,829**

Model	1	2	3	4	5	6	Total
1-Miami CBD	7,254	63	0	16,276	1,190	26	**24,809**
2-Ft. Lauderdale CBD	54	389	11	524	4,881	382	**6,241**
3-Palm Beach CBD	0	2	576	7	101	4,021	**4,707**
4-Miami-Dade Other	128,019	5,049	30	1,270,148	142,557	4,371	**1,550,174**
5-Broward Other	16,222	42,461	1,343	221,036	1,036,917	116,705	**1,434,684**
6-Palm Beach Other	415	2,141	36,660	3,546	86,935	744,517	**874,214**
Total	**151,964**	**50,105**	**38,620**	**1,511,537**	**1,272,581**	**870,022**	**3,894,829**

Top six markets are collectively over-estimates 84,000 work trips Miami CBD missing 55,000 jobs

Findings

- Tri-Rail riders
  - The model is generally correct about the trip purposes and time of day distribution
  - The model is less correct in its understanding of:
    - Captive vs. choice riders
    - Drop-off and bus/rail access trips
    - Predominant P/A trip flow and key attraction stations
    - Length of the trip spent on Tri-Rail
  - The model is not reflecting auto egress trips at all
- Work trips
  - The model over-estimates work trips in key Tri-Rail travel markets

Next Steps

- Identify reasons for low Miami CBD employment
- Investigate reasons for over-estimation of inter-county work trips
- Incorporate auto egress procedures for Tri-Rail trips
- Experiment ways to better reflect longer trips by riders traveling in the proper predominant direction
- Incorporate understanding of time of day, access mode and captive/choice Tri-Rail rider patterns into the mode choice model

Pathbuilder Tests using 2007 DART On-Board Survey

Arash Mirzaei, P.E.

North Central Texas Council of Governments (NCTCOG)

Background

- FTA recommends tests comparing model-derived transit paths with observed paths obtained from transit rider surveys
- In the September 2007 FTA forecasting workshop, David Kurth presented some of the challenges in calibration of pathbuilding
- In early 2008, NCTCOG prepared significant cleanups of the 2007 DART on-board survey that resulted in reliable origin-to-destination transit paths
- This presentation shows current NCTCOG experience in using this on-board survey to understand model limitations and calibrate a transit pathbuilder

Pathbuilder Calibration

- Definition: the pathbuilder is calibrated when it produces **<u>paths</u>** that are reasonably correct
  - "Correct" means they are the same as observed
  - "Reasonably" means some deviation from "all correct paths" is acceptable
- Method: use the pathbuilder to create zone-to-zone transit paths and compare with observed paths, and change the pathbuilder parameters to minimize the differences
  - What to compare -> Define calibration measure
  - Which parameters to change and how much -> Develop an optimization algorithm

NCTCOG Previous Pathbuilder Calibration

- Observed paths were not available
- No optimization program was used
- Calibration considered multiple items
  - Reasonableness of parameters
  - Reasonableness of transit paths and mode of access
  - Ridership by mode - light rail, commuter rail, express bus, local bus
  - Ridership by geographic groups of routes
  - Ridership at route level
  - Boardings and alightings at rail stations

NCTCOG New Pathbuilder Calibration Approach

1. Conduct transit survey that provides observed paths
2. Code a high quality transit network
3. Segment the observed trip records (origin, destination, and routes used) by time period and mode of access
4. For each segment, use the paths from the unweighted records to calculate unweighted boardings for each used route
5. For each segment, create an unweighted transit origin-destination matrix
6. Define discrete value ranges for pathbuilder parameters to be tested
7. Create a pathbuilder with values from step 6
8. Assign the origin-destination matrix to the transit network using the pathbuilder
9. Calculate the model-assigned boardings for each route
10. Record statistical measures for “modeled versus observed” boardings by route
11. Change the pathbuilder parameters and go back to step 7 until all values are tested and statistical results recorded
12. Find the optimum solution for the pathbuilder parameters based on obtaining the best statistical results

Path Comparison Challenges

- Observed paths need to be reliable: how can we make sure we have correct paths?
- Ridership rather than paths is the standard model output: how can we get the software to output paths?
- Paths are not single numbers to compare with measures like %RMSE and R^2: how should we evaluate calibration success?
- Coded networks are abstractions of reality: is the network resolution high enough to make path comparison meaningful?

Reliability of Observed Paths

- DART on-board survey path cleanup effort provided reliable paths
  - *Random selection of 74 records from the database of 6,283 records*
  - *100% determined to have a feasible path*
  - *Statistical assertion: 95% confident that more than 90% of paths are correct*

Obtaining Modeled Paths

- Transit paths are not standard outputs from TransCAD 4.8 in a programmable environment
  - Tracking specific modes as part of the path is standard in TransCAD
  - We can easily track, for example, if LRT is part of a path
- Using TransCAD 5.0, we were able to get the modeled path as an output

Path Comparison Measures

- Boardings by route
  - Easy to compare with %RMSE, R^2, and so on
  - If all paths are correct, ridership will be correct - but not vice-versa
  - How much can we learn about the success of the pathbuilder from the ridership?
- Transfer rate = (total boardings) / (total linked trips)
- Specific transit modes used
- Combined path characteristics such as generalized cost, IVTT, and OVTT
- Major routes of the path comparison

Pathbuilder Segmentation

- Mode of access
  - Walk Access
  - Drive Access
- Time period
  - 6:30 a.m. to 9:00 a.m.
  - 9:00 a.m. to 3:00 p.m.

Pathbuilder Parameters Tested

Use brute force to find the optimum values

- OVTT weight {1.5, 2.0, 2.5, 3.0, 3.5}
  - Walk access
  - Walk egress
  - Initial wait time
  - Transfer wait time
  - Transfer wait time
- IVTT weight {1.0}
  - In-vehicle time
  - Dwell time
- Transfer penalty time {3, 4, 5, 6, 7}
- Max. initial wait time {15, 20, 25, 30, 35, 40, 45}
- Max. transfer wait time {15, 20, 25, 30, 35, 40, 45}
- Value of time ($/hr) {2.73, 4, 5, 7, 9}

Optimized Parameters

- Ridership %RMSE = 55
- OVTT weight {1.5, 2.0, 2.5, 3.0, 3.5}
- IVTT weight {1.0}
- Transfer penalty time {3, 4, 5, 6, 7}
- Max. initial wait time {15, 20, 25, 30, 35, 40, 45}
- Max. transfer wait time {15, 20, 25, 30, 35, 40, 45}
- Value of time ($/hr) {2.73, 4, 5, 7, 9}

