A Combined Quantitative and Qualitative Approach to Planning for Improved Intermodal Connectivity at California Airports (TO5406)

(Quarterly Meeting)

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Outline

• Objective
• Project Status
  – Progress on Current Tasks
  – Contents of First Year Report
• System Modeling
• IAPT Development
• Next Steps
• Discussion
Objective

– Develop techniques for analyzing the effectiveness of alternative strategies for improving intermodal connectivity at airports using a combined quantitative and qualitative approach
  • Quantitative: Analytical models of airport traveler and transportation provider’s behavior, traffic networks
  • Qualitative: Descriptive case studies and analysis of agency decision making processes

– Research products:
  • Case studies of intermodal access projects at California airports
  • Develop prototype Intermodal Airport Ground Access Planning Tool (IAPT)
  • Using IAPT to evaluate selected case study projects at California airports
  • Policy recommendations and planning guidelines
Project Status - Progress on Current Tasks

- Develop prototype user interface module for the Intermodal Airport Ground Access Planning Tool.
  - Preliminary screen design distributed for review
- Develop mode choice analysis module for the prototype Intermodal Airport Ground Access Planning Tool and calibrate on data for selected region
  - Define architecture and functional structure
  - Define mode choice analysis module data structure and interfaces between the mode choice analysis module and other IAPT modules
  - Define analysis zones and assemble airport ground transportation service data for calibration region
  - Assemble air passenger survey data for the model calibration region, review and clean the survey response data and geocode to analysis zones
  - Assemble mode choice model estimation input files and perform iterative model estimation runs to develop mode choice model utility functions and parameter values
Project Status - Progress on Current Tasks

- Developing the model of transportation service provider behavior
  - Problem isolation: characteristics, assumptions
  - Modeling
  - Compatibility with other parts, such as mode choice model and connectivity measurement, of IAPT
  - Existence of solutions
  - Numerical algorithms

- Developing interface between sub-modules
  - Explore software language/application interface
  - Commence development of data table specifications
Project Status - Progress on Current Tasks

- Explore intermodal connectivity considerations in airport ground access
  - Review connectivity issues in transit network planning
  - Measuring connectivity in airport ground access
  - Integration with IAPT performance measures
Preface and Acknowledgments
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  • Capabilities and Limitations of Modeling
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  • Graphical User Interface
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  • Data Preparation for Modeling
  • Model Calibration
  • Model Validation
– Chapter 4. Modeling Transportation Provider Behavior
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  • Dynamic Interaction Between Passenger and Transportation Provider Behavior
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– References
– Appendices
  • Details of mathematical modeling
Systems Modeling - Objectives

- Evaluate improvements in intermodal connectivity from alternative airport ground access strategies

- Predict changes in mode use in response to
  - Transportation provider fare and frequency changes
  - Addition of a new mode or service

- Conduct cost and benefit analysis based on the predicted system performance using performance measures typically adopted by Caltrans:
  - Performance measure
    - Travel time
    - VMT/VHT
    - Emissions
  - Capital and operating costs at decision maker level
Systems Modeling – Mode Choice

• Role of mode choice model
  – Predict patronage on each ground access mode
    • Response to changes in ground access service levels
    • Implications for transportation provider revenue
    • Changes in vehicular traffic levels
  – Response to introduction of new services or modes
    • Enhanced intermodal connectivity

• Considerations
  – Need to reflect the factors that influence air party mode choice
    • Travel time, service frequency (waiting time)
    • Cost
    • Accessibility, transfers, etc.
    • Air party characteristics (party size, trip duration, trip purpose, luggage, etc.)
  – Need to distinguish between different market segments
    • Residents vs. visitors
    • Business vs. personal trips
    • Type of trip origin (residence, hotel, other)
Systems Modeling – Mode Choice

• **Market segmentation**
  – Reflect availability and use of specific modes
    • Private automobile
    • Rental car
    • Hotel courtesy vans
  – Reflect varying sensitivity to service levels
    • Travel time
    • Cost

• **Proposed market segment sub-models**
  – Resident business trips
  – Resident non-business trips
  – Visitor business trips (hotel origin)
  – Visitor business trips (other origin)
  – Visitor non-business trips (residence origin)
  – Visitor non-business trips (hotel origin)
Systems Modeling – Mode Choice

