Travel Forecasting for New Starts

Minneapolis, MN
June 15-16, 2006
Welcome!

- Purpose
- Approach
- Participants
- Logistics
- Agenda
- Overview of Additional Project Benefits
Purpose

• No surprises – for sponsors or for FTA
• Updates on FTA efforts since 2003
  – Capturing additional benefits of New Starts
  – Applying QC tests to forecasts
  – Vetting draft FTA guidance on forecasting
No Surprises!

Long-standing FTA principles
- Respond to problems
- Compare against low-cost option
- Hold policies constant
- Find effective, cost-effective projects

Recent improvements in FTA QC
- Summit
- FTA staff reviews of forecasts
- Making the case for a project

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Approach to This Workshop

- Early distribution of written materials
  - Think-pieces
  - Draft guidance
- Workshop
  - Summary presentations
  - Participant comments / questions
  - Wrap-up session on next steps
- Workshop summary
Participants

- Affiliation
- Experience with New Starts forecasting
Logistics

- Sessions
  - Summary presentations
  - Participant comments / questions / e-mails

- Schedule
  - Lunches provided
  - Scheduled breaks (Red Sox at Twins, 7:10pm tonight)
  - Schedule adherence (see above)

- Facilities
Agenda

• Capturing additional project benefits
  – Additional transit attributes
  – Congestion relief
  – Variable trip tables
  – Economic development
Agenda

• Quality control on forecasts
  – Predicted and actual ridership
  – Data library of on-board surveys
  – Aggregate CTPP-based model
  – Semi-independent forecasts
  – Additional QC tests
  – Summit 1.0 and 1.5
Agenda

• Quality control (continued)
  – Early service-quality analysis of alternatives
  – Dealing with uncertainties
  – Tracking performance of forecasters
Agenda

• Draft guidance
  – Properties of travel forecasting models
  – Calibration and validation
  – Methods for on-board surveys
  – Preservation of forecasts
Discussion-piece #1: “Allowances” in Benefits and Cost-Effectiveness

- New Starts ratings and project benefits
- Allowances for omissions in the CE ratings
  - Traveler value of time: work and non-work
  - Timing of costs and benefits
  - Multiplier for unmeasured congestion relief
  - Multiplier for 2nd-order unmeasured benefits
- Perspective on the hunt for new benefits
2 – Benefits from Changes in Other Transit Attributes

- Motivations
- Unmeasured attributes of transit
- Representing unmeasured attributes
- Possible approaches for New Starts
Motivations

• Current FTA policy on “constants”
  – No differences across transit modes
  – Unless calibrated with existing local guideways
  – And calibrated constants must be “reasonable”

• Recent observations for guideways
  – Ks seem necessary in well-scrubbed models
  – BRT ridership impacts > service changes

• So, look to non-time/cost service attributes
Some unmeasured attributes for trips that include:

<table>
<thead>
<tr>
<th>Use of guideway(s) and local bus</th>
<th>Exclusive use of guideway(s)</th>
<th>Time spent on a guideway</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comfort at stations</td>
<td>Comfort at stations</td>
<td>Vehicle amenities</td>
</tr>
<tr>
<td>Safety at stations</td>
<td>Safety at stations</td>
<td>Ride quality</td>
</tr>
<tr>
<td>Visibility/awareness</td>
<td></td>
<td>Personal safety</td>
</tr>
<tr>
<td>Learnability</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Span of <strong>good</strong> service</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Where IVT<sub>g</sub> and IVT<sub>b</sub> represent in-vehicle time spent on guideways and local buses, respectively
Current Strategies

• Mode choice model
• Network coding and pathbuilding

• Challenges
  – Deriving transit-mode-specific parameters
  – Representing access markets and paths
  – Controlling multi-path pathbuilders
Current Strategies (1)

• Reliance on the mode choice model
  – Approach
    • Code network and build paths conventionally
    • Determine nature of the path (rail, bus, etc.)
    • Include constant specific to transit mode
    • Perhaps apply transit-mode-specific C(IVT)s
  – Common practice (esp. with path choice in nested models)
  – Different sensitivities for different markets
  – Problems with path-mode-choice consistency?
Current Strategies (2)

- Reliance on network coding
  - Approach
    - Represent fixed attributes as boarding times
    - Employ transit-mode-specific IVT weights
    - Build paths that recognize “unmeasured” attributes
    - Pass “smarter” impedances to mode choice
  - Better approach with multi-path path-builders?
  - Virtue of internal consistency
  - Risk to QC? Insensitive across travel markets?
Challenges - 1

- Determining mode-specific Ks and Cs
  - Problems in estimation of mode choice models
    - General instability of parameter estimates
    - Even generic-transit Ks rarely survive calibration
  - Problems in calibration of mode choice models
    - Absence of similar behavior (choice riders, park-ride)
    - Inadequate data on current transit ridership
    - Grossly erroneous person-trip tables from TG & TD
  - Absence of consistent parameters nationally
Example: errors in the person-trip table and the transit network lead directly to errors in the computed calibration target and the calibrated value of $K$.