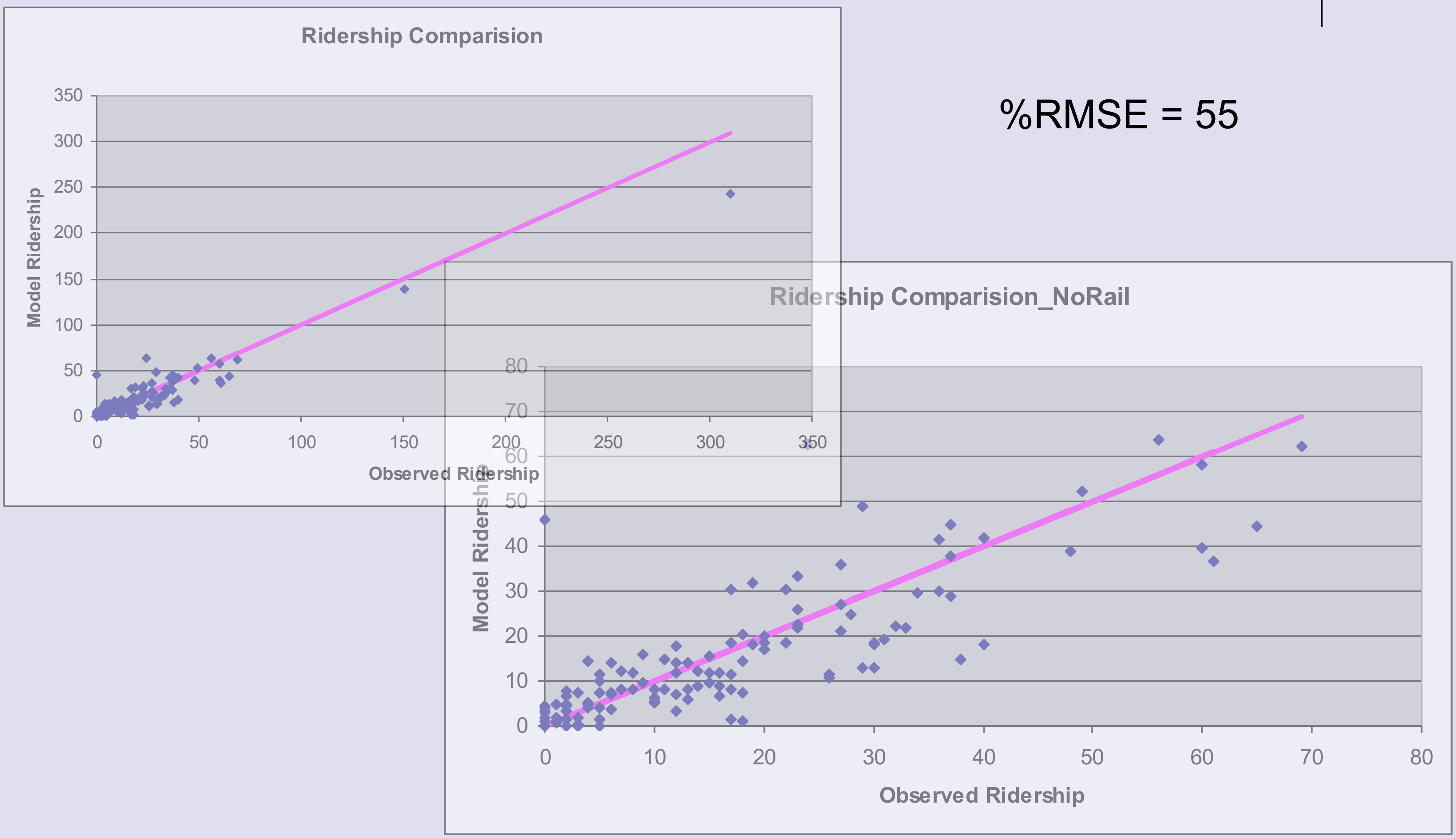
Comparison of Approaches

1. Optimized parameters with no preferential treatment for rail modes
2. NCTCOG 2002 previously calibrated model which includes preferential treatment for rail modes in regards to wait time
3. Optimized parameters with preferential treatment for rail modes in form of 0.8 IVTT weight

