INTERMODALITY PERFORMANCE MEASUREMENT OF MULTIMODAL PUBLIC TRANSPORTATION SYSTEMS

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Overview

- Background and Motivation
- Objective, Proposed Methodology, Case Study Description
- Work in Progress
“Multimodal system is a transport system that offers users diverse transport options that are effectively integrated, in order to provide a high degree of accessibility even for non-drivers”. (1)

“No agency has responsibility or authority for stitching together these modes and hence, integrated multimodal services are not available. Every organization is optimizing their own objectives and there is lack of attention for the whole system.” (2)

1. Multimodal Transportation in California
What Is Multimodal Public Transport (MPT)?

- A Typical MPT Trip

(a), (b) are unimodal trips and (c), (d) and (e) are multimodal trips

P is Park and Ride Location
Representation of Typical Multimodal Network

Representation of typical Multimodal Network
Understanding Multimodal Travel Scenario in U.S (1)

National Household Travel Survey (NHTS) data for 2009 was used to quantify the multimodal travel scenario in U.S. Below are the highlighting results:

- Remains concentrated in cores of largest metro areas
  1. NY, LA, Chicago, Washington DC, Boston, Philadelphia constitute 65% of all multimodal trips
  2. Share of multimodal transportation for the total travel in United States is 0.63% which shoots to 1.59% when there is a presence of rail.
  3. Share of multimodal transportation is more in urban area than in rural regions.
Remains segmented

1. *Hispanic travelers* have more multimodal travel with 0.9% of all trips as compared to 0.58% for non-Hispanic travelers.
2. Majority of multimodal trips (44.4%) are commute trips.
3. Multimodal share was higher for trips made by people in low income households (income $\leq$ $25,000$).
4. Weekday travel (0.78%) by multimodal travel is double than for weekend travel (0.34%).
5. Car, bus and walking are the most popular access and egress modes for multimodal travel.
6. Higher multimodal tendency in age group of 35-44 (0.82%) is observed.
Motivation - Smart Growth

- "Smart growth is an urban planning and transportation concept that advocates
  1. Growth in compact walkable urban centers
  2. Complete streets
  3. Mixed use development and
  4. Transit-oriented, walkable, bicycle-friendly land use (1)

Smart growth has been identified to improve environmental health (1) and sustainability (2).

Recently, Broward county (Florida) has realized smart growth benefits and have initiated complete streets project (3).

A multimodal transportation system with a special attention towards street design and connectivity is one of the salient features of smart growth. (4)

Transportation investments have important consequences for the environment, climate change, and open space preservation.

To understand the role of transportation infrastructure, specifically how the design of a transportation network affects performance of the system is of major concern.

Transportation Systems have been studied from the point of view of auto mode and transit mode. But a comprehensive study of a multimodal transportation system has not been done.
Importance of Performance Measure for Multimodal Transport Systems

- “Without a performance metric, how to decide how much?” (1)

- Performance measure helps the policy makers and transportation planners understand better about the impact factors, and help them make decisions on improving the MPT operations.

- The performance measure can identify which network components, that is, nodes and links have scope of improvements.

Performance Measures - Roadway Systems

- Some of the roadway performance measures are accessibility, mobility, economic development, quality of life, environmental impacts, safety, operational efficiency, system condition and Performance(1)

- The roadway performance measure has been understood by estimating influence of urban form on it (2)

- Interaction between network structure and roadway performance measure has been studied using graph theory approaches (3)


## Performance Measures – Transit Systems

<table>
<thead>
<tr>
<th>Transit System Measures</th>
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<tbody>
<tr>
<td><strong>State:</strong> Degree of Connectivity</td>
</tr>
<tr>
<td><strong>Form:</strong> Interstation spacing</td>
</tr>
<tr>
<td><strong>Structure:</strong> Directness</td>
</tr>
<tr>
<td><strong>Coverage:</strong> Land Area/Serve Area</td>
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Inspiration from Air Transportation

- **Ground Operational Efficiency Measurement**

<table>
<thead>
<tr>
<th>Location</th>
<th>Percent Increase in Average Taxi Time, 1998-2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rochester, N.Y.</td>
<td>64%</td>
</tr>
<tr>
<td>Long Beach, Calif.</td>
<td>46%</td>
</tr>
<tr>
<td>Philadelphia</td>
<td>45%</td>
</tr>
<tr>
<td>Charlotte</td>
<td>38%</td>
</tr>
<tr>
<td>Manchester, N.H.</td>
<td>37%</td>
</tr>
<tr>
<td>Buffalo, N.Y.</td>
<td>36%</td>
</tr>
<tr>
<td>New York Kennedy</td>
<td>35%</td>
</tr>
<tr>
<td>Milwaukee</td>
<td>34%</td>
</tr>
<tr>
<td>Indianapolis</td>
<td>33%</td>
</tr>
</tbody>
</table>

