Using GIS to Prioritize Investment in Bus Stops
A Tool to Coordinate Accessibility Improvements through Passenger Demand

TODD HANSEN
TRANSIT MOBILITY PROGRAM
TEXAS A&M TRANSPORTATION INSTITUTE

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Bus Stop Accessibility Index

Purpose: Develop an index that ranks each of the bus stops along the core routes based on:

1. Bus stop *physical* improvement needs for access
2. Existing demand-response trip volume around fixed route bus stops
Study Area – Houston METRO
Index Methodology

- Researcher created a two-tier methodology using:
  - Bus Stop Inventory assessments of fixed routes and physical bus stop location inventory attributes
  - Month sample of paratransit trip location data
Step 1: Physical Bus Stop Attributes

- Rank each bus stop based on
  - **Accessibility** - features that are required for access to each bus stop
  - **Amenities** - features that improve a rider’s experience while waiting for a bus

- Each index data component has a different weight based on the importance of the feature for a person with a disability to access the fixed route.
Step 1 Data Sources

- Bus Stop Inventory – 3,269 stops
  - Information about amount and quality of amenities at bus stops
  - Includes bus shelters, benches, sidewalks, ramps, lighting, and private property issues

- Google Map Street View
  - Used to test results of Tier 1 index
  - Confirmed Inventory data accuracy
### Bus Stop Inventory Example

<table>
<thead>
<tr>
<th>Route(s) Served</th>
<th>Bus ID: 162</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inspected by:</td>
<td>F. Smith</td>
</tr>
<tr>
<td>Date:</td>
<td>4/13/2013</td>
</tr>
<tr>
<td>Street:</td>
<td></td>
</tr>
<tr>
<td>Spot:</td>
<td>Neaside</td>
</tr>
<tr>
<td>Cross Street:</td>
<td></td>
</tr>
<tr>
<td>Direction:</td>
<td>South</td>
</tr>
</tbody>
</table>

#### Amenities

<table>
<thead>
<tr>
<th>Amenities</th>
<th>Qty</th>
<th>Type</th>
<th>Rate</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shelter</td>
<td>1</td>
<td>N</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Bench</td>
<td>1</td>
<td>Wood</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Trash Can</td>
<td>1</td>
<td>Concrete</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Flag</td>
<td>1</td>
<td>Multi-Slat</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Bus Stop Pole</td>
<td>1</td>
<td>Ground</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

#### Accessibility

<table>
<thead>
<tr>
<th>Details</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sidewalk</td>
<td>053 - Broken</td>
</tr>
<tr>
<td>Ramps</td>
<td>077 - One</td>
</tr>
</tbody>
</table>

#### Security/Safety

<table>
<thead>
<tr>
<th>Street Lights</th>
<th>Street Lights</th>
</tr>
</thead>
<tbody>
<tr>
<td>117 - Two</td>
<td>123 - Other Lighting Provided</td>
</tr>
<tr>
<td>128 - No Site Light Present</td>
<td></td>
</tr>
</tbody>
</table>

#### Landmarks

- 213 - Shop
- 170 - College / University

#### Nearby Issues

- Sidewalk broken near ramp. Late night, hardly any traffic or people presence. Safety issue for Operators during layover.

#### Bus Stop / Shelter Pictures

1. Pole Picture
2. Approaching View
3. Front View
4. Departing View
Data Components Used in Step 1

Accessibility
- Sidewalks
- Ramps & Curbs
- Bus Landing Pad

Amenity
- Shelter
- Bench
- Street/Shelter Lights

• *Private Property Issues included at request of the agency*

• *Crosswalk data not available in the Bus Stop Inventory*
Step 1 – Weights and Ranking

- Each component is weighted by importance for use by individuals with a disability
- Worked with METROLift staff to confirm the appropriateness of weights
- Index ranks each bus stop from 0 to 10
  - By adding the weighted features by bus stop
  - 0 = Ideal/ Least Need to 10 = Worst/ Most Need
Physical Element Weight Assignment

*Importance for Persons with Disabilities to Access the Fixed Route*

Maximum Total Score = 10

- **Accessibility Elements**
  - Sidewalks (30 percent)
  - Ramps (20 percent)
  - Bus Landing Pad (15 percent)

- **Amenity Elements**
  - Shelter (10 percent)
  - Bench (10 percent)
  - Street or Shelter Lights (10 percent)

- **Private Property and Construction Issues** (5%)
Physical Bus Stop Score Results

Tier 1 Index (Rounded)

<table>
<thead>
<tr>
<th>Index Score (Rounded)</th>
<th>Number of Bus Stops</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>140</td>
<td>4%</td>
</tr>
<tr>
<td>1</td>
<td>443</td>
<td>14%</td>
</tr>
<tr>
<td>2</td>
<td>841</td>
<td>26%</td>
</tr>
<tr>
<td>3</td>
<td>394</td>
<td>12%</td>
</tr>
<tr>
<td>4</td>
<td>577</td>
<td>18%</td>
</tr>
<tr>
<td>5</td>
<td>273</td>
<td>8%</td>
</tr>
<tr>
<td>6</td>
<td>239</td>
<td>7%</td>
</tr>
<tr>
<td>7</td>
<td>122</td>
<td>4%</td>
</tr>
<tr>
<td>8</td>
<td>78</td>
<td>2%</td>
</tr>
<tr>
<td>9</td>
<td>122</td>
<td>4%</td>
</tr>
<tr>
<td>10</td>
<td>40</td>
<td>1%</td>
</tr>
</tbody>
</table>
Step 2. Accessibility Index
(Physical Attributes + Trip Volume)

