A Meso-Scale Model of Pedestrian Demand

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Study Team

- **University of Maryland – National Center for Smart Growth**
  - Kelly J. Clifton, Associate Professor
  - Carolina Burnier, PhD student Urban Studies and Planning
  - Shuo Huang, MS student Urban Studies and Planning
  - Min Wook Kang, PhD, Civil Engineering
- **Toole Design Group**
  - Bob Schneider, PhD student UC Berkeley

Presentation Outline

- Review Purpose & Objectives
- Model Description
- Application Results
- Challenges and Limitations
- Implementation

Research Objective

We aim to develop a method to estimate pedestrian demand at intersections (numbers of pedestrians) using readily available data in a GIS framework.

Guiding Principles

- Employ data available for all Maryland communities
- Model sensitive to land use and socio-demographics
- Use a Geographic Information Systems framework
- Develop a user-friendly methodology for practitioners

Pedestrian Volume Model Components

- **Pedestrian Network & Land Use Zonal System**
- **Trip Generation – How many trips?**
  - Sensitive to land use and demographics
  - Estimated from 2001 NHTS for Baltimore region
- **Trip Distribution – Where are they going?**
  - Based upon gravity model
- **Network Assignment – By what path?**
  - Minimum travel time

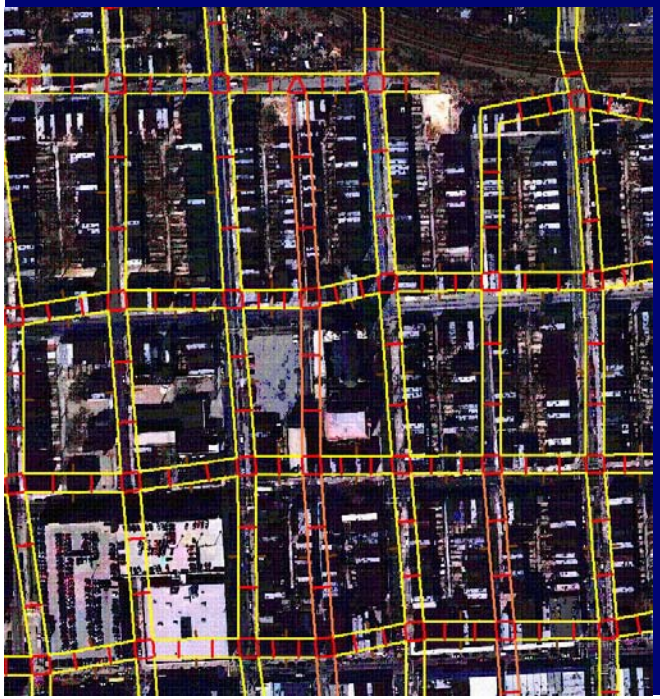
Data Needs

- **Use archived data available for Maryland communities**
  - US Census of Population and Housing
  - US Census TIGER files
  - MD Property View
  - National Household Travel Survey for Baltimore metro area
  - Aerial photos
  - Pedestrian-Vehicular collisions
- **Pedestrian counts (model calibration)**

Pedestrian Network

Census TIGER line file provides topology and basic characteristics

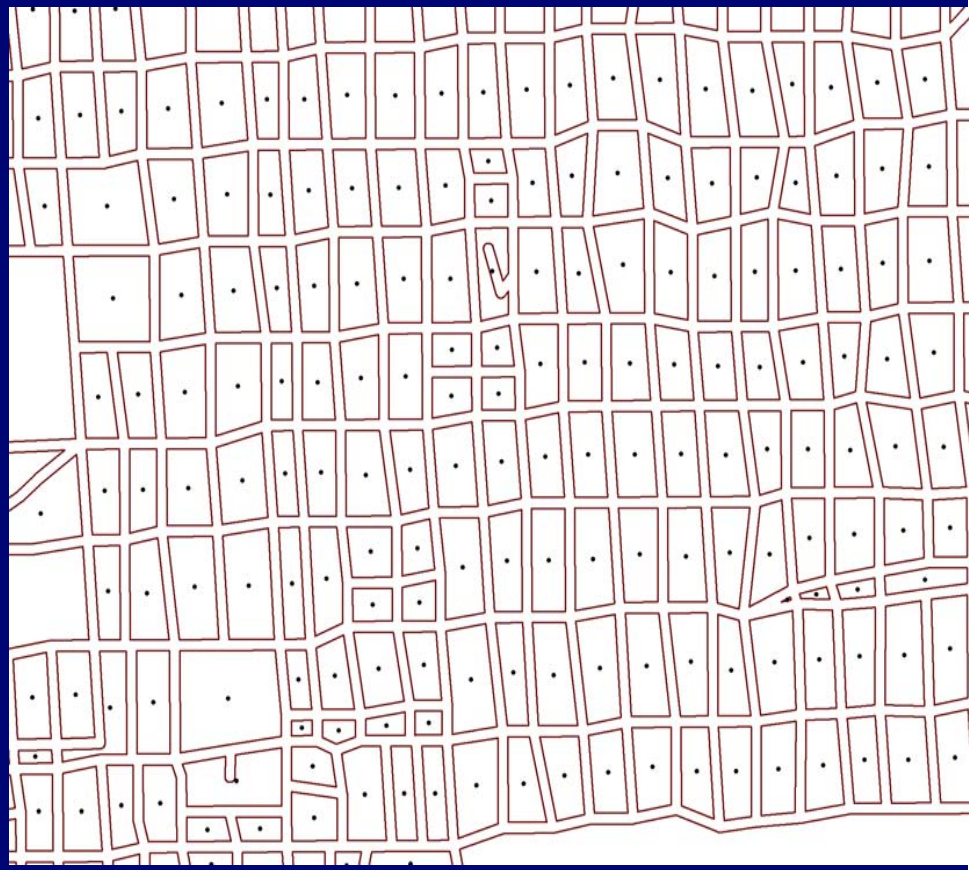
Expands single street link to pedestrian links (sidewalks & crosswalks