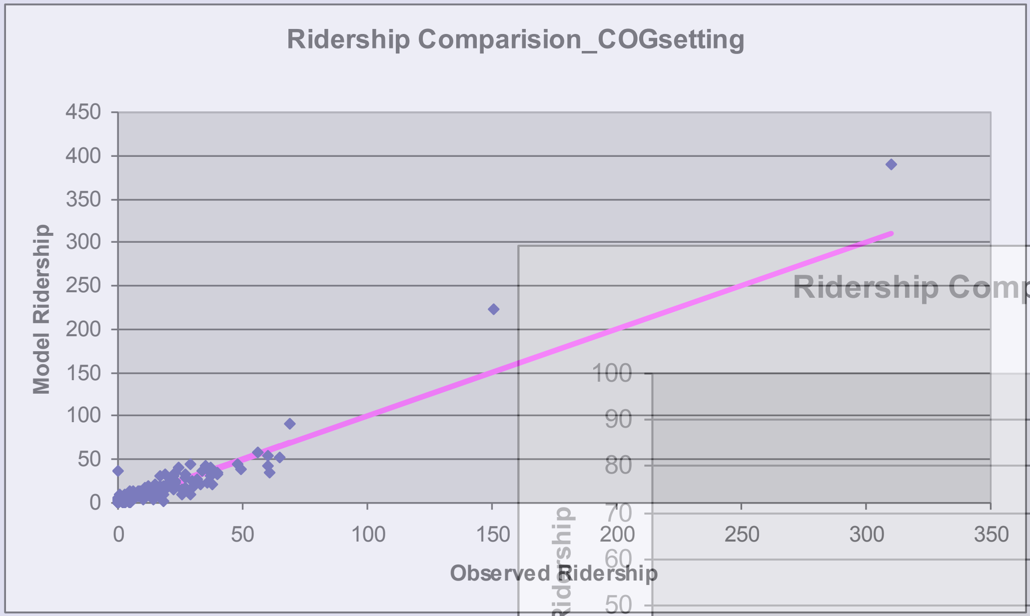
Optimized Run

Boardings

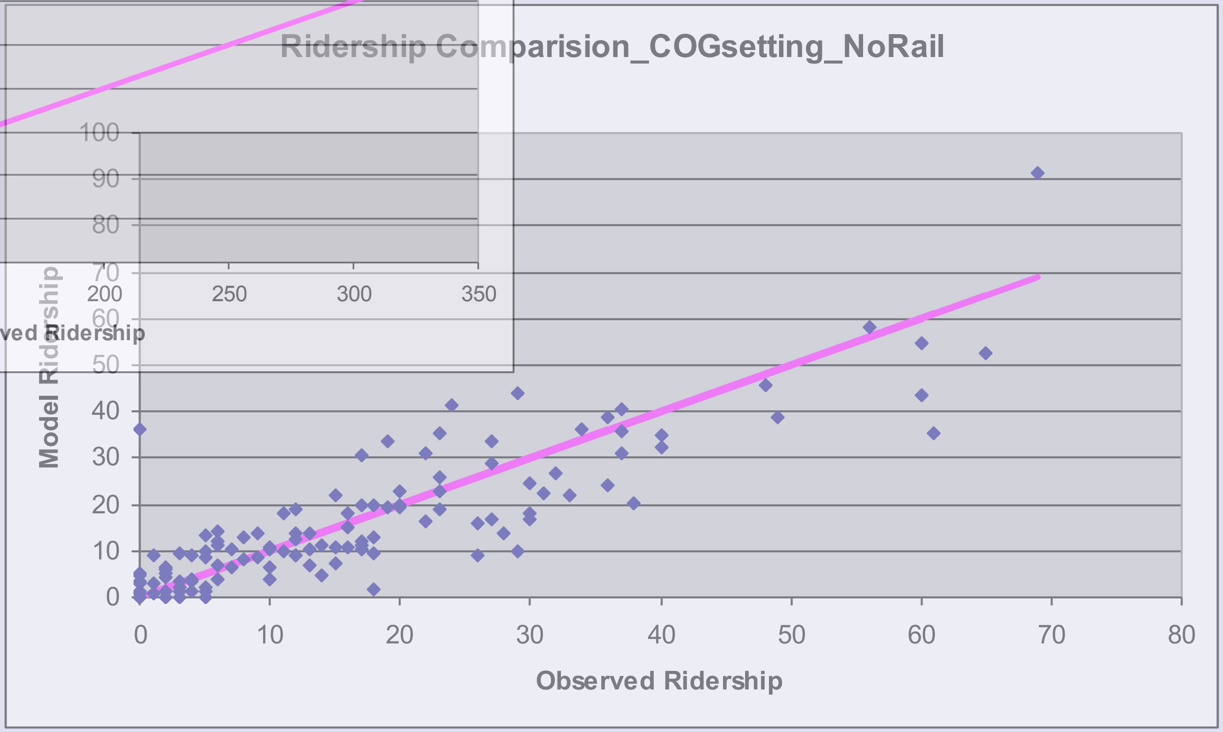
%RMSE = 55



NCTCOG 2002
Boardings

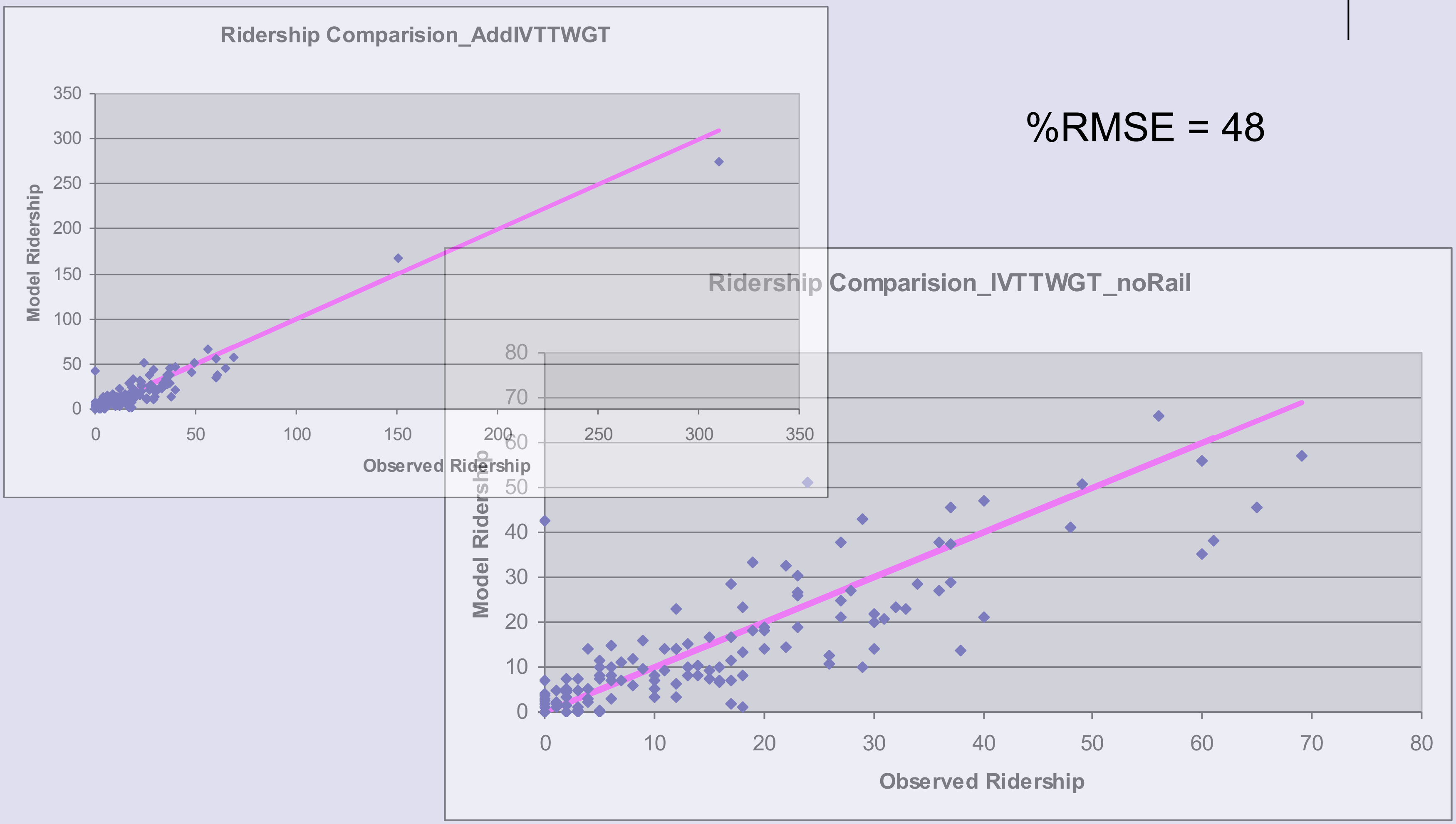


%RMSE = 62



Optimized Run with 0.8 Rail IVTT

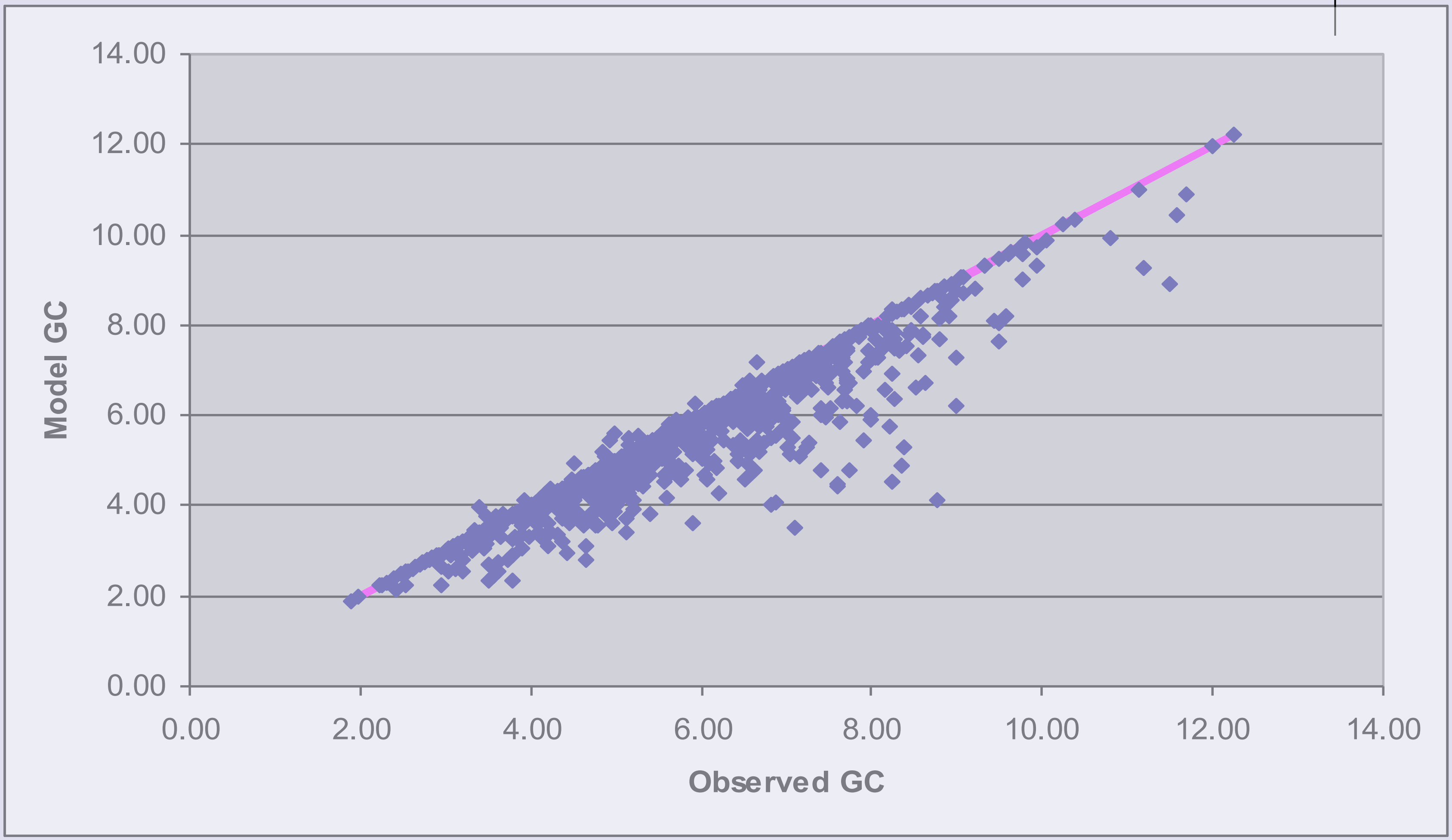
Boardings



%RMSE = 48

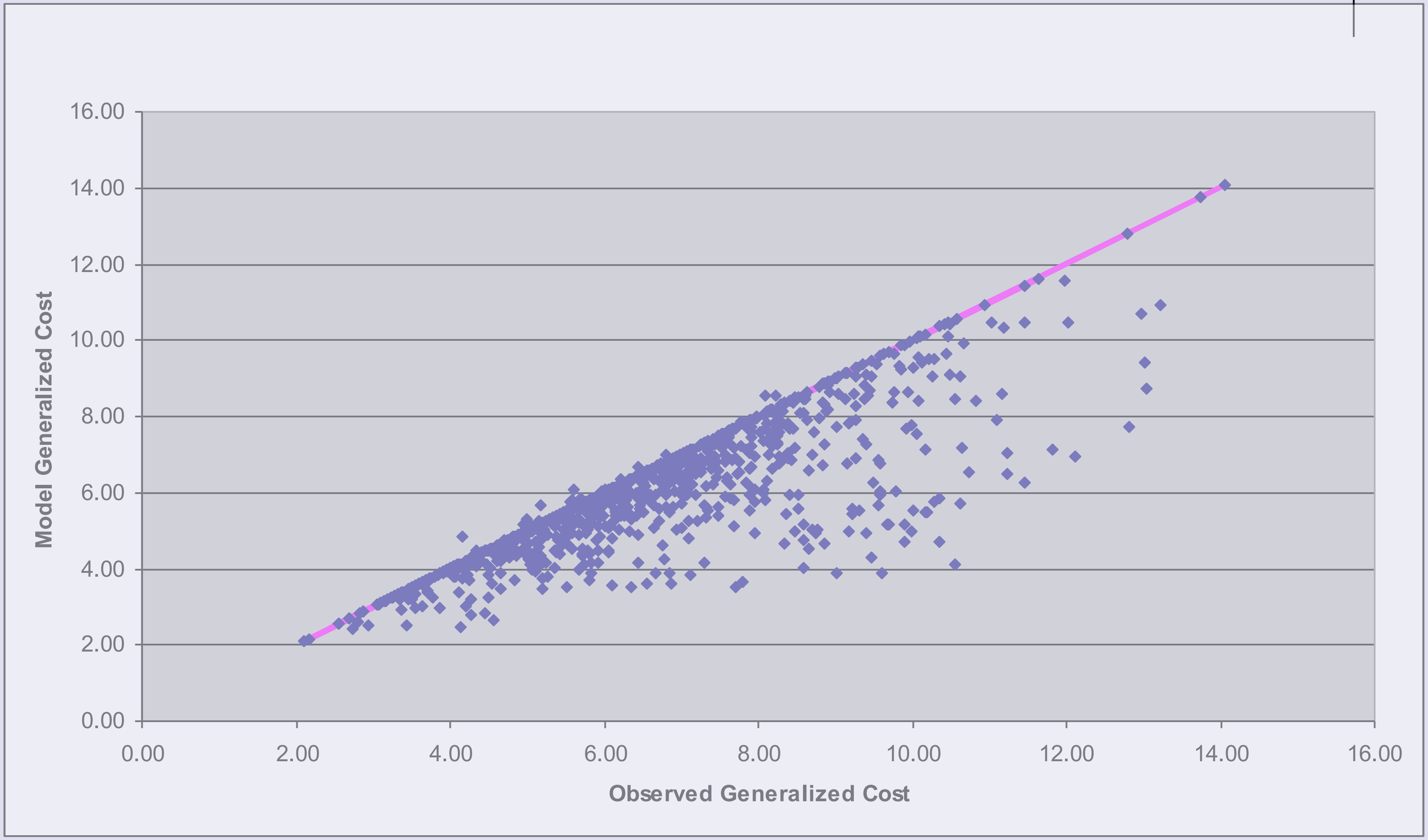
Optimized Run

Generalized Cost



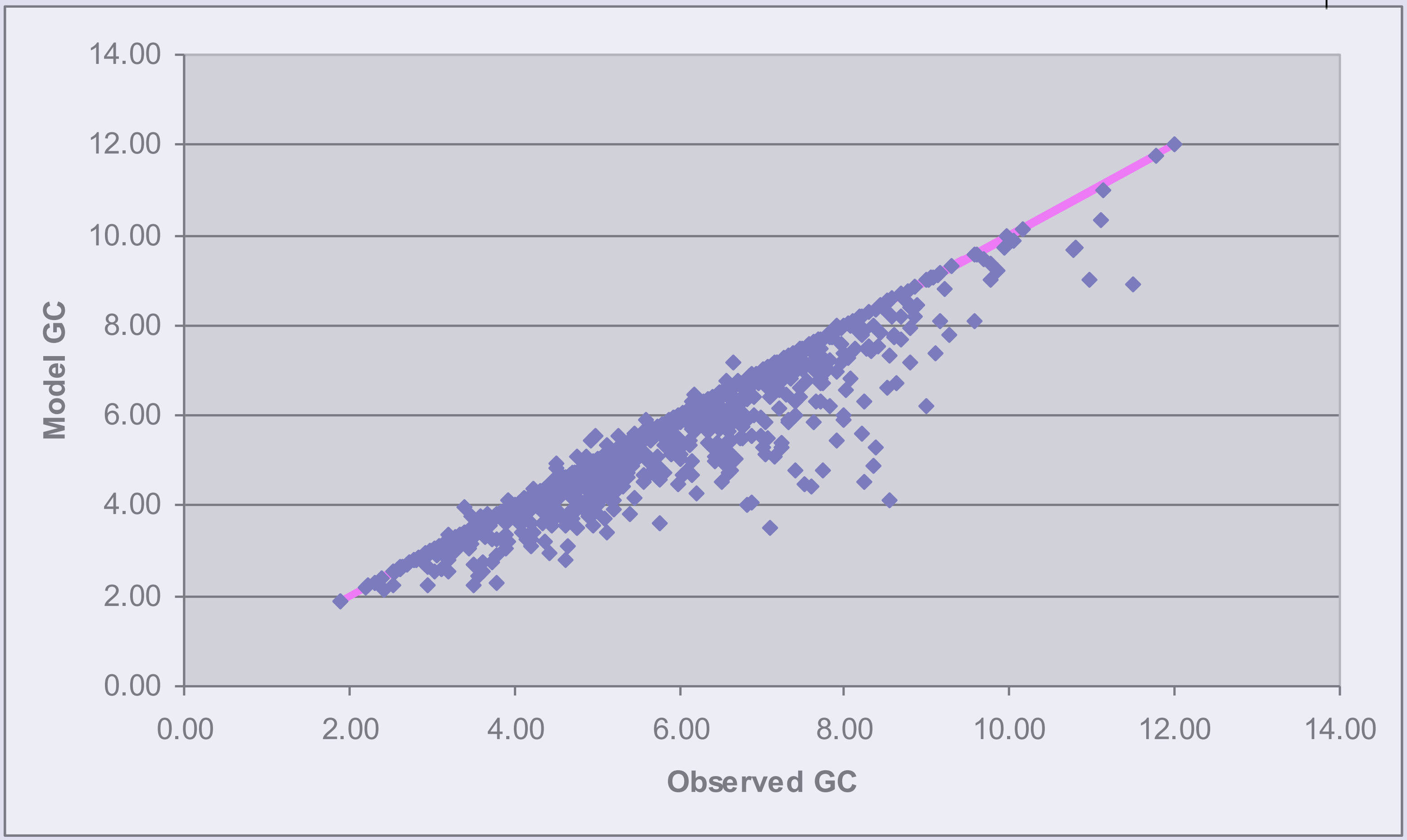
NCTCOG 2002

Generalized Cost



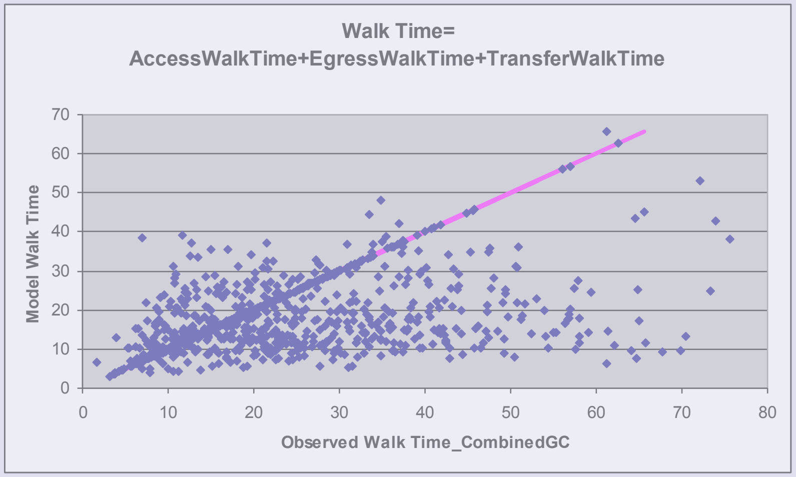
Optimized Run with 0.8 Rail IVTT