Sum of the person-trips in these cells is the denominator of the target transit share calculation for this transit mode “$M$” serving this travel market “$S$.”
Challenges - 1

• Sources of error in person-trip tables
  – Demographic/socio-economic estimates
  – Highway speeds
  – Generation and distribution models

• Sources of error in transit connectivity
  – Walk-access coding rules
  – Drive-access coding rules
  – Path-building conventions
Challenges - 2

• Isolating trips with guideway-only paths
  – Zones typically larger than max-walk-distance
  – Parts of I and J may require bus connections
  – Options:
    • Zones sized to max-walk-distance,
    • Or access partitioning within zones, and separate path for access/line-haul market, and separate mode-choice calculation for each market
    • Or enumeration method for model application
Challenges – 2

Zone I: 1 mile square
Walk-rail: 25%
Walk-transit: 100%

Maximum walk distance = 0.5 mi.

Zone J: 1 mile square
Walk-rail: 12.5%
Walk-transit: 100%

What transit options are available to whom?

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Challenges - 2

• Paths from I to J
  – Detailed
    • walk-rail-walk
    • walk-bus-rail-walk
    • walk-rail-bus-walk
    • walk-bus-walk
    • drive-rail-walk
    • drive-rail-bus-walk
  – Typical
    • walk-local-walk
    • walk-premium-walk
    • drive-transit-walk

• Markets from I to J
  – Detailed
    • 25 x 12.5 = 3.125%
    • 100 x 12.5 = 12.5%
    • 25 x 100 = 25%
    • 100 x 100 = 100%
    • 100 x 12.5 = 12.5%
    • 100 x 100 = 100%
  – Typical
    • 100 x 100 = 100%
    • 100 x 100 = 100%
    • 100 x 100 = 100%
Challenges - 3

• Isolating guideways within multi-paths
  – I-J “path” may include many path options
  – I-J impedances may be probability weighted
  – Test of $\text{IVT}_{\text{gdwy}} > 0$ may be very misleading
  – Some trips from I to J use local-only paths
  – $K_{\text{gdwy}}$ inappropriate for local-only component of trips from I to J
Challenges with multi-path pathbuilders

- Multiple paths from I to J
- Probability-weighted impedances
  - $\text{IVT}^\text{skim}(\text{rail}) = \%\text{rail} \times \text{IVT}^\text{path}(\text{rail})$
  - $\text{IVT}^\text{skim}(\text{bus}) = \%\text{bus1} \times \text{IVT}^\text{path}(\text{bus1})$
  - $\%\text{bus2} \times \text{IVT}^\text{path}(\text{bus2})$
- Questions: if $\text{IVT}(\text{rail}) = 5$
  - what is the actual rail time?
  - what is the $\%\text{rail}$?
  - should a $K(\text{rail})$ apply in mode choice?
Possible Approaches for FTA

• Potential methods
  – Current policy: K=0 except from local data
  – K & C(IVT) determined by project attributes

• Potential applicability
  – Defaults for “new” New Starts
  – Caps for New Starts expansions

• Alternative implementation strategies
An Illustration

• K & C(ivt) determined by project attributes
  – Guideway-like characteristics
    - Reliability
    - Branding/visibility
    - Ride quality
  – Span of service
  – Passenger amenities
    - Stations/stops
    - Vehicles
  - Schedule-free service
  - Learnability
An Illustration (continued)

- Application rules for path characteristics:
  - Guideway only, drive-acc: full K
  - Guideway only, walk-acc: some % of K
  - Guideway & local bus: some % of K
  - Guideway IVT: less onerous C

- Relevant to build and baseline alternatives
An Illustration (continued)

• Implementation
  – Option 1: within mode choice models
    • Modification of local models for Ks and Cs
    • Higher user benefits → better cost-effectiveness
    • Higher ridership forecasts (big park/ride increase?)
  – Option 2: post-forecast computations
    • Isolation of new guideway trips
    • Calculation of benefits for those trips using Ks, Cs
    • Higher user benefits but same ridership forecasts
Next Steps

- Decision on Options 1 and 2 (or 3?)
- Testing of implications
- Effective in January 2007
  - Seems possible with Option 1
  - Challenge with Option 2
3 – Evaluation of Highway Congestion Relief Benefits

- Background
- Confirmation of problems
- Tests of alternative remedies

Bill Woodford, AECOM Consult
FTA recognizes that transit projects can reduce highway congestion and improve mobility for highway users.