Use aerial photos to make corrections and add links (paths, trails, facilities not adjacent to road network

Pedestrian Analysis Zones

- Representation of activities/land uses
- Similar to TAZ concept
- For areas with small block area: Create centroid of block face
- For areas with large blocks: Use block face



Trip Generation

- **Estimates the number of walk trips produced and attracted to a PAZ**
- **Productions and Attractions for:**
  - Home Based Walk Trips
  - Non-Home Based Walk Trips
- **Estimated using NHTS – Baltimore Add On data**

Trip Generation – HB Walk

Attractions and Productions for HB Walk Trips

HB Walk (Walk trips/PAZ) =
[exp (-1.034232 -0.9455401*vehicle ownership
+2.371351*street connectivity
+0.0070639*percent commercial
+0.0001527*residential dwelling units)]*total dwelling units in PAZ

Trip Generation – NHB Walk

Equations for Attractions and Productions for NHB Walk Trips

- **Not enough NHB trips in NHTS to estimate directly:**
  - Employed NHB Trip Generation Models for the San Francisco Bay Area (BAYCAST-90) for all modes
  - Estimated an Equation to “skim” walk trips using 2001 NHTS for Baltimore Area

Trip Generation – NHB Walk

- **Equations for Productions for NHB Walk Trips**

NHB Productions (Total trips/PAZ) =
0.798*Other Employment
+2.984*Retail Employment
+0.916*Service Employment
+0.707*Total Households

Note: all of the variables are calculated the PAZ level

- **Convert All Trips to Walk Trips**

Prob (Walk trip) = exp (UWalk) / (1+ exp(UWalk))
Where, UWalk = - 4.286918
+ 3.041807*Connectivity
+ 0.0051575*percent commercial

Note: variables in this model are calculated at the ¼ mile buffer of the trip end.

Trip Generation – NHB Walk

- **Equations for Attractions for NHB Walk Trips**

  NHB Productions (Total trips/PAZ) =
  0.636*Other Employment
  +3.194*Retail Employment
  +0.730*Service Employment
  +0.803*Total Households