• **General structure of the proposed model**
  - **Nested logit**
    - Widely adopted for airport ground access mode choice
    - Allows for analysis of sub-modes and service choices
    - Permits different substitution patterns across different modes
      - Addresses *Independence of Irrelevant Alternatives* problem
  - **Utility functions**
    - General form: \( a_0 + a_1 \cdot \text{var1} + a_2 \cdot \text{var2} + \ldots \)
    - Variables
      - Cost/Income
      - In-vehicle travel time
      - Waiting time
      - Auto access travel time (to primary mode)
      - Walking distance
Systems Modeling – Mode Choice

- Proposed nested structure

  - Private Auto
    - Drop-off *(residents and visitors with residence trip origin only)*
    - Park *(residents only)*
      - On-airport Daily lot
      - On-airport Economy lot
      - Off-airport lot
  - Rental Car *(residents only – visitor rental car use modeled separately)*
  - Exclusive Ride
    - Taxi
    - Limousine
  - Shared-Ride Van
  - Scheduled Airport Bus
  - Public Transit
    - Local bus
    - Regional rail *(BART, Caltrain, VTA Light Rail)*
Systems Modeling – Mode Choice

• **Data assembly for mode choice model estimation**
  – Air party characteristics and relevant service measures for all available modes are necessary in order to estimate the model
  – Air party characteristics have been obtained from MTC air passenger survey data files after data cleaning
  – Mode service data has been assembled individually for three Bay Area airports through web resource and meeting with airport planning staff

• **Data tables specification**
  – Air party characteristics
  – Available alternative modes service measure, separated by three categories
    - Constant for all air passengers
    - Vary with analysis zone
    - Vary with trip duration
Systems Modeling – Mode Choice

- Some representative variables for those four tables
  - Air party characteristics
    - Party ID, party size, origin analysis zone, household income…
  - Mode service measures that are constant for all air parties
    - Walking time from parking lot to terminal, headway and travel time of shuttle bus for off-airport parking lots or rental car facility…
  - Mode service measures that vary by analysis zone
    - Highway travel time and cost, Taxi fare, door to door shuttle travel time and cost, access time and distance to transit (BART, CALTRAIN, VTA and bus transit are all included), transit travel time and cost, access time and distance to scheduled bus stop, scheduled bus travel time and cost…
  - Mode service measures that vary with trip duration
    - Parking cost in different types of on-airport parking lots (hourly, daily and economy) and off-airport parking lots, rental car cost…
Systems Modeling – Transportation Provider Behavior

• Objectives for modeling:
  – Represent the behavior of the transportation providers in response to the actions of air passengers, other providers, airport authorities and local government
    • Predict service decisions in response to
      – Fare and frequency changes by other providers
      – Addition of a new mode or service
Systems Modeling – Transportation Provider Behavior

• **Characteristics**
  
  – **Public providers:**
    - Including: rail, shuttle bus, APM link, transit bus, on-airport parking
    - Subject to constraints from airport authority regarding access to terminals
    - May include airport financial support or government subsidy
    - Strategies may vary among providers

  – **Private providers:**
    - Including: rental car, off-airport parking, taxi, limo, shared-ride van, scheduled airport bus, hotel courtesy van, charter bus
    - Strategy: to maximize revenue and profit
      - Consider capital and operating costs
Systems Modeling – Transportation Provider Behavior

• **Main factors affecting provider behavior**
  – Public providers
    • Changes in revenues and costs
    • Passenger response to service characteristics
    • Availability of government subsidies
    • Local government policy and airport regulation
  – Private providers
    • Changes in revenues and costs
    • Passenger response to service characteristics
    • Local government policy and airport regulation: airport access restrictions, service area constraints, and airport fees

• **Assumptions:**
  – All the providers within a mode considered to collectively compete with other modes
  – Fare and operating frequency (headway) are decision parameters
  – Geographic pattern of demand is known based on air passenger survey
  – Fare and service changes cannot be too frequent
Each access/egress path in the door-to-door service chain has a primary mode; Primary mode provider has to consider how to interface with or provide secondary access/egress modes:

- Private car, off-airport parking and shuttle
- Rental car and shuttle
- Private car, BART and APM
- Bus, BART and APM
- Private car and airport parking
- Taxi
Problem Simplification

General traffic networks

Transit network

Airport access/egress path

Primary Mode 1

Primary Mode i

Primary Mode N

Secondary mode i_1

Secondary mode i_k

O/D Zone j

Airport

Egress/Access path

D/O
Systems Modeling – Transportation Provider’s Behavior

Transportation provider’s behavior modeling

Airport authority and local government can control the behavior of transportation providers through policy and regulation on airport access, revenue, …

Nash Game:
For a given typical OD pair, the airport and Zone i, there is a full competition between available modes in Zone i.