- User benefits = transit + highway
- But, early experience showed unexplainable highway benefits (magnitude and geographic location)
Consequently:

- FTA considers only transit-user benefits
- Congestion-relief benefits not counted
- Congressional direction to FTA and FHWA to conduct research on ways to credit congestion-relief benefits

(2004 House appropriations)
Background

• Research approach
  – Confirm existence & magnitude of problem
  – Diagnose likely causes
  – Propose solutions
  – Prepare recommendations
Confirm Problem

- Examine two test cases with “well-behaved” mode choice models and alternative definition
  - Case 1: Modest project with small change in vehicle trips
  - Case 2: Mega project with large ridership impacts

- Compute and map user benefits
- Analyze highway assignment results
Case 1 – Change in Auto Vehicle Trips

Productions + Attractions
Case 1 – Auto User Benefits

[Maps showing changes in auto user benefits]
Case 1 – Change in Assigned VHT
Case 2 – Change in Auto Vehicle Trips

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Productions

Attractions
Case 2 – Auto User Benefits
Case 2 – Change in Assigned VHT
Conclusions

- Auto User Benefits are unstable
- Magnitude of Auto User Benefits compared to Transit User Benefits sufficient to materially misstate cost-effectiveness
- Apparent cause is lack of assignment stability
Assessment of Techniques to Improve Stability

- Trip table precision – bucket rounded integers appears to aggravate problem
- Real numbers do not, however, solve problem
Assessment of Techniques to Improve Stability

- Fixed iteration shares do not appear to address problem

Equilibrium Assignment  Fixing base factors  Fixing build factors
Assessment of Techniques to Improve Stability

- Tighter equilibrium closure criteria does improve link assignment stability... eventually
Assessment of Techniques to Improve Stability

- Incremental assignment rapidly generates a stable solution...
- But with substantially different User Benefit results than equilibrium assignment.
Relationship between Tighter Closure and User Benefits

- Tighter closure necessary but not sufficient for meaningful User Benefits
Relationship between Tighter Closure and User Benefits

• Stabilized User Benefits requires:
  – Tighter closure
  – Consistent-across-the-board (CAB) evaluation of “best” transportation option:
    • Time vs. distance vs. cost
    • Path skimming, mode choice, assignment
  – Even so…
    • Widespread benefits
    • Substantial effort required to confirm reasonableness
Case 1 – Tighter Closure + CAB
Case 2 – Tighter Closure + CAB
Conclusions

• Highway assignment stability can be improved with existing equilibrium assignment techniques:
  – Extremely time consuming – 1000s of iterations
  – Very high degree of consistency required among different model components
  – Model revision/revalidation may be required
Conclusions

• Highway congestion benefits still not practical
  – May require modifications to highway assignment and mode choice procedures
  – Requires development of meaningful time/capacity estimates
  – Unclear how consistency can be achieved across metropolitan areas
  – Burdensome new Federal review for New Starts

• FTA: continue with transit benefits only
4 – Mobility Benefits from Variable Trip Tables

- Background
- An approach
- Barriers
- Conclusion
Background

• “Fixed” trip tables
  – Implications
    • TSM person-trip tables for all alternatives
    • Benefits from mode choice only
    • No benefits from rearranged travel patterns
  – Long-standing FTA policy
    • Unavailability of appropriate methods
    • Avoidance of another source of over-predictions
  – Reassessment
An Approach

- Simplest setting (for this task)
  - Logit for mode choice and destination choice
  - Logsum from mode choice $\rightarrow$ destination choice

$$\text{Prob}(j \text{ given } i) = \frac{\exp(C_{ls} \times \logsum_{ij}) \times \text{size}_j}{\sum_j[\exp(C_{ls} \times \logsum_{ij}) \times \text{size}_j]}$$

From mode choice; same term used in Summit to compute user benefits
An Approach

• Another logsum-based measure
  – Same principles as mode-choice logsum
  – Inclusive of benefits from mode choice and destination choice

(1) \( \logsum_i = \ln\{\sum_j[\exp(C_{ls} \times \logsum_{ij}) \times \text{size}_j]\} \)

(2) Price of all travel from I = \( \frac{\logsum_i}{(C_{ivt} \times C_{ls})} \)

(3) User benefits = \( (\text{price}_{\text{build}} - \text{price}_{\text{base}}) \times \text{productions}_i \times (-1) \)
An Approach

Price of travel from i to j

Benefits for existing trips from i to j

Benefits for new trips from i to j

Trips from i to j
An Approach

Price of all travel from zone i

Prods0

Benefits for all productions from zone i

Trips produced from zone i

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An Approach

Properties
- Captures the benefits of any change
  - Any choice in the mode choice model
  - Any attribute of any choice
- Isolates benefits by source
  - Changes in mode/access/path choices
  - Changes in destination choices
A 10-zone Test of the Approach

• Models
  – Binary logit mode choice
  – Logit trip distribution ("destination choice")
    • Singly constrained (i.e., choice model only)
    • Doubly constrained (so column sums = attractions)
  – Linked with logsum variable

• Test: 20-minute (IVT) reduction for transit travel from zone 1 to zone 2
Test Measures

• Singly constrained trip distribution
  – Total user benefits from TD logsum
  – TD benefits = total benefits – MC benefits

• Doubly constrained trip distribution
  – Total user benefits from TD logsum (same)
  – MC benefits from $\Delta$ expenditures
### Test Results

<table>
<thead>
<tr>
<th>Zone</th>
<th>dPrice (mins)</th>
<th>UBtot (hrs)</th>
<th>UBmc (hrs)</th>
<th>UBtd (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.00</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>2</td>
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<td>110.4</td>
<td>2.4</td>
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<td>3</td>
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<td>0.0</td>
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<td>0.0</td>
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<tr>
<td>10</td>
<td>0.00</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>---</td>
<td><strong>112.9</strong></td>
<td><strong>110.4</strong></td>
<td><strong>2.4</strong></td>
</tr>
</tbody>
</table>