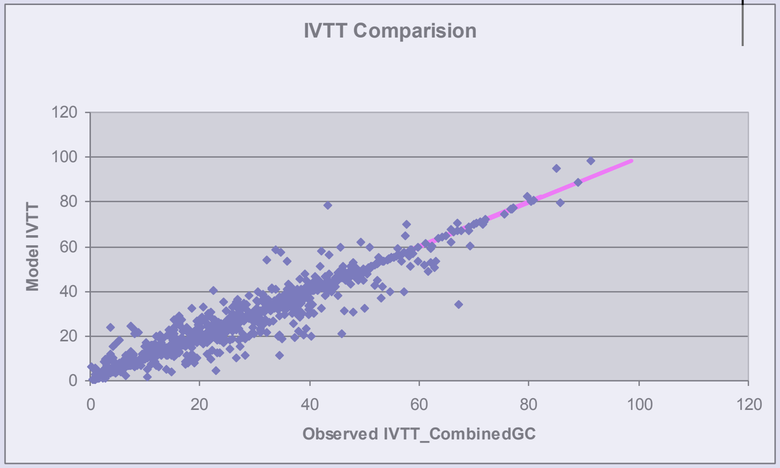
Generalized Cost

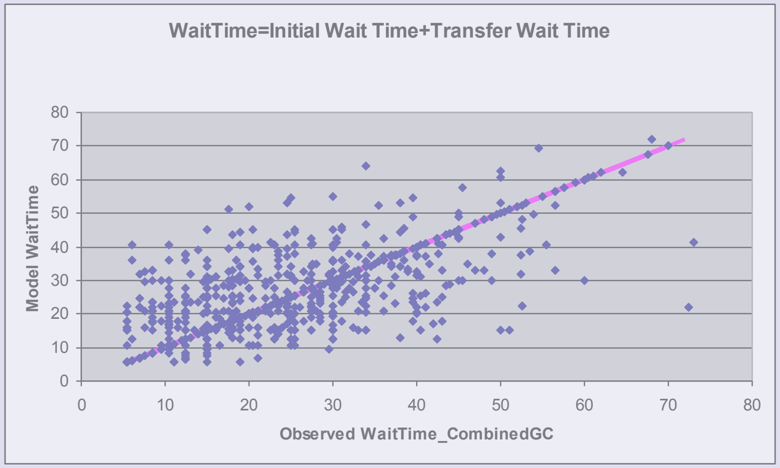


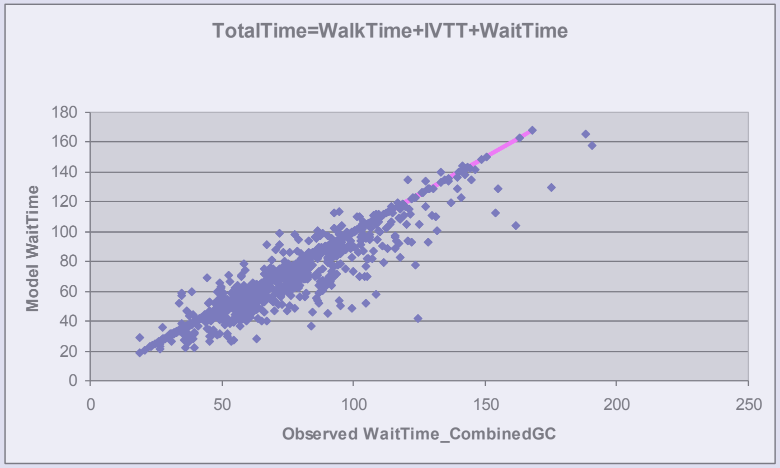
Optimized Run with 0.8 Rail IVTT

Path Times









Distribution by Transit Mode

Linked Trips	Observed		Optimized Run		NCTCOG		Opt. with 0.8 Rail IVTT	
Using Modes	#	%	#	%	#	%	#	%
LRT (No CRT)	408	35%	350	30%	572	49%	385	33%
CRT (No LRT)	14	1%	14	1%	25	2%	14	1%
LRT & CRT	20	2%	15	1%	18	2%	18	2%
Bus Only	727	62%	790	68%	554	47%	752	64%
Total	**1,169**	**100%**	**1,169**	**100%**	**1,169**	**100%**	**1,169**	**100%**