Transportation providers can affect passenger behavior through fare and service changes but cannot control it.

Model choice model

Airport Survey

Airport passenger demand

Zone 1 demand
Zone 2 demand
Zone i demand
Zone N demand
There are two ways to formulate the problem

- **Rule based approach**
  - Simplified decision rules based on observed transportation provider behavior
    - Example: shared ride van company response to BART extension to SFO

- **Nash Game – multiple performance index maximization**
  - Full competition under the assumption that each competitor knows other competitors' strategy and outcome – full information
  - Each player is to choose their fare and operation frequency to maximize the total profit
    - Maximize total revenue with fixed resources
    - Maximize total profit
  - Under certain conditions, numerical algorithm exists for computing the Nash equilibrium for multiple competitors

For both approaches, need to address the trade-offs faced by each provider

- Revenue, operation frequency (capital and operation cost) and profit
IAPT Development – Introduction to GUI

• **Purpose**
  – Facilitate user interaction with IAPT
    • Problem specification
    • Data entry
    • Run model
    • View, print and save outputs
  – Minimize need for user to understand internal model structure

• **Typical GUI functionality**
  – Representative screen designs
Intermodal Airport Ground Access Planning Tool

Version 0.1
Select airport and press OK or press Cancel to return to previous screen.
## Intermodal Airport Ground Access Planning Tool

### Airport:
- **OAK** Oakland International Airport

### Select Project:
- - select one - -
  - New Project
  - 1 BART Connector - baseline
  - 1.1 BART Connector - $5 fare
  - 1.1.1 BART Connector - $5 fare, 5 min hdw
  - 2 Improved AirBART Link
  - 2.1 Improved AirBART Link - free

Select project and press **OK** or press **Cancel** to return to previous screen.

Select Existing Project
Automated people mover connection between BART Coliseum station and airport terminal. Elevated guideway with one track in each direction. Each car carries up to 10 people. 3 car max. consist. Four intermediate stations. 10 minute headway. $5 fare between airport and BART, $2.50 to intermediate stations. {new text shown in blue}
**Initial Data Entry Screen**

- **Define Project**
  - **Data Entry**
    - Regional Data
  - Define MOPs
    - Airport Data
  - Run Model
    - Project Data
  - View Output
  - Help

<< Select Type of Data to Enter
Display Highway Data Types

Region: San Francisco Bay Area

- - select one - -
Highway travel times
Highway distances
Highway tolls

Select option and press **OK** or press **Cancel** to return to previous screen
Select Data Table Import

Region: San Francisco Bay Area

Highway travel times
- - select action - -
Import data
Delete data
View/edit data

Select action and press OK or press Cancel to return to previous screen
Region: San Francisco Bay Area

Import highway travel time data file

Select File to Import
Select Data Table View/Edit

Region: San Francisco Bay Area

Highway travel times

- - select action - -
Import data
Delete data
View/edit data

Select action and press OK or press Cancel to return to previous screen

OK  Cancel
### Intermodal Airport Ground Access Planning Tool

**Region:** San Francisco Bay Area

**Data table:** HTIME_Bay_Area_SJC_v2

#### Highway travel times

<table>
<thead>
<tr>
<th>TAZ</th>
<th>AM_Peak</th>
<th>PM_Peak</th>
<th>Off-peak</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>55.1</td>
<td>72.3</td>
<td>41.8</td>
</tr>
<tr>
<td>2</td>
<td>54.3</td>
<td>71.5</td>
<td>40.2</td>
</tr>
<tr>
<td>3</td>
<td>56.4</td>
<td>74.8</td>
<td>43.6</td>
</tr>
<tr>
<td>4</td>
<td>52.3</td>
<td>68.7</td>
<td>39.3</td>
</tr>
<tr>
<td>5</td>
<td>53.9</td>
<td>69.1</td>
<td>40.5</td>
</tr>
<tr>
<td>6</td>
<td>54.6</td>
<td>70.4</td>
<td>40.9</td>
</tr>
</tbody>
</table>

Press **Save** to save edited values or **Cancel** to return to previous screen.