**Singly Constrained Destination-Choice Model**

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## Test Results (2)

**Doubly Constrained Destination-Choice Model**

<table>
<thead>
<tr>
<th>Zone</th>
<th>dPrice (mins)</th>
<th>UBtot (hrs)</th>
<th>UBmc (hrs)</th>
<th>UBtd (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.02</td>
<td>-2.0</td>
<td>1.1</td>
<td>-3.1</td>
</tr>
<tr>
<td>2</td>
<td>-1.66</td>
<td>138.3</td>
<td>108.0</td>
<td>30.3</td>
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<td>3</td>
<td>0.01</td>
<td>-1.6</td>
<td>4.3</td>
<td>-5.9</td>
</tr>
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<td>4</td>
<td>0.02</td>
<td>-3.5</td>
<td>2.7</td>
<td>-6.2</td>
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<td>-2.5</td>
<td>3.6</td>
<td>-6.1</td>
</tr>
</tbody>
</table>

*Total --- 112.9 134.9 -22.0*
Observations on the Test

• Singly constrained destination choice
  – Internally consistent results for MC and TD
  – Meaningful UBmc and UBtd

• Doubly constrained destination choice
  – Consistent results with TD prices
  – Inconsistent results with MC prices
  – So, MC-level expenditure calculations for changes in person-trip tables → meaningless
Barriers and Tentative Conclusion

- Narrow set of conditions for success
  - Logit trip distribution models
  - Logsum from mode choice
- General absence of these conditions
- Apparently small contribution from TD
- Trade-off with added model complexity
- Conclusion(?): low priority for FTA
5 – Mobility Benefits from Variable Trip Ends

- Motivations
- Risks of double-counting
- Location benefits
- Barriers and conclusions
Motivations

• “Economic development benefits”
  – Often-cited goal for New Starts projects
  – Absent from FTA’s rating process
    • Fixed trip tables → no land-use changes
    • Land use rating considers setting, not impacts

• Recent interest at FTA and in Congress in “economic development”
Risks of Double Counting

• Research conclusion:
  Development impacts are the consequence of accessibility improvements
• New Starts ratings criteria capture well the impacts on mobility/accessibility
• So, many possible measures of economic development impacts would double-count the same benefits
Location Benefits

- Two possibilities
  - Benefits from shifts in location choices of households and businesses (analogous to changes in destination choices)
  - Benefits from reduced expenditures on travel because of more focused development (from outlying suburb to urban core)
Problems

• Absence of an established state of the practice in land-use forecasting
• Difficulties in differentiating policy-driven impacts from project-caused impacts
• Potentially overwhelming magnitude of reductions in overall travel  ➔ no help in differentiating proposed projects
• Opportunities for manipulation
Status

- No promising avenues toward valuing benefits of development consequences
- FTA has no current plans for further pursuit of ways to quantify benefits of revised locational choices as an increment beyond direct mobility benefits
6 – Predicted and Actual Ridership on New Starts Projects

- Phase I: overview
- Phase II: case studies
- Conclusions
Phase I

• Selection criteria for projects
  – Full Funding Grant Agreement
  – Not included in the Pickrell report
  – Open to service (21 projects)
  – Forecast of guideway ridership (19 projects)
Phase I

• Assessment of post-1990 projects (FTA):
  – Exceeded AA forecast: 3 of 19
  – At least 80% of AA forecast: 3 of 19
  – At least 70% of AA forecast: 4 of 19

• Assessment of pre-1990 projects (Pickrell):
  – Exceeded AA forecast: 0 of 10
  – At least 80% of AA forecast: 0 of 10
  – At least 70% of AA forecast: 1 of 10
Update on the 1990 Projects

• Update on pre-1990 projects
  – Ridership now close to forecast: 2 of 10
  – Ridership growing but ways to go: 2 of 10
  – Ridership largely unchanged: 3 of 10
  – Ridership has declined: 3 of 10
Phase I

• Conclusions
  – Risk is higher for starter projects
  – Risk is higher with less-common modes
    • Downtown circulators
    • Bus guideways
  – Travel forecasting usually ends with the conclusion of Alternatives Analysis
Phase II

• Approach
  – Detailed review of 7 of the 19 projects
  – Reliance on available documentation
  – “Forensic” analysis
  – Two “successful” forecasts
  – Five “less successful” forecasts
Phase II

• Conclusions
  – Forensic analysis nearly impossible with current data sources
  – Experience matters, but not always
  – Offsetting errors help “successful” forecasts
    • Underestimated population/employment growth
    • Underestimate guideway share of transit trips
Conclusions (continued)

- “Less success” has many sources
  - Overestimated population/employment growth
  - Unanticipated changes in travel patterns
  - Overstated service levels, understated fares
  - Post-forecast changes in project scope
Overall Conclusions

- Forecast accuracy may be improving.
- Models cause only some of the problems.
- There is still a long way to go.
- We need more information if we are to learn more from future projects.