Distribution by Number of Transfers

Number of Transfers	Observed		Optimized Run		NCTCOG		Opt. with 0.8 Rail IVTT	
	#	%	#	%	#	%	#	%
0	264	23%	354	30%	299	26%	336	29%
1	510	44%	558	48%	400	34%	556	47%
2	331	28%	223	19%	408	35%	244	21%
3+	64	5%	34	3%	62	5%	33	3%
Total	**1,169**	**100%**	**1,169**	**100%**	**1,169**	**100%**	**1,169**	**100%**

Other Possible Tests

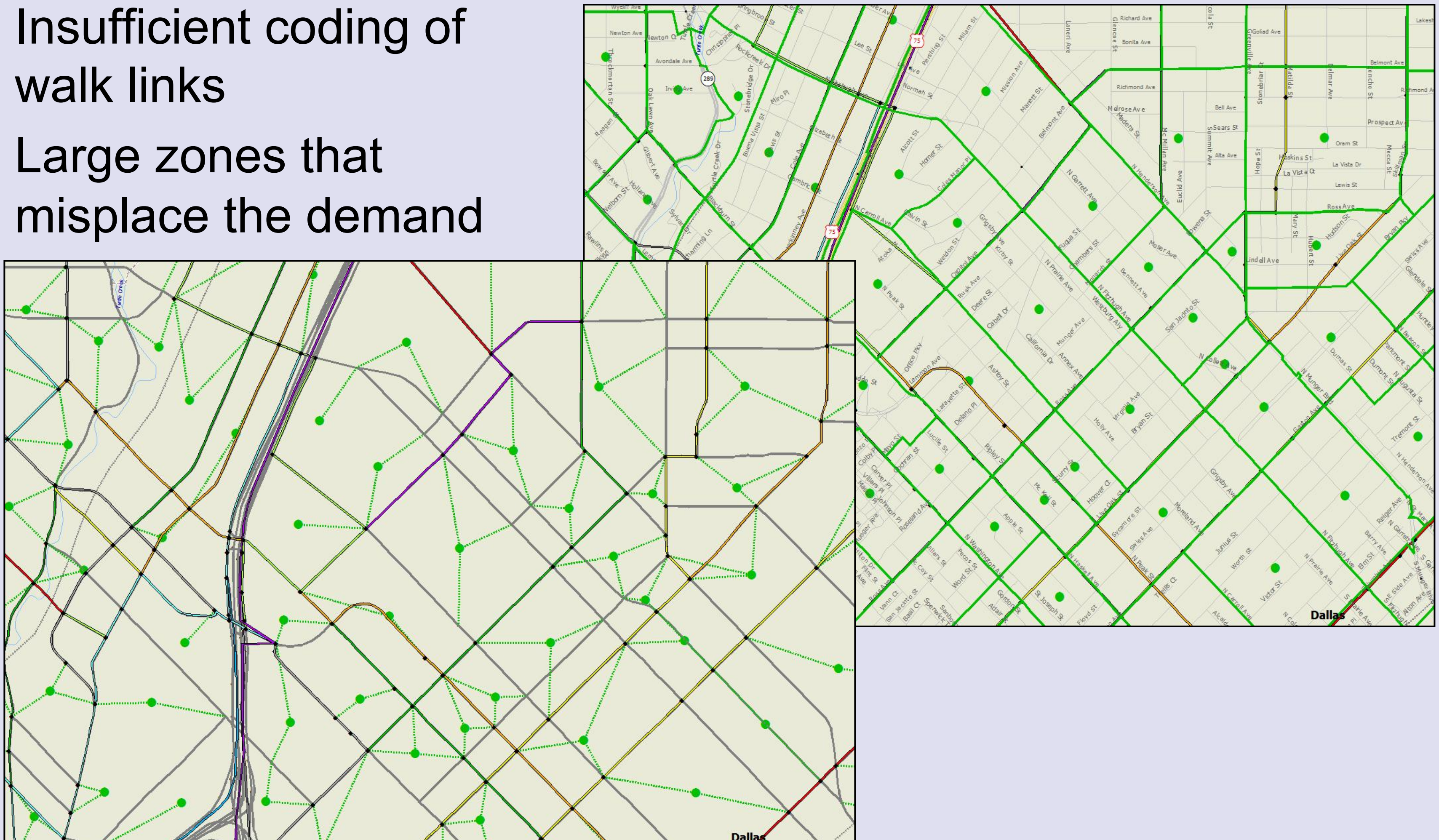
- For observed paths using rail
  - Percent of modeled paths using rail
  - If path does not include rail:
    - The reduction in travel time needed to "bring out" the rail path
    - Impact of using zone centroids rather than actual origin and destination locations
- For observed paths using bus only
  - Percent of modeled paths using bus(es) only
  - Examination of paths using rail

Other Possible Tests (continued)

- For observed paths with no transfers
  - Percent of modeled paths without transfers
  - Examination of possible reasons for misses
- Repeat for observed paths with 1 and 2+ transfers

Hypotheses on Sources of Errors – Walk Time

- Insufficient coding of walk links
- Large zones that misplace the demand



Hypotheses on Sources of Errors – Wait Times

- Initial Wait
  - Half of headway and a max may not properly represent the supply system
  - Schedules may not follow uniform headway, particularly for long headways
- Transfer Wait
  - Transfer among heavily used routes may be timed in certain time periods
- NCTCOG may conduct a wait time study - but existing studies challenge our current way of coding wait time

Route_ID	Route_Name	Track	Time	Distance	PKHDWY	OPHDWY	MODEGROUP
1	Route 6001000	6001000	7.00	2.91	5.00	15.00	6
2	Route 6001	6001	7.00	2.91	5.00	15.00	6
3	Route 58	58	37.00	6.50	20.00	45.00	5
4	Route 58000	58000	42.00	7.23	20.00	45.00	5
5	Route 533	533	73.00	13.91	20.00	45.00	5
6	Route 533000	533000	78.00	14.71	20.00	45.00	5
7	Route 528	528	83.00	16.84	23.00	51.00	5
8	Route 541	541	86.00	16.74	--	90.00	5
9	Route 528000	528000	79.00	16.44	25.00	51.00	5
10	Route 541000	541000	82.00	16.34	--	90.00	5
11	Route 520000	520000	85.00	17.84	--	180.00	5
12	Route 520	520	89.00	18.24	--	180.00	5
13	Route 5920	5920	39.00	9.02	25.00	--	5
14	Route 56	56	42.00	10.52	75.00	--	5
15	Route 527000	527000	31.00	6.23	25.00	40.00	5
16	Route 527	527	33.00	6.33	25.00	40.00	5
17	Route 5950	5950	29.00	11.88	15.00	--	5

www.DART.org

Customer Information: (214) 979-1111

Route 11 Weekday/Entre Semana Northbound
PM listings in Bold type/PM en Números Obscuros
Effective March 3, 2008
-- denotes no service to this stop this trip

BARLOW & MONTREAL	HAMPTON RAIL STATION (ARRIVAL)	HAMPTON RAIL STATION (DEPARTURE)	MARLBOROUGH & JEFFERSON	BECKLEY & JEFFERSON	EWING & SABINE	LAMAR & ELM	WEST TRANSFER CENTER
4:36	4:40	4:40	4:47	4:55	5:01	5:15	5:16
5:21	5:25	5:25	5:32	5:40	5:46	6:00	6:01
5:45	5:49	5:49	5:56	6:04	6:11	6:20	6:21
5:53	5:57	6:08	6:16	6:24	6:31	6:40	6:41
6:18	6:22	6:28	6:36	6:44	6:51	7:00	7:01
6:38	6:42	6:48	6:56	7:04	7:11	7:20	7:21
6:58	7:02	7:08	7:16	7:24	7:31	7:40	7:41
7:18	7:22	7:28	7:36	7:44	7:51	8:00	8:01
7:38	7:42	7:48	7:56	8:04	8:11	8:20	8:21
7:58	8:02	8:08	8:16	8:24	8:31	8:40	8:41
8:18	8:22	8:28	8:36	8:44	8:51	9:00	9:01
8:58	9:02	9:10	9:17	9:25	9:31	9:40	9:41
BARLOW & MONTREAL	HAMPTON RAIL STATION (ARRIVAL)	HAMPTON RAIL STATION (DEPARTURE)	MARLBOROUGH & JEFFERSON	BECKLEY & JEFFERSON	EWING & SABINE	LAMAR & ELM	WEST TRANSFER CENTER
9:36	9:40	9:50	9:57	10:05	10:11	10:20	10:21
10:16	10:20	10:30	10:37	10:45	10:51	11:00	11:01
10:56	11:00	11:10	11:17	11:25	11:31	11:40	11:41
11:36	11:40	11:50	11:57	**12:05**	**12:11**	**12:20**	**12:21**
12:16	**12:20**	**12:30**	**12:37**	**12:45**	**12:51**	**1:00**	**1:01**
12:56	**1:00**	**1:10**	**1:17**	**1:25**	**1:31**	**1:40**	**1:41**
1:36	**1:40**	**1:50**	**1:57**	**2:05**	**2:11**	**2:20**	**2:21**
2:16	**2:20**	**2:30**	**2:37**	**2:45**	**2:51**	**3:00**	**3:01**
2:56	**3:00**	**3:08**	**3:16**	**3:24**	**3:31**	**3:40**	**3:41**
--	**3:28**	**3:28**	**3:36**	**3:44**	**3:51**	**4:00**	**4:01**
3:39	**3:43**	**3:48**	**3:56**	**4:04**	**4:11**	**4:20**	**4:21**
3:59	**4:03**	**4:08**	**4:16**	**4:24**	**4:31**	**4:40**	**4:41**