  Note: all of the variables are calculated the PAZ level

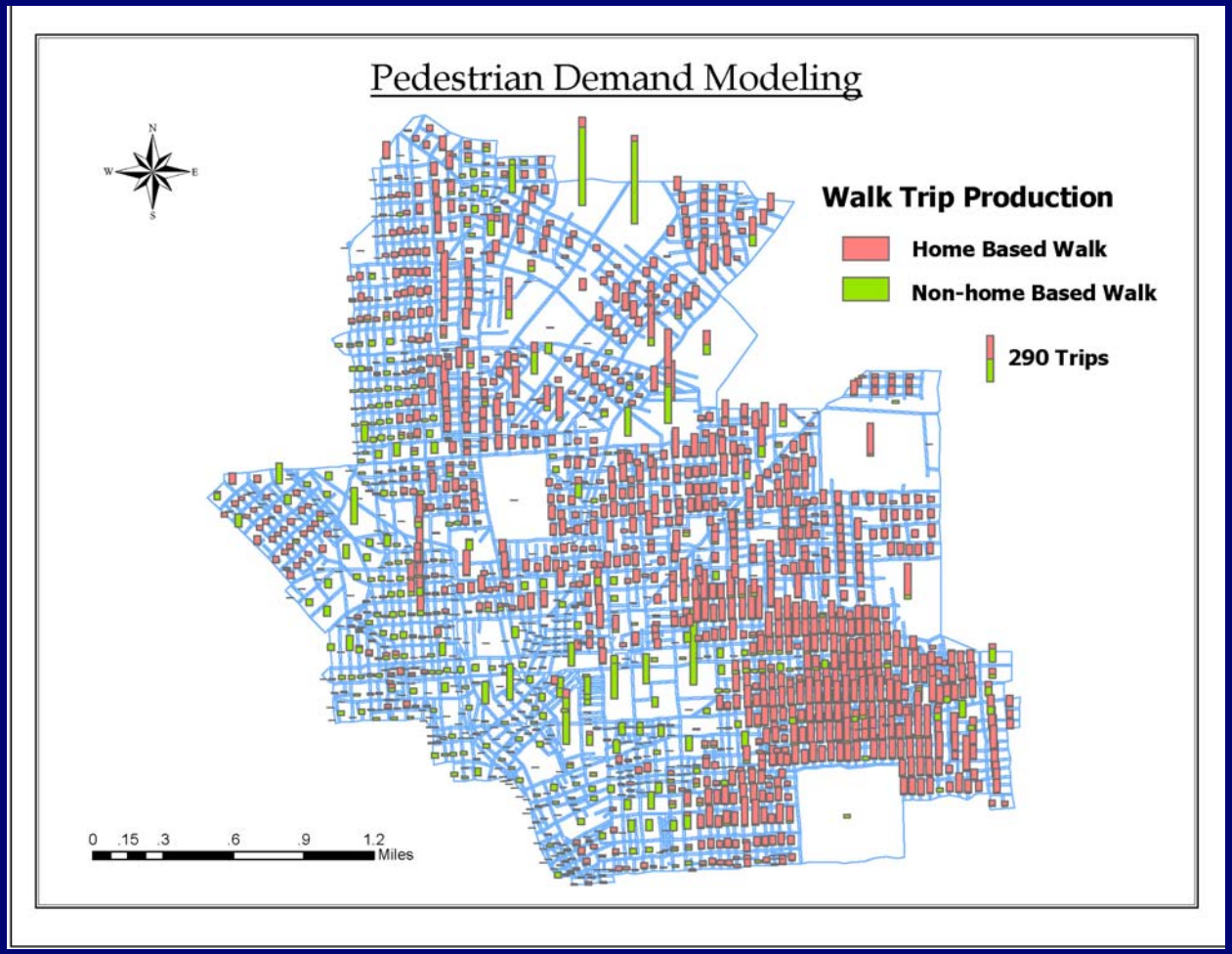
- **Convert All Trips to Walk Trips**

  Prob (Walk trip) = exp (UWalk) / (1+ exp(UWalk))