“Hey, we’re only humble travel forecasters ........
...... and we have much to be humble about.”
7 – Data Library

- Motivations and application
- Assembled datasets
- Early insights
Motivations

• Learn from 30 years of New Starts experience
• Understand travel patterns of rail projects
• Improve planning, forecasting, and as a result, decision-making
Approach

• Collect available on-board survey datasets
• Develop common tabulations regarding
  – Characteristics of the transit rider,
  – Geography of the trips
  – Characteristics of the trips by trip purposes
• Distribute the information where it may be useful - Available on CD
Use of the Data Library

- Understand likely travel patterns of proposed projects
- Provide precedent for project characteristics and forecasting results
- Bolster “case” for proposed projects
- Beware of data problems
Datasets

- Baltimore Light Rail & MARC Commuter Rail
- Buffalo Metro Rail
- Dallas Light Rail and TRE Commuter Rail
- Los Angeles Metro Rail (Blue and Green lines)
- Portland MAX Light Rail
- Salt Lake City TRAX
- San Diego Trolley and Coaster Commuter Rail
- San Jose Light Rail
- St. Louis Metrolink
Early Insights – Trip Purposes

Trip Purposes for All Systems

- Baltimore - LRT
- Buffalo
- Dallas LRT
- Los Angeles
- Portland
- Salt Lake City
- San Diego - LRT
- San Jose
- St. Louis
- Baltimore - MARC
- Dallas TRE
- San Diego - Coaster

Legend:
- NHB
- HBO
- HBW
Early Insights – Access Mode

Access Mode for Home Based Work Trips - Light Rail Systems

- Unknown
- Drop-off
- Park and Ride
- Bus
- Non-motorized

Cities: Baltimore, Buffalo, Dallas, Los Angeles, Portland, Salt Lake City, San Diego, San Jose, St. Louis
Early Insights – Egress Mode

Production End Egress Mode for Home Based Work Trips - Commuter Rail Systems

- Unknown
- Light Rail
- Pick-up
- Park and Ride
- Bus
- Non-motorized

Baltimore
Dallas TRE
San Diego
Early Insights – CBD Attractiveness

CBD Attractiveness by Trip Purpose

- Buffalo: HBW - 48%, HBO - 48%, NHB - 0%
- Dallas - LRT: HBW - 22%, HBO - 12%, NHB - 5%
- Los Angeles - LRT: HBW - 8%, HBO - 5%, NHB - 5%
- Portland: HBW - 31%, HBO - 13%, NHB - 2%
- Salt Lake City: HBW - 41%, HBO - 26%, NHB - 2%
- San Diego - LRT: HBW - 30%, HBO - 10%, NHB - 5%
- St. Louis: HBW - 49%, HBO - 22%, NHB - 17%
- Dallas - TRE: HBW - 57%, HBO - 22%, NHB - 1%
- San Diego - CR: HBW - 37%, HBO - 12%, NHB - 5%
Early Insights – Unusual Markets

Park-and-Ride Access with Bus Egress by System

- Baltimore LRT: 0.4%
- Buffalo LRT: 0.2%
- Dallas - LRT: 0.8%
- Los Angeles - LRT: 1.2%
- Portland LRT: 1.4%
- Salt Lake City LRT: 0.8%
- San Diego - LRT: 0.0%
- San Jose LRT: 0.5%
- St. Louis LRT: 0.7%
- Baltimore MARC: 7.0%
- Dallas - TRE: 0.6%
- San Diego - CR: 6.7%
Implementation

• Big picture quality control
  – Consistency with observed travel patterns
  – Precedents for unexpected characteristics
  – Basis for explaining deviations from past experience -- What’s different?

• Help FTA and project sponsors evaluate forecasts in the context of past experience

June 2006
8 – CTPP-based Aggregate Model

- Background and approach
- Light rail model
- Commuter rail model

Bill Woodford, AECOM Consult
Background

• New generation of rail projects offers opportunity to understand markets outside very largest metropolitan areas

• FTA and project sponsors require procedures to apply these insights to new projects:
  – Relatively simple, robust approach
  – Transferable using consistently available data
Overview

• Aggregate Rail Ridership Forecasting (AARF) Model
  – Relates:
    • Y2000 CTPP JTW
    • ~Y2000 station locations / NTD service quality
  – To:
    • NTD ~Y2000 rail ridership

• Purpose: Supplement conventional models with:
  – Understanding of potential markets
  – Insights into reasonableness of forecasts
Data for the LRT Model

- Excluded very largest metro areas
- Ridership reported in 2000 NTD, or more survey on an expanded system