Preliminary Conclusions

- Objective function of the optimization based on boarding RMSE created paths that are consistently less costly than estimated observed cost; to reach to consistent results (correct paths and boarding) a more complex objective function and optimization process is needed

- The boarding values included many small values, which may cause abrupt changes in RMSE without showing any meaningful behavioral trend

- Close examination of the coded network and observed route boarding should be done to ensure every reasonable observed route is coded properly

Preliminary Conclusions (continued)

- Calculation of "Observed GC" needs close examination, since it is calculated through model manipulation
- Effect of walk network may be significant in the success of the proper calibration since it is a major issue for transit walk users
- Effect of proper coding of both initial wait time and transfer wait time deserves close examination
- Both data and model inaccuracies limit the calibration level: over calibration could be misleading

Acknowledgment

- FTA staff: for providing ideas and help in analyzing the results
  - Jim Ryan
  - Ken Cervenka
- NCTCOG Model Group staff: for managing the project, analysis, and presentation
  - Kathy Yu
  - Hua Yang

Analytical Support of Cases for Projects

Session 9

- Information requirements
- The need for clear focus
- An approach
- Implications for current practice

Information Requirements

- Contents of the ≈5-page case for the project
  - Context (key activity centers, transportation facilities/services)
  - Current conditions
  - Anticipated future (No-build) conditions
  - Merits of the project
    - Benefits of the low-cost alternative
    - Additional benefits from the build alternatives (LPA)
  - Uncertainties
- Stand-alone document for non-technical readers

The Need for Clear Focus

- Many generalities but few insights
  - Demographics, activity centers, development plans
  - Increasing congestion, aggregate transit ridership
- Lots of model statistics but no information
  - Aggregate ridership changes
  - Increased transit shares
  - Project boardings

An Approach

- Work backwards from the benefits
  - Isolate the users of the build alternative/LPA
  - Identify the travel markets with the largest benefits
  - Describe the specific causes of those benefits
  - Describe the TSM benefits for those markets
  - Explain the limitations on TSM performance
  - Describe the future conditions for those markets
  - Describe the current conditions for those markets
- Forego interesting-but-unhelpful extras

Implications for Practice

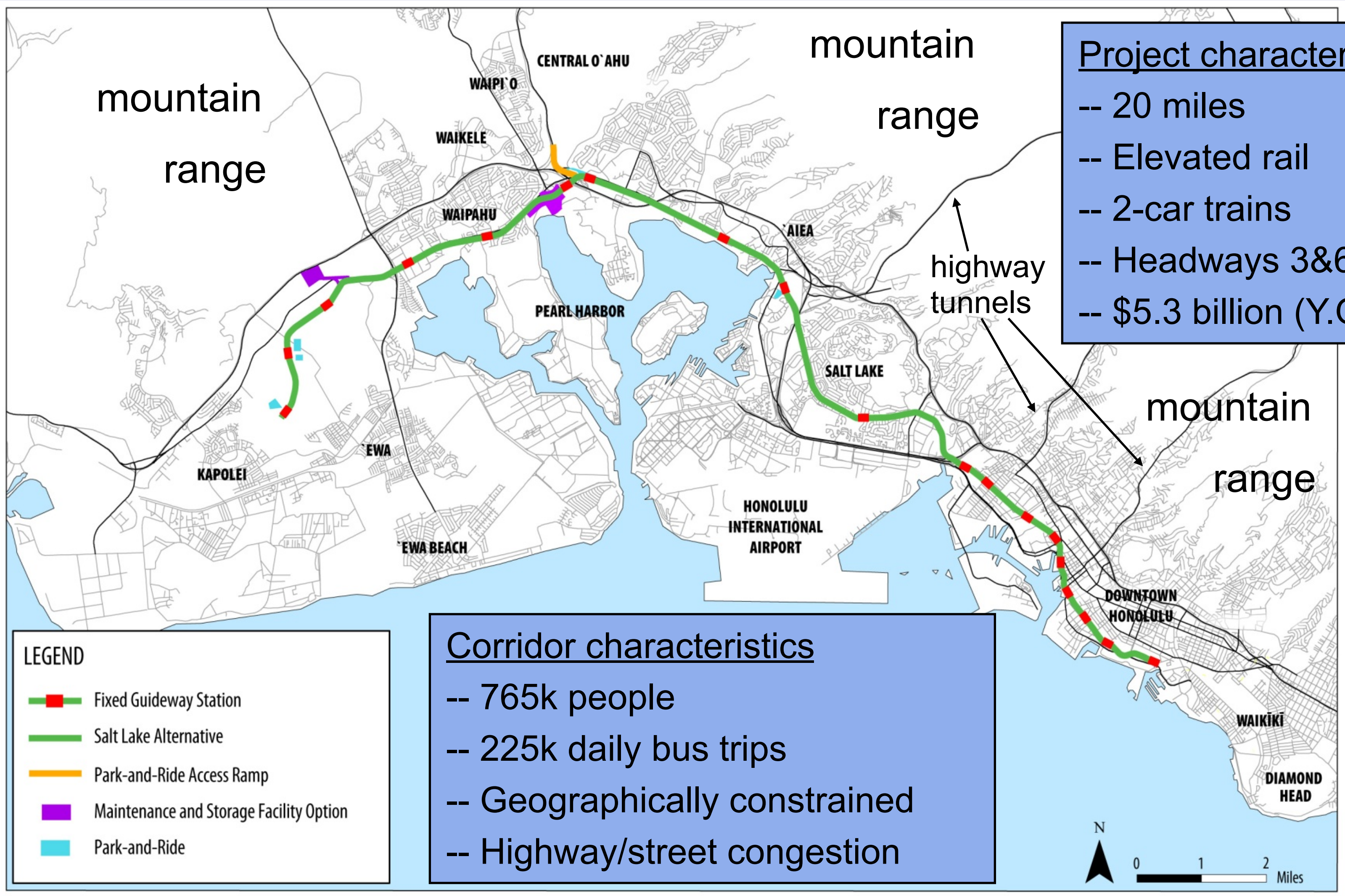
- Technical approach
  - Isolation of trips using the project
    - Guideway trip tables from mode choice
    - Select-link analysis from transit assignment
  - Analysis of causes of benefits
    - Time savings by market (O-D, purpose, access)
    - Comparison of impedances for principal benefitting markets
- Management
  - Provisions in scopes of work
  - Resources

Implications for Practice (continued)

- FTA initiatives
  - Rating of the case for each proposed project
    - Coherent, compelling arguments → high
    - Disjointed, ungrounded ramblings → low
    - All of the others → medium
  - Possible adjustment of "justification" ratings
  - Coordination with project sponsors
    - With technical staff (scope, budget …; early starts)
    - With managers (importance, attention, resources….)