  Where, UWalk = - 4.286918
  + 3.041807*Connectivity
  + 0.0051575*percent commercial

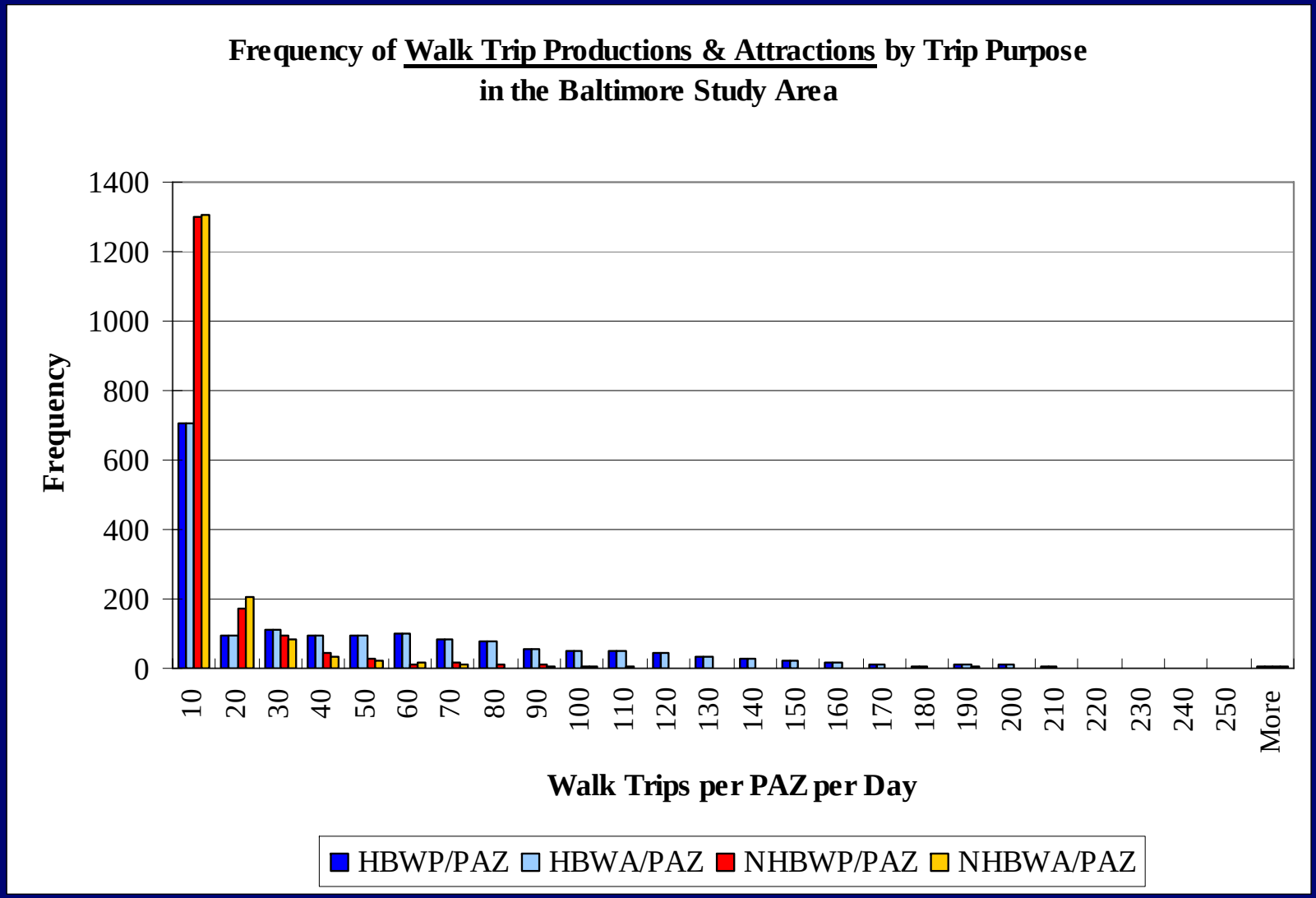
  Note: variables in this model are calculated at the ¼ mile buffer of the trip end.