<table>
<thead>
<tr>
<th>System &amp; year</th>
<th>Trips</th>
<th>System &amp; year</th>
<th>Trips</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baltimore 2000</td>
<td>27,415</td>
<td>Sacramento 2000</td>
<td>29,102</td>
</tr>
<tr>
<td>Buffalo 2000</td>
<td>23,155</td>
<td>Salt Lake City 2002:</td>
<td>33,615</td>
</tr>
<tr>
<td>Cleveland 2000</td>
<td>14,062</td>
<td>San Diego 2000:</td>
<td>83,474</td>
</tr>
<tr>
<td>Dallas 2000</td>
<td>37,682</td>
<td>San Jose 2001</td>
<td>30,295</td>
</tr>
<tr>
<td>Denver 2001</td>
<td>31,423</td>
<td>St. Louis 2002:</td>
<td>37,281</td>
</tr>
<tr>
<td>Portland 2000:</td>
<td>73,562</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Data for the Commuter Rail Model

- Included all but the very largest metro areas
- Year 2000 NTD (APTA for ACE)

<table>
<thead>
<tr>
<th>System</th>
<th>Trips</th>
<th>System</th>
<th>Trips</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baltimore-DC MARC</td>
<td>20,851</td>
<td>San Francisco Peninsula</td>
<td>30,616</td>
</tr>
<tr>
<td>Dallas-Ft. Worth TRE</td>
<td>4,229</td>
<td>San Jose ACE</td>
<td>3,500</td>
</tr>
<tr>
<td>LA Metrolink:</td>
<td>26,300</td>
<td>Seattle Sounder</td>
<td>1,120</td>
</tr>
<tr>
<td>Miami Tri-Rail</td>
<td>7,381</td>
<td>DC VRE</td>
<td>8,057</td>
</tr>
<tr>
<td>San Diego Coaster</td>
<td>4,327</td>
<td></td>
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</tr>
</tbody>
</table>
Level of Service Variables

- **LRT**
  - None used (similar LOS across country)

- **Commuter rail**
  - Speed (NTD vehicle miles/vehicle hours)
  - Train miles per direction route mile
  - Connection to rail distributor (only Seattle has none)
### CTPP JTW Selection

<table>
<thead>
<tr>
<th></th>
<th>10</th>
<th>11</th>
<th>12</th>
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</tr>
</tbody>
</table>

**Stratifications:**
- HH Income (Part I)
- Auto Ownership (III)
- Employment Density (II)

- 0.8*1.0*JTW(90 to 8)
- 0.8*0.1*JTW(90-to-7)
- 0.6*0.1*JTW(81-to-7)
Calibration Approach

• Tests of alternative model forms
  – Home-end / work end JTW station radii
  – Purpose segmentations
  – Access mode segmentations

• Criteria
  – “Reasonable” coefficient values
  – Higher r-squared values
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) + 0.445 * 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
### LRT Model

**Predicted vs. Observed**

<table>
<thead>
<tr>
<th>City</th>
<th>Observed Weekday Unlinked Trips</th>
<th>Drive Access Work Rail Trips</th>
<th>Other Rail Trips</th>
<th>Total Rail Trips</th>
<th>Percentage Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baltimore</td>
<td>27,415</td>
<td>13,336</td>
<td>28,704</td>
<td>42,040</td>
<td>53.3%</td>
</tr>
<tr>
<td>Buffalo</td>
<td>23,155</td>
<td>4,168</td>
<td>13,753</td>
<td>17,921</td>
<td>-22.6%</td>
</tr>
<tr>
<td>Cleveland</td>
<td>14,062</td>
<td>7,088</td>
<td>13,098</td>
<td>20,187</td>
<td>43.6%</td>
</tr>
<tr>
<td>Dallas</td>
<td>37,682</td>
<td>9,866</td>
<td>21,050</td>
<td>30,916</td>
<td>-18.0%</td>
</tr>
<tr>
<td>Denver</td>
<td>31,423</td>
<td>12,474</td>
<td>21,454</td>
<td>33,928</td>
<td>8.0%</td>
</tr>
<tr>
<td>Portland</td>
<td>73,562</td>
<td>13,320</td>
<td>52,431</td>
<td>65,751</td>
<td>-10.6%</td>
</tr>
<tr>
<td>Sacramento</td>
<td>29,102</td>
<td>8,539</td>
<td>25,389</td>
<td>33,928</td>
<td>16.6%</td>
</tr>
<tr>
<td>Salt Lake City</td>
<td>33,615</td>
<td>8,272</td>
<td>26,525</td>
<td>34,797</td>
<td>3.5%</td>
</tr>
<tr>
<td>San Diego</td>
<td>83,474</td>
<td>13,019</td>
<td>60,468</td>
<td>73,487</td>
<td>-12.0%</td>
</tr>
<tr>
<td>San Jose</td>
<td>30,295</td>
<td>9,338</td>
<td>38,168</td>
<td>47,506</td>
<td>56.8%</td>
</tr>
<tr>
<td>St. Louis</td>
<td>37,381</td>
<td>10,182</td>
<td>20,547</td>
<td>30,729</td>
<td>-17.8%</td>
</tr>
</tbody>
</table>
LRT Model
Predicted vs. Observed