- **Modeling taxi times**
- **Computing unimpeded taxi times**
- **Extra taxi times**
- **Ground operational efficiency measurement**
- **Operational improvement solutions**
Objectives

- To define and develop multimodal performance measure.
- To understand influence of driving forces on the multimodal public transport efficiency.
- To compare the influence of driving forces for different regions.
- To identify the potential limitations in the driving forces and propose solutions.
Driving Forces of Multimodal Transport Systems (MTS)

MTS

- Network Planning
- Physical Network Structure
- Transit Network Structure
- Urban Form
- Interconnectivity
Proposed Methodology (1)

- Data collection of networks for different modes
- Create a Multi-Modal network at a physical and operational level.
- Search for ideal multimodal trip routes for O/D pairs from NHTS data
- Compute ideal multimodal travel time for trips
- Compute efficiency at disaggregate level of the multimodal trips
Proposed Methodology (2)

- Determining driving forces for every trip buffer area
- Estimating the influence of driving forces on disaggregate efficiency
- Computing aggregate performance measure from disaggregate-trip level efficiency measures
- Identifying the potential drawbacks in driving forces and propose solutions. Example: development of infrastructure, transit routes etc.
## Case Study – Hillsborough County

<table>
<thead>
<tr>
<th>Case Study Region</th>
<th>Hillsborough County</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land Area of region</td>
<td>1,051 sq. miles</td>
</tr>
<tr>
<td>Different Modes Available</td>
<td>Car, Bus (HART), Walk, Bike</td>
</tr>
<tr>
<td>Coverage of Street Network</td>
<td>6795 miles</td>
</tr>
<tr>
<td>Coverage of Bus Network</td>
<td>27 Local Routes, 866 miles</td>
</tr>
<tr>
<td>Operational time range of bus system</td>
<td>5:00 AM to Midnight</td>
</tr>
<tr>
<td>Spatial Coverage of bus network</td>
<td>562 sq. miles</td>
</tr>
<tr>
<td>Line-measure connectivity index of bus network</td>
<td>140 intersections / mile</td>
</tr>
</tbody>
</table>
Case Study— Hillsborough County (Cont’d)
Work in Progress

- Implementation of the methodology using GISDK, TransCAD, and SPSS tools for Hillsborough County.
- Implementing similar methodology for other regions
THANK YOU

Questions? Comments? Suggestions?
Network Planning

- Coverage: The spatial coverage of origins and destinations covered by the network.
- Frequency: Frequency of services.
- Legibility: The ability of the network to be understood by users and potential users to maximize “many to many” trip opportunities.
- Directness: Direct services can reduce travel times.

Physical Network Structure

- **Hierarchy** - refers to the differentiation that exists in street networks.
- **Topology** - identifies the connectivity and the connection patterns that exist in street networks.
- **Morphology** - describes the regularity of street networks, their shape and fragmentation.
- **Scale** - captures the intensity of the street network within a specialized area. (1)

Transit Network Measures

- State measure complexity of network, and depicts how developed a transit system is.
- Form investigates link between metro systems and built environment depicting if the system is oriented towards regional accessibility, local coverage or regional coverage.
- Structure examines the intrinsic properties of current networks, indicators of connectivity and directness.

Urban Form

- Density
- Diversity
- Design
- Destination Accessibility
- Distance to transit
- Demand Management (1)

Interconnectivity Measures

- Node-measure degree centrality: Normalized score based on total number of direct connections to other network nodes.
- Node-measure transfer center (cluster) connectivity index: Sum of connecting powers for all the lines cross through a transfer center.
- Line-measure connecting power: Connectivity power of a line which is a function of transit characteristics.
- Line-measure connectivity index: Sum of connecting powers all nodes in a line (1)

Data Collection of Networks for Different Modes

1. Street network: Florida DOT website (1)
2. Transit routes, location of route stops, transfer stations, park and ride stops: Hillsborough Area Regional Transit website (2)
3. Route schedules: Hillsborough Area Regional Transit website (2)
4. Geography of Hillsborough county: U.S Census website (3)
5. Land Use Characteristics of Hillsborough county: Hillsborough MPO (4)

Create a Multi-Modal Network at a Physical and Operational Level (1)

- The spatial data of networks is in ArcGIS format and schedule data is in text format.
- TransCAD converts spatial data in geographic format.
- Inbuilt TransCAD tools like “Networks”, “Route Systems” and “Transit Network” are used to create a multimodal network with schedules for transit routes.
Create a Multi-Modal Network at a Physical and Operational Level (2)

Section of Multimodal Network developed in TransCAD
**Proposed Efficiency Measures**

**Efficiency Measures:**

1. The Degree of Competitiveness (DOCO) shows comparisons between two travel route times/distance for same O/D pair.

2. The Degree or Circuity (DOCI) shows how much additional travel time is required by the current multimodal network as compared to the directly connected hypothetical transit network. (1)

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