Trip Generation



- *1,709 PAZs in the Study Area*

1. Trip Generation



Trip Distribution

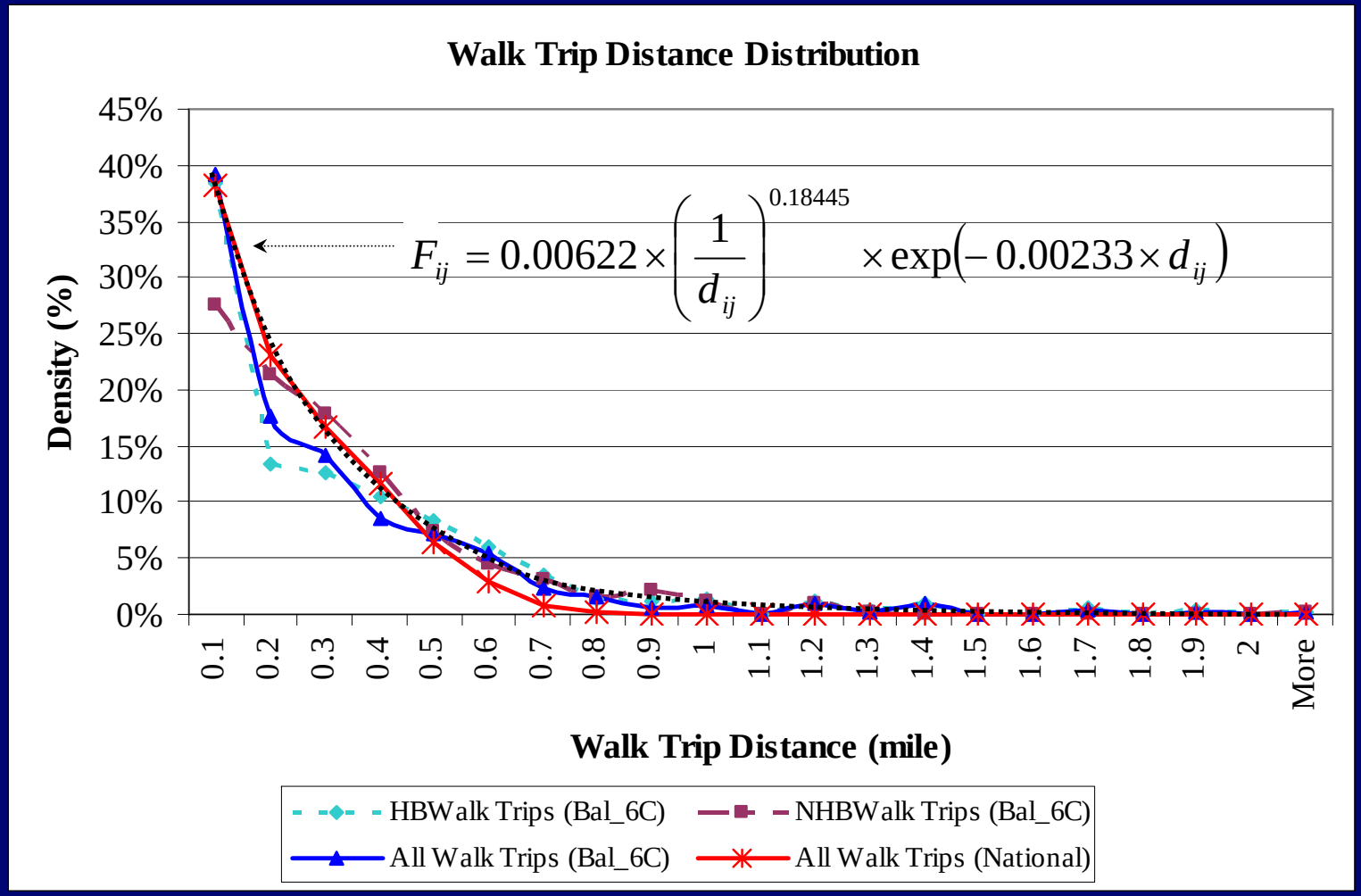
- Estimates the flows between origins and destinations
- Results in a trip table or OD matrix
- Use traditional approach – gravity model
- Distributes trips based upon the number of attractions and the distance separating PAZs.