Final Weekday LRT Ridership

Modeled Weekday Ridership

Observed Weekday Ridership

Model
Target
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

June 2006
## Commuter Rail Model
### Predicted vs. Observed

<table>
<thead>
<tr>
<th>City</th>
<th>Observed Ridership</th>
<th>Modeled Ridership</th>
<th>Percent Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baltimore</td>
<td>20,851</td>
<td>19,145</td>
<td>-8.2%</td>
</tr>
<tr>
<td>Dallas</td>
<td>4,229</td>
<td>1,586</td>
<td>-62.5%</td>
</tr>
<tr>
<td>Los Angeles</td>
<td>26,300</td>
<td>26,450</td>
<td>0.6%</td>
</tr>
<tr>
<td>Miami</td>
<td>7,381</td>
<td>7,061</td>
<td>-4.3%</td>
</tr>
<tr>
<td>San Diego</td>
<td>4,327</td>
<td>5,017</td>
<td>15.9%</td>
</tr>
<tr>
<td>San Francisco</td>
<td>30,616</td>
<td>31,032</td>
<td>1.4%</td>
</tr>
<tr>
<td>San Jose</td>
<td>3,500</td>
<td>3,127</td>
<td>-10.7%</td>
</tr>
<tr>
<td>Seattle</td>
<td>1,120</td>
<td>1,642</td>
<td>46.6%</td>
</tr>
<tr>
<td>Virginia</td>
<td>8,057</td>
<td>9,972</td>
<td>23.8%</td>
</tr>
</tbody>
</table>
Commuter Rail Model
Predicted vs. Observed

Weekday Commuter Rail Ridership

Modeled Weekday Ridership

Observed Weekday Ridership

Model
Target
Next Steps

- FTA testing through 2006
- Beginning in 2007
  - AARF forecasts part of QC tests
  - Documented in requests for entry to PE
9 – Semi-independent Forecasts

- Motivations
- Strategy and detailed approach
- Implementation
Motivations

• Experience over the past four years
  – Closer scrutiny of predicted deltas
    • Build versus baseline
    • New transit trips and user benefits
    • Better understanding of the project
  – Previously unknown model “properties”
    • Transit pathbuilding
    • Mode choice
  – Inadequacy of fixed “cap” on user benefits
Motivations

• Deltas highlight areas for attention
  – Better understanding, or
  – Problems for correction

• So, “quality control” forecasts
  – Generated by project sponsor
  – Compared against sponsor’s forecast
  – Used to solidify explanation of sponsor’s forecast, or to revise it

June 2006
Strategy

• “Quality-control” forecast
  – Prepared for the build alternative
  – Grounded in the “sponsor’s” forecast for the baseline alternative
  – Based on standardized methods
    • “Best” transit paths
    • Incremental mode choice model
  – Not a replacement for sponsor’s forecast
Strategy

• Local conditions vs. national consistency
  – Local conditions
    • Grasped by sponsor’s models
    • Reflected in the baseline forecast
  – National consistency
    • Simplified methods
    • Transparent properties
Details

• Best transit paths
  – Separately for walk-access & drive-access
  – Properties
    • No “favoring” of path types
    • Minimization of multi-path effects
    • Preservation of combined-headway effects
  – Dependence on local pathbuilder software
    • Straightforward with older all-or-nothing algorithms
    • Probably less so with multi-path algorithms
Details: Pathbuilding Weights

Impedance Weights for Path Selection

<table>
<thead>
<tr>
<th>Impedance</th>
<th>Units</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-vehicle time for (most) transit modes</td>
<td>Minutes</td>
<td>1.0</td>
</tr>
<tr>
<td>In-vehicle time for commuter rail</td>
<td>Minutes</td>
<td>0.8</td>
</tr>
<tr>
<td>All out-of-vehicle time</td>
<td>Minutes</td>
<td>2.0</td>
</tr>
<tr>
<td>Drive-access time</td>
<td>Minutes</td>
<td>2.0</td>
</tr>
<tr>
<td>Transfers</td>
<td>Number</td>
<td>5.0</td>
</tr>
<tr>
<td>Fare (cents) (peak / off-peak)</td>
<td>Cents</td>
<td>0.15 / 0.075</td>
</tr>
</tbody>
</table>

--- --- --- Subject to revision --- --- ---

June 2006
Details: Mode Choice Model

• Incremental logit
  – Focuses only on transit service changes
  – Considers small set of alternatives
  – Uses coefficients from mid-range of national experience
Details: Incremental Mode Choice Model