- **Bus Stops within ¼ Mile.** GIS spatial join between locations of Origins and Destinations with a ¼ mile buffer around bus stop

- **Trip Volume at Each Stop:** Results in quantity of trip points around each stop, that then is used to weight stops by quantity of trip

- **50/50 Weighting:** Half of the final score from the Physical Attributes, half from Trip Volume
Step 2 – Data Sources

- Paratransit pickups and dropoffs data ranked by highest potential ride frequency
  - Two data sets with addresses and trip counts, rather than a manifest sample
- Other data sources considered:
  - Paratransit customer home location data ranked by proximity to bus stops
  - General public fixed-route data ranked by stop boardings and alightings
Step 2 – GIS Process

- Objective: find pickup and dropoff amounts within a ¼-mile of fixed-route bus stops
  - Import shapefile data of bus stops
  - Create ¼-mile buffer area for each bus stop point
  - Import shapefile data of pickups and dropoffs
  - Intersect pickup and dropoffs points with buffer areas
Step 2 – Combining Data

- Objective: combine Trip Volume data with Physical Attributes data
  - Export tables of intersected pickup and dropoff points
  - Format in Microsoft Excel, aggregate Bus IDs from pickup and dropoff points using pivot tables
  - Add trip volume counts to matching Bus ID numbers in the index
Step 2 – Adjusting Scores

- **Objective:** calculate total scores with all data inputs
  - Use Z-scores to assign value compared to the trip volume mean to each Bus Stop
    \[ Z = \frac{X - \mu}{\sigma} \]
  - Bus stops are given a percentage ranking based on the total trip volume data
  - Percentage values multiplied by 10 to equate to physical attribute data
<table>
<thead>
<tr>
<th>Tier II Data</th>
<th>Z-Scores</th>
<th>Percent Ranks</th>
<th>Changing Percent Rank 0's</th>
<th>Percentiles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pickups</td>
<td>Percentage Pickups per Total (47,386)</td>
<td>Pickups Z-Score</td>
<td>Pickups Percent Rank</td>
<td>Pickups Percent Rank (0's to 0.001)</td>
</tr>
<tr>
<td>726</td>
<td>0.27%</td>
<td>3.796921973</td>
<td>0.989</td>
<td>0.989</td>
</tr>
<tr>
<td>333</td>
<td>0.13%</td>
<td>1.480997397</td>
<td>0.961</td>
<td>0.961</td>
</tr>
<tr>
<td>3</td>
<td>0.00%</td>
<td>-0.463672094</td>
<td>0.093</td>
<td>0.093</td>
</tr>
<tr>
<td>74</td>
<td>0.03%</td>
<td>-0.045273506</td>
<td>0.711</td>
<td>0.711</td>
</tr>
<tr>
<td>266</td>
<td>0.10%</td>
<td>1.086170561</td>
<td>0.949</td>
<td>0.949</td>
</tr>
<tr>
<td>14</td>
<td>0.01%</td>
<td>-0.398849777</td>
<td>0.212</td>
<td>0.212</td>
</tr>
</tbody>
</table>
Notes about Trip Volume

- Pickups or dropoffs within more than one buffer zone were duplicated for each bus stop.
- Some trip points would need to use fixed routes beyond the study area.
- Not all demand-response trips can be taken using fixed routes.
- ¼-mile buffer reflect Euclidean distance, not true travel distance.
Final Index with Paratransit Ridership

<table>
<thead>
<tr>
<th>Index Score (Rounded)</th>
<th>#</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>140</td>
<td>4%</td>
</tr>
<tr>
<td>1</td>
<td>23</td>
<td>1%</td>
</tr>
<tr>
<td>2</td>
<td>295</td>
<td>9%</td>
</tr>
<tr>
<td>3</td>
<td>483</td>
<td>15%</td>
</tr>
<tr>
<td>4</td>
<td>588</td>
<td>18%</td>
</tr>
<tr>
<td>5</td>
<td>606</td>
<td>18%</td>
</tr>
<tr>
<td>6</td>
<td>644</td>
<td>20%</td>
</tr>
<tr>
<td>7</td>
<td>322</td>
<td>10%</td>
</tr>
<tr>
<td>8</td>
<td>137</td>
<td>4%</td>
</tr>
<tr>
<td>9</td>
<td>28</td>
<td>1%</td>
</tr>
<tr>
<td>10</td>
<td>3</td>
<td>0%</td>
</tr>
</tbody>
</table>
## Results of Final Accessibility Index