Trip Distribution

- Apply Gravity Model for Pedestrian Trip Distribution

$$T_{ij} = P_i \left[\frac{A_j F_{ij} K_{ij}}{\sum_j A_j F_{ij} K_{ij}} \right]$$

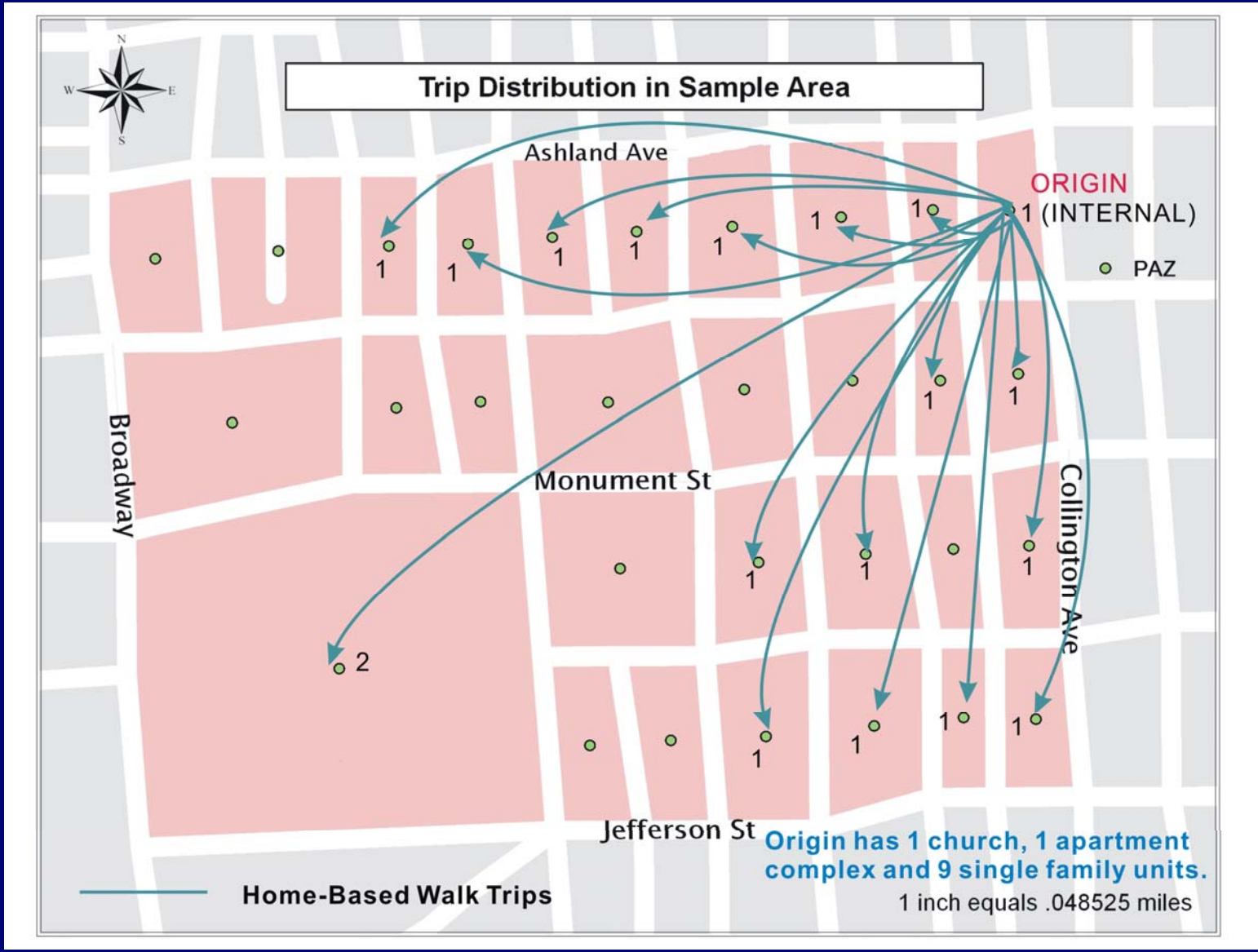
Trip Distribution - Distance



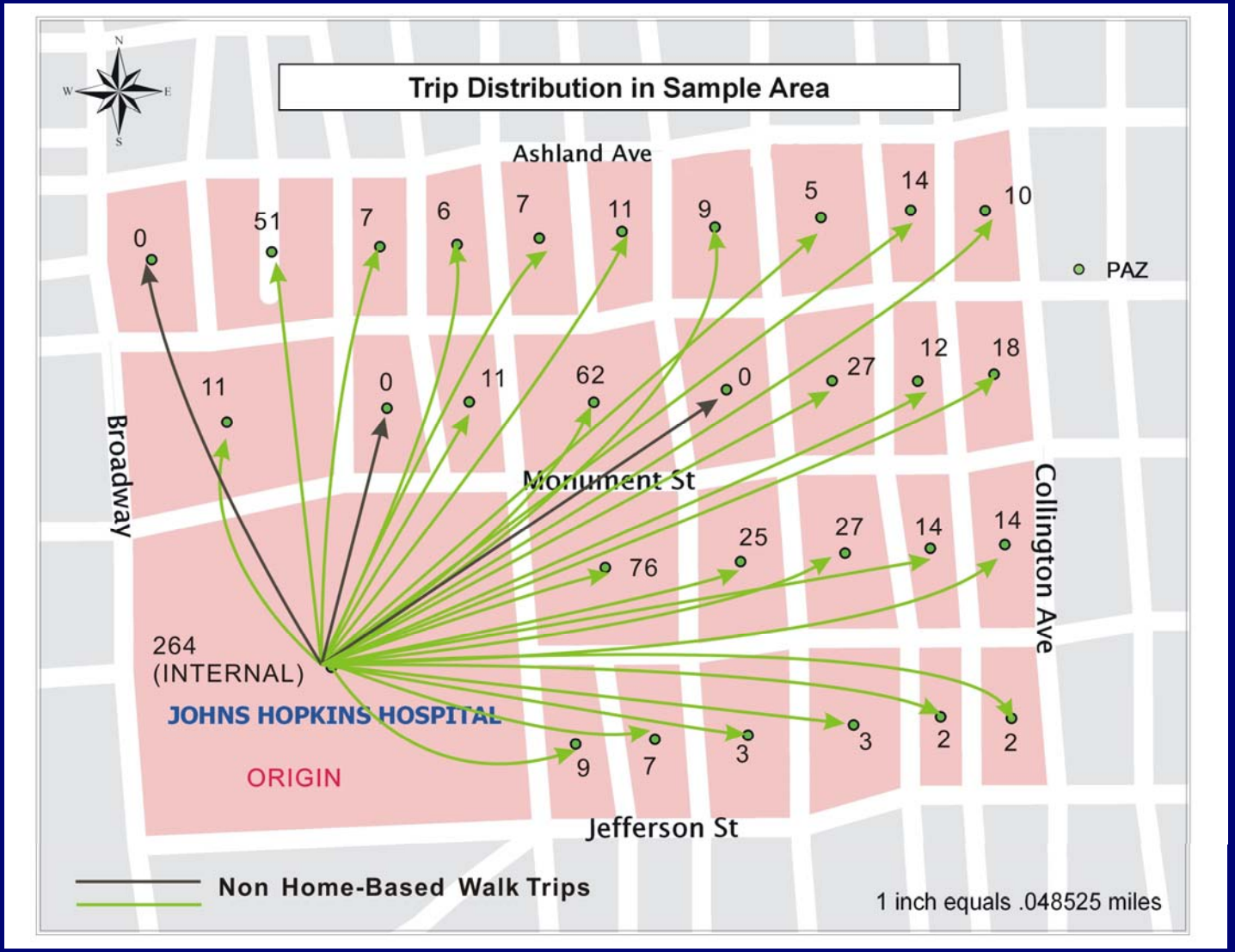
Where, Fij = Friction factor
dij = walk trip distance (meter)