Choice

Auto

Transit

Transit/walk

Transit/drive
## Mode Choice Coefficients

### Coefficients in the Mode Choice Model

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Units</th>
<th>HBW</th>
<th>HBO</th>
<th>NHB</th>
</tr>
</thead>
<tbody>
<tr>
<td>IVT for (most) transit modes</td>
<td>Minutes</td>
<td>-0.020</td>
<td>-0.010</td>
<td>-0.020</td>
</tr>
<tr>
<td>IVT for commuter rail</td>
<td>Minutes</td>
<td>-0.016</td>
<td>-0.008</td>
<td>-0.016</td>
</tr>
<tr>
<td>All out-of-vehicle time</td>
<td>Minutes</td>
<td>-0.040</td>
<td>-0.020</td>
<td>-0.040</td>
</tr>
<tr>
<td>Drive-access time</td>
<td>Minutes</td>
<td>-0.040</td>
<td>-0.020</td>
<td>-0.040</td>
</tr>
<tr>
<td>Transfers</td>
<td>Number</td>
<td>-0.100</td>
<td>-0.050</td>
<td>-0.100</td>
</tr>
<tr>
<td>Fare (cents)</td>
<td>Cents</td>
<td>-0.003</td>
<td>-0.0015</td>
<td>-0.0015</td>
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<tr>
<td>Guideway flag(s)</td>
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<td>TBD</td>
<td>TBD</td>
</tr>
<tr>
<td>Transit-access logsum</td>
<td>Utiles</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
</tr>
</tbody>
</table>

--- --- --- Subject to revision --- --- ---
Details: Mechanics

- Development of “best” transit paths
  - Walk and drive access
  - Baseline and build alternatives
- Aggregation of sponsor forecasts
  - Preserving trip purposes, market segments
  - Transit trips by (1) walk and (2) drive access
  - Baseline and build alternatives
- Application of the incremental MC model
Implementation

- Testing through 2006
- Function in Summit version 1.5
- Effective January 2007
  - Projects requesting entry into PE
  - Projects in PE(?)
10 – Other Quality-Control Tests

- Motivations
- Strategy
- Two new QC tests
- Implementation
Motivation

• Recent experience
  – Unknown properties of models
  – Inconsistencies between alternatives

• Existing QC tests
  – Deltas in district-level trip tables, benefits
  – Thematic maps of benefits
  – Benefits by change in transit availability
Motivation

• Gaps in existing QC tests
  – Causes of benefits unclear
    • In-vehicle, walk, wait, or transfer time?
    • Fares?
    • Constants and mode-choice nesting structure?
  – Role of the project unclear
    • Introduction of transit guideway?
    • Other transit changes in the build alternative?
Motivation

• Findings for one recent proposed project
  – Tests
    • 80% of benefits from $\Delta$wait + $\Delta$transfer times
    • 70% of benefits on zone-to-zone paths that did not include the proposed guideway
  – Analysis
    • Benefits generated by large-scale improvements in bus headways (only) in the build alternative to foster bus access to the new guideway
Strategy

• Parallel with semi-independent forecasts
  – Best walk-access and drive-access paths
  – Incremental mode choice

• Additional tests
  – Benefits from each service attribute
  – Benefits for paths involving new guideway

• Potential application in sponsor’s models
Test 1: Causes of Benefits

- Isolation of deltas: “partial” forecasts

\[ \exp(w + x + y + z) \]

\[ = \exp(w) \times \exp(x) \times \exp(y) \times \exp(z) \quad [\text{complete}] \]
\[ = 1.0 \times \exp(x) \times \exp(y) \times \exp(z) \quad [\text{partial #1}] \]
\[ = \exp(w) \times 1.0 \times \exp(y) \times \exp(z) \quad [\text{partial #2}] \]
\[ = \exp(w) \times \exp(x) \times 1.0 \times \exp(z) \quad [\text{partial #3}] \]
\[ = \exp(w) \times \exp(x) \times \exp(z) \times 1.0 \quad [\text{partial #4}] \]

where \( w, x, y, \) and \( z \) are \( b(\Delta \text{ service variable}) \)
Test 2: Role of the Project

• Benefits related to project if:
  – Build IVT(gdwy) > Base IVT(gdwy) = 0
  – Build IVT(gdwy) > Base IVT(gdwy) > 0

• Benefits not related to project if:
  – Build IVT(gdwy) = 0
  – Build IVT(gdwy) = Base IVT(gdwy)
  – Build IVT(gdwy) < Base IVT(gdwy) [?!]
Some Details

• Multi-path transit pathbuilders
  – Various ways of identifying families of paths
  – Probabilities for individual paths
  – Probability-weighted attributes

• Implications
  – Test 1 probably unaffected
  – Test 2 may not be possible with multi-paths
Implementation

- Testing through 2006
- Function in Summit version 1.5
- Effective January 2007
  - Projects requesting entry into PE
  - Projects in PE(?)
- *Ad hoc testing already in use at FTA when needed*
11 – Summit Update

- Spreadsheet example
- Software versions
Spreadsheet example

- Prototypical mode choice model
- Extraction of information for Summit
- Summit calculations
  - Trips by change in transit availability
  - Price change for “non-transit”
  - Price changes for transit (by availability)
  - Capping
  - Price changes for all travel (by transit availability)
  - User benefits: total, transit, and auto
Summit Version 1.0

• Updates from version 0.99x
  – Full i/o compatibility with software packages
  – Options for transfer of mode choice results
    • Special binary file (as with 0.99x)
    • Matrix file format of local software package
  – Additional reporting
    • Capping effects
    • Playback of input records

• Projected: September 2006
Summit Version 1.5

• Updates from Version 1.0
  – Semi-independent forecasts
  – New quality-control tests
    • Sources of benefits
    • Role of the project