<table>
<thead>
<tr>
<th>Index Score</th>
<th># of Stops</th>
<th>% of Total</th>
<th>Monthly Pickups w/in ¼ Mile</th>
<th>Monthly Dropoffs w/in ¼ Mile</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>4</td>
<td>0%</td>
<td>1,611</td>
<td>1,764</td>
</tr>
<tr>
<td>9</td>
<td>36</td>
<td>1%</td>
<td>4,695</td>
<td>4,684</td>
</tr>
<tr>
<td>8</td>
<td>133</td>
<td>4%</td>
<td>20,780</td>
<td>21,047</td>
</tr>
<tr>
<td>7</td>
<td>338</td>
<td>10%</td>
<td>53,223</td>
<td>54,229</td>
</tr>
<tr>
<td>6</td>
<td>602</td>
<td>19%</td>
<td>85,599</td>
<td>87,929</td>
</tr>
<tr>
<td>5</td>
<td>628</td>
<td>19%</td>
<td>34,322</td>
<td>35,425</td>
</tr>
<tr>
<td>4</td>
<td>572</td>
<td>18%</td>
<td>15,990</td>
<td>16,424</td>
</tr>
<tr>
<td>3</td>
<td>478</td>
<td>15%</td>
<td>7,709</td>
<td>7,747</td>
</tr>
<tr>
<td>2</td>
<td>289</td>
<td>9%</td>
<td>1,618</td>
<td>1,762</td>
</tr>
<tr>
<td>1</td>
<td>17</td>
<td>1%</td>
<td>18</td>
<td>25</td>
</tr>
<tr>
<td>0</td>
<td>141</td>
<td>4%</td>
<td>39,822</td>
<td>42,368</td>
</tr>
</tbody>
</table>

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1-361-868-3141|transit.tamu.edu

Accessibility Improvement Need Index
- Ideal Stop
- Worst Stop
Stop Example: Medium Accessibility, Low Trip Demand

Accessibility Index Score: 2

- Sidewalk is complete and flat; missing in some portions
- No bus landing pad
- No ADA ramps
- No bench or bus shelter
- Very few Pickups and Dropoffs around it
Stop Example: Poor Accessibility, Medium Trip Demand

Accessibility Index Score: 9

- Sidewalk is completely missing
- No ADA Ramps present
- Bus Landing Pad is not adequate
- No Bus Shelter, Bench, or area Lighting
- Moderate level of Pickups and Dropoffs
Stop Example: Medium Amenities, High Trip Demand

Accessibility Index Score: 7.25

- Missing sidewalk
- Existing bus pad, shelter, and bench
- Large number of METROLift trips within ¼ mile
Stop Example: Poor Accessibility, No Trip Demand

Accessibility Index Score: 4

- Industrial area with poor accessibility elements, but no METROLift trips within ¼ mile
Further Index Use

- Prioritize stops for accessibility investment
- Estimate capital costs and operational savings of investments
- Identify paratransit customers around bus stops to offer travel training
- Coordinate with City or other entities for comprehensive infrastructure improvements
Acknowledgements

- Houston METRO and METRO Lift

- Other TTI Transit Mobility team members
  - Matt Killary
  - Suzie Edrington
  - Shuman Tan
Further Questions

Todd Hansen
Assistant Transportation Researcher
713-613-9205
t-hansen@tti.tamu.edu
ALTERNATIVE INDICES
Tier 2 Summary Statistics

Paratransit Pickups and Dropoffs

Paratransit Homelocations

General Public Boarding and Alightings

Boarding/Alightings/Pickups/Dropoffs
Tier 2 Index Comparison

Summary Data from All Indexes

Number of Bus Stops

Index Score (Rounded)

All Ridership
General Ridership
Paratransit Ridership
Paratransit Households
TIER 1 WEIGHTING
Sidewalks
(Highest Weight 6/20 or 30%)

- Highest weight in the index—necessary to reach a stop
- Accounts for missing, broken, or uneven sidewalk adjacent to bus stop, and length of sidewalk needed
- Considers whether the sidewalk meets ADA regulations (grading/thickness) or if it is a “High Risk Stop*”

*High Risk Stop designated by Bus Stop Inventory – poor condition
Ramps / Curbs
(Weight 4/20 or 20%)

- Considered essential for many riders with disabilities
- Provides access to limited mobility and wheelchair users
- Accounts for missing ramps and whether the ramps meet ADA regulations
Bus Landing and Cross Walk Weight

- Bus Landing Pad (3/20 or 15%)
  - Helps all riders and particularly those with wheelchairs access the bus
  - Accounts for suitable bus landing pad or not
Shelter, Bench and Lighting Weights

- **Shelter (2/20 or 10%)**
  - Considers whether or not a shelter exists at a particular stop

- **Bench (2/20 or 10%)**
  - Considers whether the bus stop has a bench and if the bench needs to be replaced or fixed

- **Street/Shelter Lighting (2/20 or 10%)**
  - Accounts for whether lighting is present and possibly obscured by area trees or structures
Private Property or Construction Issues (1/20 or 5% Weight)

- Stop is located in or close to private property and whether stop needs an engineering design permit to be improved
- Helpful for determining difficulty in improving the accessibility at a bus stop location