Data source: 2001 NHTS

Trip Distribution: Home Based Walk Trips



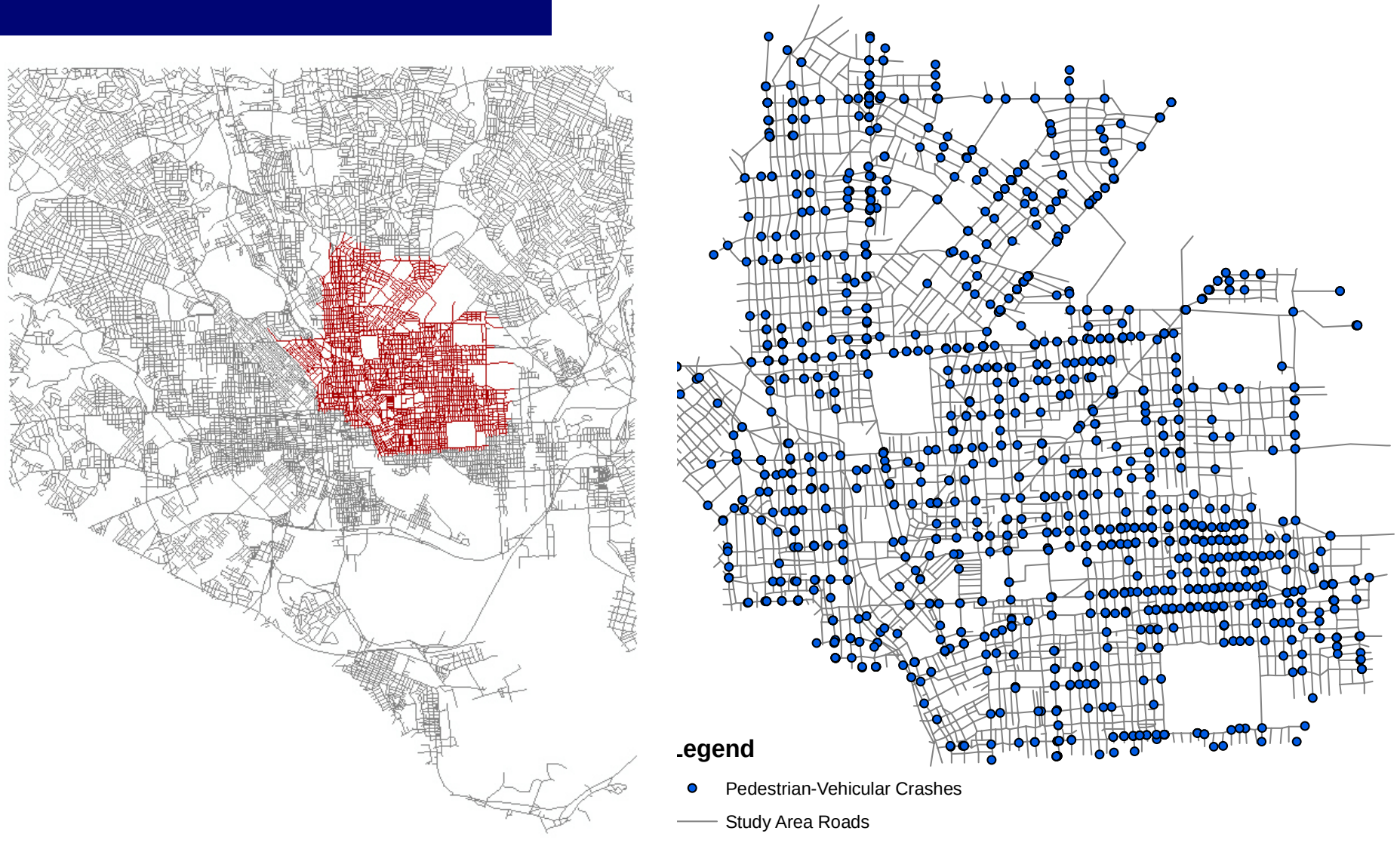
Trip Distribution: Non-Home Based Walk Trips