Honolulu Rail Project

Salt Lake Blvd Alignment



Project characteristics

- -- 20 miles
- -- Elevated rail
- -- 2-car trains
- -- Headways 3&6 mins.
- -- $5.3 billion (Y.O.E. $)

Corridor characteristics

- -- 765k people
- -- 225k daily bus trips
- -- Geographically constrained
- -- Highway/street congestion

Honolulu Rail Project

Anticipated Elements of the Case

- Setting and current/future conditions
  - Geographic constraints on development, roadways
  - Urban core: most jobs, “established” households
  - Western expansion: “new” households, few jobs so far
  - Long commutes and severe congestion
  - Slow buses – from the west and within the core
  - Heavy bus ridership
  - Continued trends – congestion, westward expansion

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Anticipated Elements of the Case (continued)

- Problems
  - Transit access from the west to the core
  - Transit movements within the core
  - Transit support for mixed development of the west

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Anticipated Elements of the Case (continued)

- Merits of the project
  - TSM alternative
    - Expresses on paint-separated freeway HOV lanes
    - Arterial BRT services, particularly in the core
    - Fundamental constraint: severe congestion and mixed-traffic bus operations

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Anticipated Elements of the Case (continued)

- Merits of the project (continued)
  - Rail alternative
    - Full separation from traffic
    - Dramatic savings in transit running times
    - Ancillary benefits in transit headways (from equilibration)
    - Effective in addressing all three problems
    - Very high user-benefits, with high costs → good CEI
- Uncertainties (up next)

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Anticipated Elements of the Case (continued)

- Some observations
  - Elements of the case = big-picture concepts
  - Principal travel markets, service impacts → crucial
  - Travel forecasting details/statistics → out of place
  - Information from the forecasts but not about the forecasts
- Start early; update often; involve FTA staff

Uncertainty Analysis

Session 10

- Requirement, purposes, and contents
- Candidate sources of uncertainty
- Analytical approaches
- Thoughts/questions
- Analysis of uncertainties in Honolulu

FTA Requirements

- SAFETEA-LU requires FTA to:
  - Rate projects with respect to the likelihood that they will maintain their ratings as they move through project development
  - Evaluate the performance of forecasting contractors
- FTA policy guidance requires sponsors to:
  - Analyze and document capital-cost uncertainties
  - Analyze and document <u>project</u>-rider uncertainties
  - Effective
    - six months after guidance issued
    - ≈ late fall 2009

Purposes

- Analysis of uncertainties improves:
  - Honesty in presentation of forecasts
  - Quality control of forecasts
  - Information for decision-makers
  - Comparisons of predicted and actual outcomes
  - FTA assessments of contractors (and others)

Contents

- A range of forecasts for the horizon year (and the opening year?)
  - Upper bound
  - Most likely
  - Lower bound

  } { opening year (and horizon year?)
- Specific sources of significant uncertainty
  - Source
  - Current assumption
  - Alternative outcomes, likelihoods, and implications
- Documentation (in appendices) of analyses

Candidate Sources

- (1) The model: (a) inputs and (b) responses
  - Demographics
    - Population, employment, income levels
    - Location/magnitude of changes, particularly in the corridor
  - Transportation context
    - Highway: congestion, parking prices, gasoline price
    - Transit: background transit service levels and fares
  - The project
    - Physical scope: stations, park/ride lots, grade separation
    - Service plan: guideway services, integration with bus system

Candidate Sources (continued)

- (2) New items beyond the model's experience
  - New transit modes (and model parameters)
    - Transit mode-specific constants and coefficients
    - Nesting coefficients for transit access and line-haul
  - New behaviors
    - Choice riders
    - Formal park-ride access
    - Free-fare riders (students, CBD free-fare zone)
    - Circulation travel on fixed guideways

Analytical Approaches

- (1) The model: (a) inputs and (b) responses
  - Build-up of the ridership forecasts
  - For the LPA, certainly; maybe for other alternatives
  - Validation forecast, plus increments to 2030, i.e.:

    1 - Transit service levels
    2 - Demographics
    3 - Highway service levels
    4 - Parking costs

  - Assessment
    - Key drivers of the forecasts
    - Items with significant uncertainties?
  - Alternative assumptions for the range of forecasts

Analytical Approaches

- (1) The model – examples of uncertain drivers
  - Substantial growth in CBD employment
    - Basis?
    - Consistency with recent history?
  - Parking costs
    - CBD densities within range of data for parking-cost model?
    - Suburban parking costs – entirely new phenomenon?
  - Cuts to "redundant" bus services in the project corridor
    - Riders facing forced transfers that add time compared to bus?
    - Fewer bus cutbacks and fewer project riders?

Analytical Approaches (continued)

- (2) New items beyond the model's experience
  - New modes, new behaviors
  - Approaches
    - Data and insights from similar projects in similar settings
    - FTA guidance on transit alternative-specific effects
    - ARRF estimates as a second set of "data" for matching
  - Range of possible outcomes
  - Assumptions for the range of forecasts

Analytical Approaches (continued)

- (2) New items – examples
  - Circulation travel
    - Lots of stations within dense regional core
    - Reliability of non-home-based travel models (TG? TD?)
    - Experience elsewhere with circulation trips on guideways
  - Expectation of many multi-transfer guideway trips
    - Lots of these riders with good second choices?
    - Reliability of estimated transfer penalty, guideway effects?
    - Fewer guideway riders, more parallel-bus riders?

Summary of Analytical Results

- Standard estimate: vv,000 guideway trips/day
- Upper bound: xx,000 guideway trips/day
- Best estimate: yy,000 guideway trips/day
- Lower bound: zz,000 guideway trips/day

Upside Uncertainties	Downside Uncertainties
1. Source with most potential	1. Source with most potential
2. Source with 2^{nd}-most potential	2. Source with 2^{nd}-most potential
3. Source with 3^{nd}-most potential	3. Source with 3^{nd}-most potential
4. Source with 4^{th}-most potential	4. Source with 4^{th}-most potential
5. <more?>	5. <more?>

Thoughts / Questions

- Forecasting – an inherently uncertain task
  - Single-number forecasts – unrealistic, misleading
  - Range of possible outcomes
    - Honest portrayal of limits of technical work
    - Sharing of risk between tech staff and decision-makers
    - Basis for assessments of accuracy, performance
- Implementation
  - Effective: ≈ late fall 2009
  - Agency/consultant scopes, schedules, and budgets

Uncertainties in Honolulu

Bill Davidson – PB

- The Honolulu Rapid Transit Project
- Summary of results
- Supporting analyses
- Assumptions for the range of forecasts

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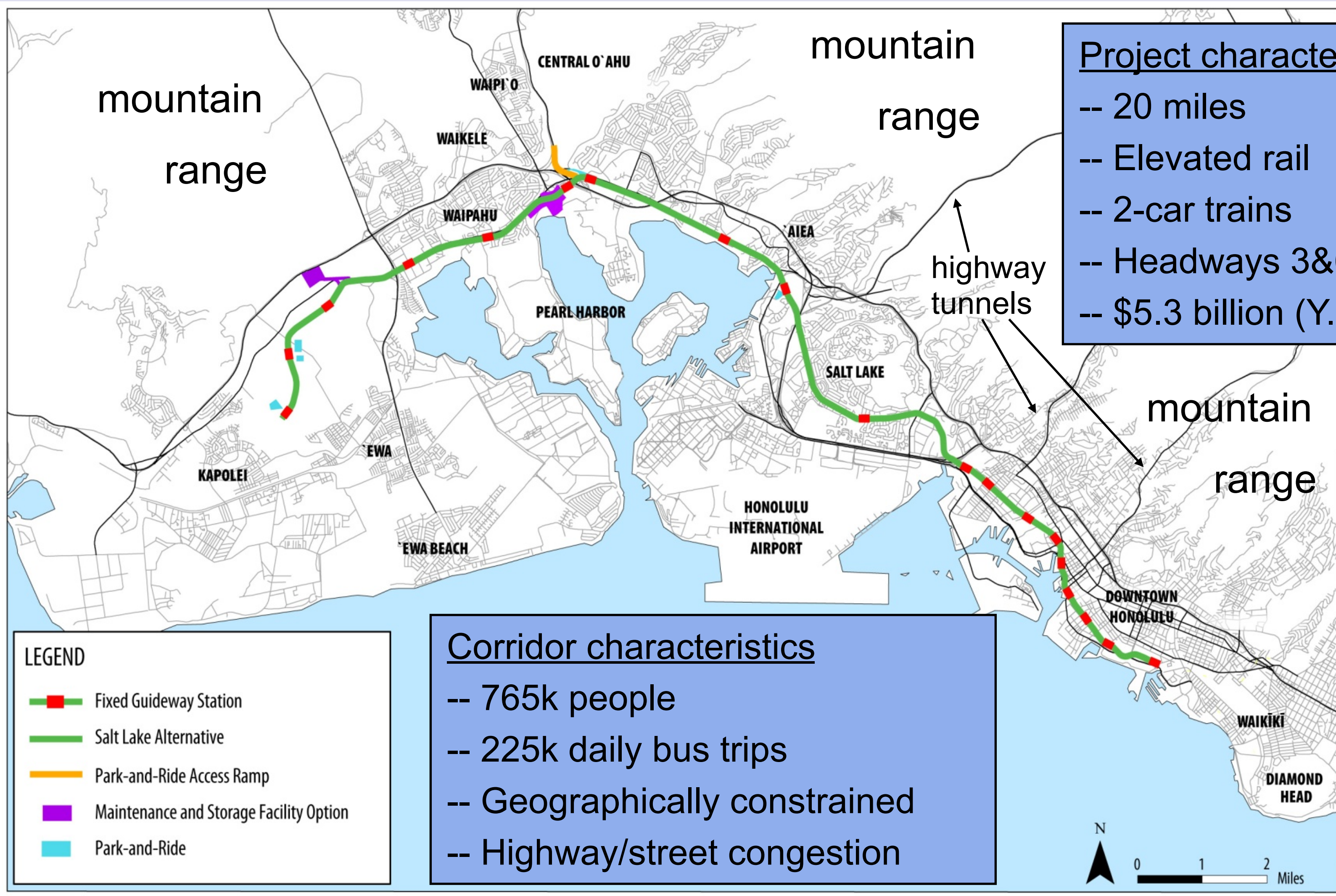

<u>Project characteristics</u>

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Analysis

Model Inputs and Responses

Rail-trip Build-up	Forecast							
Attribute	#1	#2	#3	#4	#5	#6	#7	#8
Person trips	--	’05	’18	’18	‘30	‘30	‘30	’30
Highway speeds	--	’05	’18	’18	‘05	‘05	’30-	’30
Bus speeds	‘30	’30	’18	’30	‘30	’05+	’30	‘30
Transit network	‘30	‘30	’18	‘30	‘30	‘30	’30	’30
Transit demand	’05a	’05p	’18	’18p	’30h	’30b	’30c	‘30
Rail trips per day	60k	73k	73k	77k	86k	72k	118k	87k

Notes:

- Transit demand ’05a is the 2005 on-board survey.
- Bus speeds ’05+ are based on highway speeds from the assignment of 2005 person trips onto the 2030 highway network.
- Highway speeds ’30- are from the assignment of 2030 person trips onto the 2005 highway network.