Press **Export** to export data table in CSV format.

View or Edit Data Table Contents.
Intermodal Airport Ground Access Planning Tool

Select Access Mode

Airport: OAK  Oakland International Airport
Project: 1.1  BART Connector - $5 fare

- - select one - -
Add New Mode
Auto drop
Auto park
Rental car
Hotel courtesy van
Taxi
Limousine
Door-to-door van
Scheduled bus
BART (shuttle bus)
AC Transit

Select mode and press OK or press Cancel to return to previous screen. Press Delete to remove mode from list for this project.
Intermodal Airport Ground Access Planning Tool

Airport: **OAK**  Oakland International Airport

Project: **1.1**  BART Connector - $5 fare

Mode: **BART (Connector)**

**Data Entry**
- Regional Data
- Airport Data
- Project Data

**Press** **Save** to save edited values or **Cancel** to return to previous screen

**Press** **Next** to display additional data for the selected mode

**Fixed travel time:** 12.0 min
**Average wait time:** 2.5 min
**Walk distance:** 200 feet
**Fixed travel cost:** 0.00 $/party
**Fixed travel cost:** 5.00 $/person
**Fixed travel cost:** 0.00 $/day

Display Access Mode Data
Intermodal Airport Ground Access Planning Tool

Airport: OAK  Oakland International Airport
Project: 1.1  BART Connector - $5 fare
Mode: BART (Connector)

Zonal travel time table:

- AM peak travel time variable: BART_Peak
- PM peak travel time variable: BART_Peak
- Off-peak travel time variable: BART_O-P
- Access travel time variable: Auto_BART

Press Save to save edited values or Back to return to previous screen
Press Next to display additional data for the selected mode

Display Access Mode Data
Intermodal Airport Ground Access Planning Tool

<table>
<thead>
<tr>
<th>Airport:</th>
<th>OAK  Oakland International Airport</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project:</td>
<td>1.1  BART Connector - $5 fare</td>
</tr>
</tbody>
</table>

Select MOP:

- - select one - -

<table>
<thead>
<tr>
<th>Add New Measure of Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1  BART Connector Ridership</td>
</tr>
<tr>
<td>2  BART Connector Revenue</td>
</tr>
<tr>
<td>3  Other HOV Ridership</td>
</tr>
<tr>
<td>4  Auto Vehicle Trips</td>
</tr>
<tr>
<td>5  Auto VMT</td>
</tr>
</tbody>
</table>

Select MOP(s) and press **OK** or press **Cancel** to return to previous screen.

Select Existing MOP
Intermodal Airport Ground Access Planning Tool

Airport: OAK  Oakland International Airport
Project: 1.1  BART Connector - $5 fare
MOP: 3  Other HOV Ridership

Output Measure:
Passengers
Select menu to change output measure

MOP Description:
Ridership on door-to-door vans, scheduled airport bus, and AC Transit. {new text shown in blue}

Modes:
- Auto drop
- Auto park
- Rental car
- Hotel courtesy van
- Taxi
- Limousine
- Door-to-door van
- Scheduled bus
- BART (Connector)
- AC Transit

Edit text and mode selections and press OK to save changes or Cancel to return to previous screen

Edit MOP Definition
IAPT Development – Typical Application Data Flow

**Software processes after airport and project selection**

1. **Step 1: Calibrate air passenger mode choice model based on survey data**
2. **Step 2: Travel time for given mode and OD**
3. **Step 3: Select alternatives**
   - Addition of a new mode
   - Service changes
     - Frequency
     - Fare
4. **Step 4: Iterative process to reach an equilibrium**
5. **Step 5: System performance**
   - Travel time
   - VMT/VHT
   - Emissions
   - Revenues and operating costs

**Transportation provider model**
- Competition between modes

**Passenger mode choice model**
- Nested Logit model

**Traffic network model**
Next Steps

- Program GUI in VB
- Specify required data structures
- Calibrate mode choice model
- Develop prototype transportation provider model
- Explore application of transportation provider model to representative problem
- Program IAPT modules
- Explore application of intermodal connectivity measures to IAPT
Open Topic Discussion

• IAPT development
• Other topics