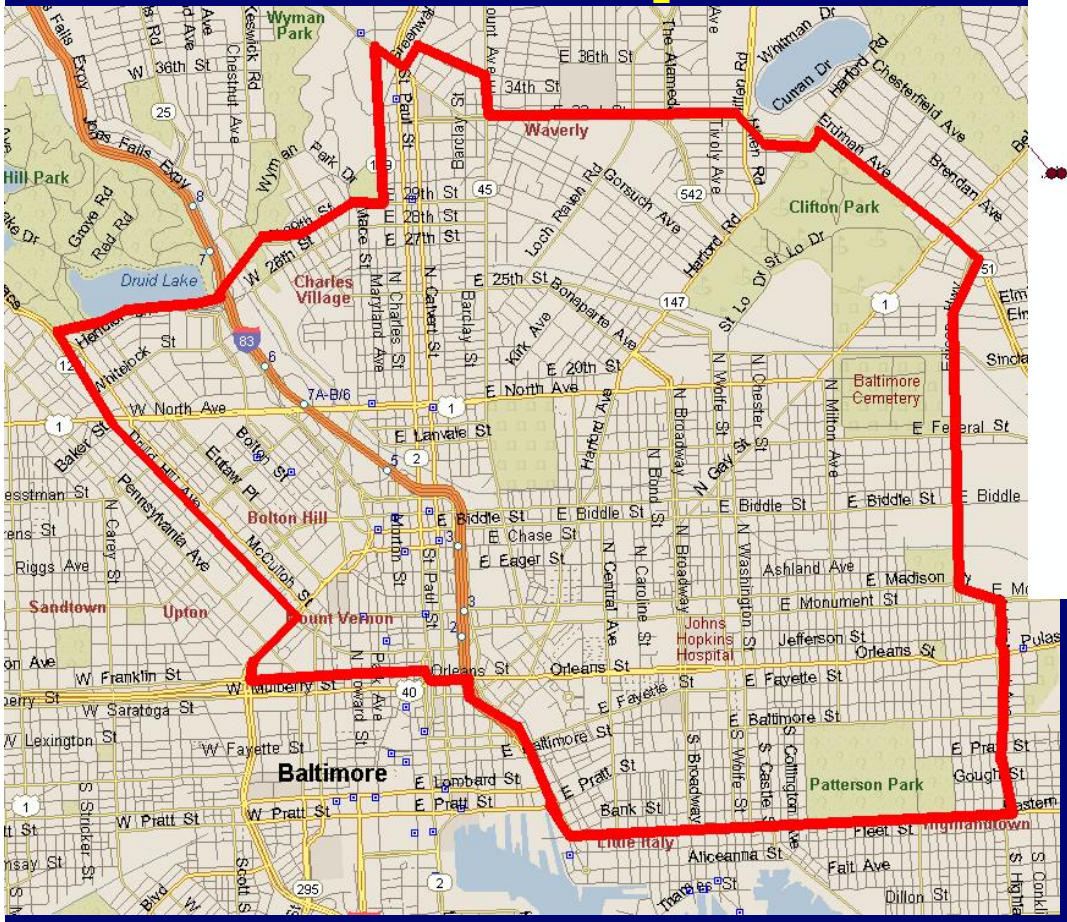
Route Assignment

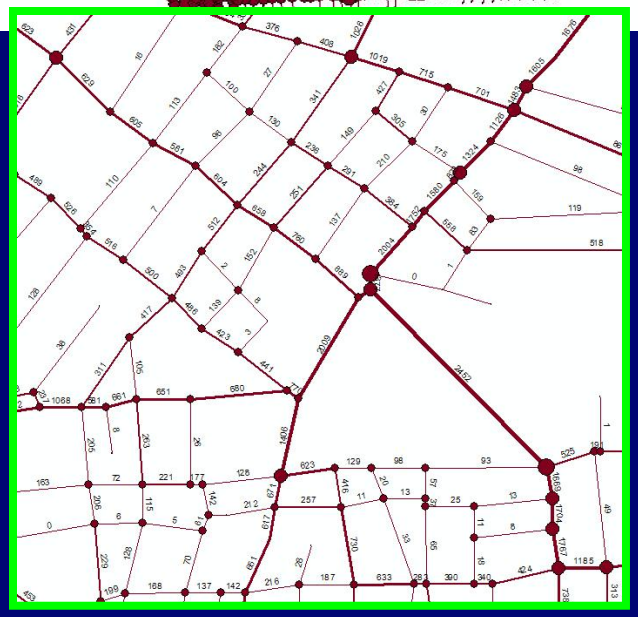
- Estimates the path taken by each trip and assigns to the pedestrian network
- Developed an executable program using C++ to calculate the shortest path for each pair of PAZs
- “All or nothing” assignment to network
- Sums pedestrian volume at each intersection.
- Limited by computational capacity of GIS

Baltimore City



Model Output





–Volumes are accumulated on intersections and links.

–Result is estimate of 24 hour pedestrian volumes

Study area comparison

	Baltimore City	Prince George's County
Area Size (Square Miles)	10	4
Number of road segments	4322	478
Number of PAZ	1709	860
PAZ Type	Block centroid	Block face

Time cost estimates (hrs)

	Baltimore City	Prince George's County
Preparation of input files	4	4
Network construction	16	16
Land use calculation	16	8
Trip generation	5	5
Trip distribution (OD matrix)	4	1
Trip distribution (Tij table)	4	4
Trip assignment (File preparation)	4	4
Trip assignment (Processing)	48	6
Intersection volume	2	2
Total	160	54

Pedestrian Volumes

24 Pedestrian Volumes at Intersections

Results range from 0-1700 pedestrians per intersection per 24 hr period

Validation

- **Obtained peak hour counts for Baltimore City**
  - 7-9 AM, 11 AM-1PM and 4-6 PM
  - For ~40 intersections
- **Estimated volumes with Pedestrian Demand Model**
  - 24 hours
  - Summed to the 4 nodes of the intersection
- **Used NHTS to calculate percentage of walk trips that occurred during peak hours:**

  AM peak – 12.1%; Mid day peak – 16.1%; PM peak – 17.7%
- **Calculated volume share for peak hours from the estimated volumes**
- **Compared average peak hour counts to estimated volumes for each intersection**

Challenges and Limitations

- Pedestrian network and PAZs – limits on number of PAZs GIS system can handle ~ 1700
- Only two trip purposes – home-based and non-home based walk trips – due to limitations of NHTS
- Computational capacity for network assignment – long time to run
- Assignment based on shortest travel time
- Limited availability of pedestrian counts to validate model
- Improve model performance

Questions?