Analysis
Model Inputs and Responses

- Solid existing foundation ≈ 60k rail trips/day
- Follow-up items from the build-up
  - Demographics a key driver; west-end jobs???
  - Large highway investment, little added congestion
- Follow-up items from review of service plan
  - Massive restructuring of the bus system
  - Rail headways

Analysis
Model Inputs and Responses

- Demographics: west-end jobs
  - Large gains of households/jobs in adopted plan
  - Market forces pushing household growth
  - Job growth may depend on “unhappy” policies
  - Test results: 2030 with 2017 jobs distribution → 94k
  - Assumptions for the range of forecasts
    - UB: 2017 distribution pattern in 2030
    - BG: MPO long range plan projections
    - LB: Increased job growth in Ewa/Kapolei

Analysis
Model Inputs and Responses

- Large highway investment
  - Only modest congestion increases 2005→2030
    - Only 1,000 rail riders added by worse congestion
  - $3 billion highway improvements in adopted plan
  - Test results: no highway improvements→118,000
  - Assumptions for the range of forecasts
    - UB: 2018 highway plan
    - BG: 2018 highway plan + selected projects
    - LB: full adopted regional plan

Analysis
Model Inputs and Responses

- Massive bus-system restructuring
  - Geographic constraints → most routes in corridor
  - Rail alignment → affects large majority of routes
  - Test for "unhappy TSM riders" → 5,000 of 87,000
  - Assumptions for the range of forecasts
    - UB: Bus service plan unchanged
    - BG: Bus service plan, but with 5 routes restored
    - LB: Bus service plan, but with 10 routes restored

Analysis

Model Inputs and Responses

- Rail Headways
  - 3-minute peak / 6-minute off-peak
    - 2-car trains on 4-car-capable platforms
  - Phased implementation
    - Service level & passenger load balancing
  - Test result: 5-min peak / 10-min offpeak → 79,400
  - Assumptions for the range of forecasts
    - UB: 3-minute peak/6-minute off-peak
    - BG: 3-minute peak/6-minute off-peak
    - LB: 5-minute peak/10-minute off-peak

Analysis

New Items beyond the Model's Experience

- Follow-up items on model inexperience
  - Absence of current formal park-ride riders
  - Bus-access to rail
  - Multi-transfer trips
  - Guideway effects
  - Special markets – circulation trips

Analysis

New Items beyond the Model's Experience

- Absence of current formal PnR riders

Current lot	Cars	Spaces	Bus routes
Hawaii Kai	?	134	1, 80, 80A, 82, 95
Mililani Mauka	30	176	52, 88A, 98
Royal Kunia	12	149	97, 434
Wahiawa	40	50	52, 62, 83, 83A, 98
Haleiwa	?	20	52, 83A, 76

- Few lots
- Chickens and go-carts
- Lots of bus service
- Few park/ride trips

- Initial forecast with model calibrated with Honolulu' 05
  - 90,400 daily rail trips
  - Walk 17%, bus 63%, FPnR 0.5%, IPnR 2.7%, KnR 17%
- Calibration against access-to-rail trips from Portland
  - Revised forecast: 98,600 daily rail trips
  - Walk 15%, bus 56%, FPnR 23%, IPnR 2%, KnR 4%

Analysis

New Items beyond the Model's Experience

- Absence of current formal PnR riders (continued)
  - Calibration against auto-access trips in San Diego
    - 87,000 daily rail trips
    - Walk 18%, bus 67%, FPnR 8%, IPnR 4%, KnR 4%
  - Assumptions for the range of forecasts
    - UB: use Portland drive access shares or ARRF II
    - BG: use San Diego drive access shares or ARRF II
    - LB: standard forecast assumptions

Analysis

New Items beyond the Model's Experience

- Bus-access to rail
  - Honolulu 2005 access shares
    - 91% walk access, 9% auto access
    - 35% 0-car, 30% 1-car, 35% 2+ car
    - Only 8% of 1-car household riders drive to transit in 2005
    - Only 16% of 2+ car household riders drive to transit in 2005
  - Forecast with model calibrated with Honolulu' 05
    - 29% of bus access comes from 1-car households
    - 45% of bus access comes from 2+car households
  - Assumptions for the range of forecasts
    - UB: standard forecast results
    - BG: shift 2+car hhold bus-access trips to drive access
    - LB: shift 25% of 2+car hhold bus-access trips to auto

Analysis

New Items beyond the Model's Experience

- Multi-transfer trips
  - More than 50% of rail riders must transfer more
  - Path-choice OK in the model? Transfer penalty?
  - Already checked for unhappy tsm riders
  - Test for competing bus paths in build → 32 trips
    - Only Home-Based Work
    - Transfer > 2, bus path better than rail path
  - Assumptions for the range of forecasts
    - UB: no change
    - BG: no change
    - LB: no change

Analysis

New Items beyond the Model's Experience

- Unmeasured guideway effects
  - Rail = local bus in standard forecasts
  - Rail substantially improves unmeasured attributes

    - Visibility/learnability - Schedule flexibility for riders
    - Reliability - Amenities at stops, on vehicles

  - Test Results: full "other" effects → 103,400
  - Assumptions for the range of forecasts
    - UB: K=14.5/5.5 minutes + $C(ivt_{rail}) = 0.85 \times C(ivt_{other})$
    - BG: K=7/3 minutes + $C(ivt_{rail}) = 0.95 \times C(ivt_{other})$
    - LB: Standard Forecast

Analysis

New Items beyond the Model's Experience

- Circulation trips
  - Re-estimated original WMATA model using 2002 data
  - Densities along Honolulu corridor relatively similar to Washington DC densities
  - Circulation riders
    - 14,600 rail trips
    - Added to the 87,000 trips from the standard forecast
    - Just under 15% of total rail ridership

Specifications

For the UB, LB, and BG Forecasts

Source of Uncertainty	Lower Bound	Best Estimate	Upper Bound
Western End Employment	Increased Job Growth	Current Plan	2017 Distribution Pattern
2030 Highway Investments	2030 Highway Investment Plan	More Modest Investment Plan	No Improvements
Bus Restructing Revisions	Revise Top Ten Routes	Revise Top 5 Routes	Existing Bus Plan
Fixed Guideway Service Levels	5 Minute Peak/10 Minute Off-Peak	3 Minute Peak/6 Minute Off-Peak	--
Drive Access Behavior	Re-distribution of Access Modes	San Diego or ARRF II	Portland or ARRF II
Bus Access to Rail (2+car hholds)	shift 25% of 2+car hhold bus-rail to auto	shift 2+car hhold bus-rail to drive-rail	Standard forecast results
Mutli-Transfer Rail Trips	--	--	--
Unmeasured Effects	Local Bus	50% of Effect	100% of Effect

Summary of Results

- Standard estimate: 87,000 rail trips per day
- Upper bound: xx,000 rail trips per day 105,000
- Best estimate: yy,000 rail trips per day 95,000
- Lower bound: zz,000 rail trips per day 80,000

Upside Uncertainties	Downside Uncertainties
1. Unmeasured attributes	1. Unhappy TSM riders
2. Drive access behavior	2. Rail headways
3. Highway congestion levels	3. 2+ car households bus access
4. West End employment	4. West End employment

Conclusions on the Forecasts

- Strong confidence in lower end
- Concerned about drive access behavior
  - Important design implications
- West End development and highway improvement investments will have measurable impact on ridership
  - Very difficult to determine confidence levels
- Standard estimate likely an under-estimate

Observations on the Effort

- New way of thinking about forecasting
  - Direct connection to the real world
  - Insights
  - Not about model mechanics
- Learning process → new investigations
  - West End employment growth
  - Examination of highway investments
  - Drive access behavior
- Direct contribution to case for the project
  - FTA assistance in understanding the benefits of the project

Observations on the Effort

- Client support and interest
- New task in the work plan
  - QA/QC
  - Uncertainty analysis
- Peer review topics