Collection and Analysis of GPS-Based Travel Data for Understanding and Modeling Activity-Travel Patterns in Time and Space

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Motivation for Time-Space Geography

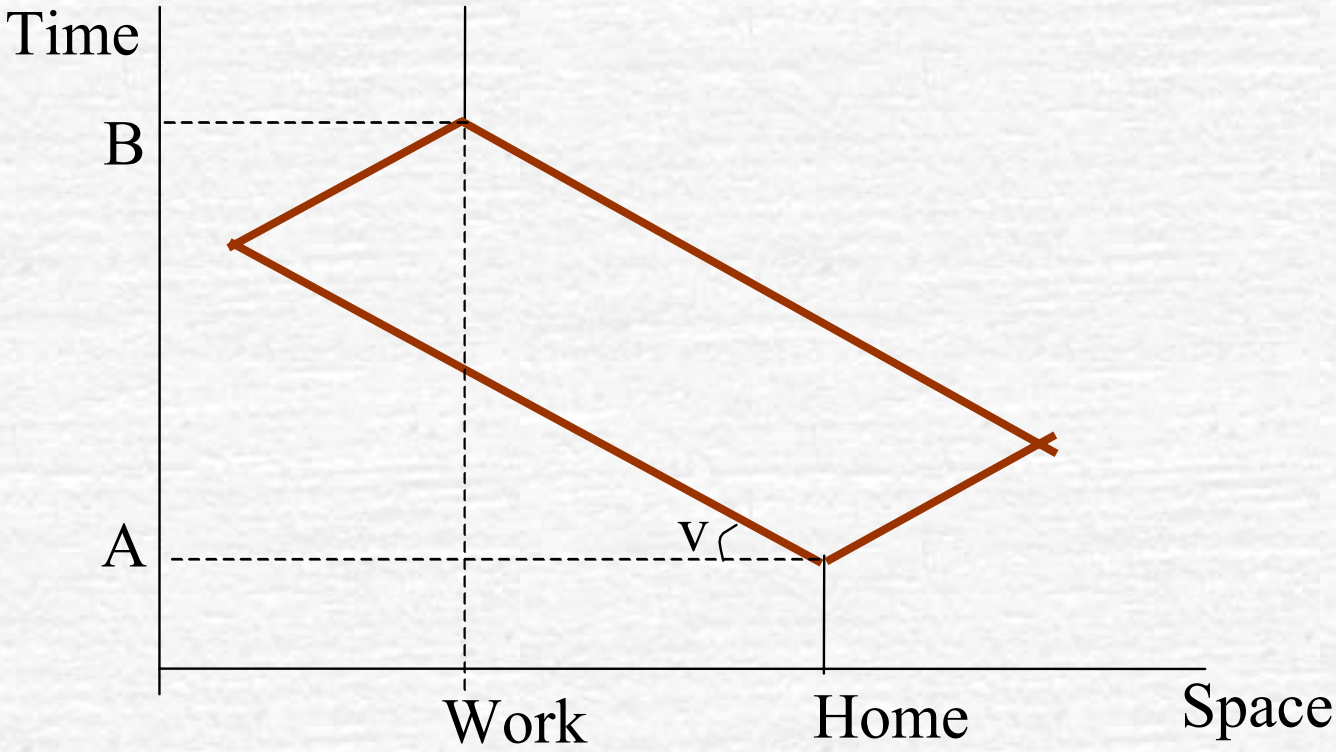
- Derived nature of travel demand – activities distributed in time and space
- Action "space" governed by modal accessibility and "time" availability
- Representation of time-space continuum offers strong behavioral framework for modeling activity-travel patterns
  - Opportunities and constraints
  - Interactions/interdependencies among agents
- Key distinction between tour-based and activity-based microsimulation model systems

Time Use and Activity Perspectives

- Speed is finite and time is limited
- Individual's trajectory in time and space confined to Hägerstrand's prism
- Need to recognize spatio-temporal constraints on individual's movement
- Time use and activity-based approaches to modeling transport demand emerging

A Time-Space Prism

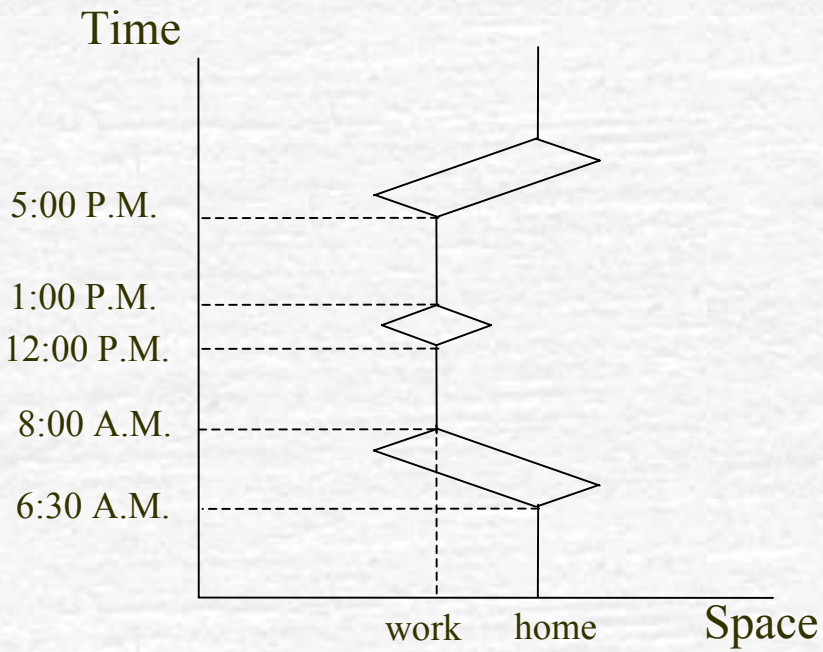
- A simplified representation of time-space constraints



Role of Time-Space Geography

- Prism-Constrained Activity-Travel Simulator (PCATS)
  - Comprehensive activity-based microsimulation model
- Time-space geography plays critical role in:
  - Defining destination choice set by mode availability
  - Defining activity type choice set by destination availability
  - Interdependency among trips with respect to destinations and schedules (timing)
  - Interdependency among individuals – joint activity-travel engagement

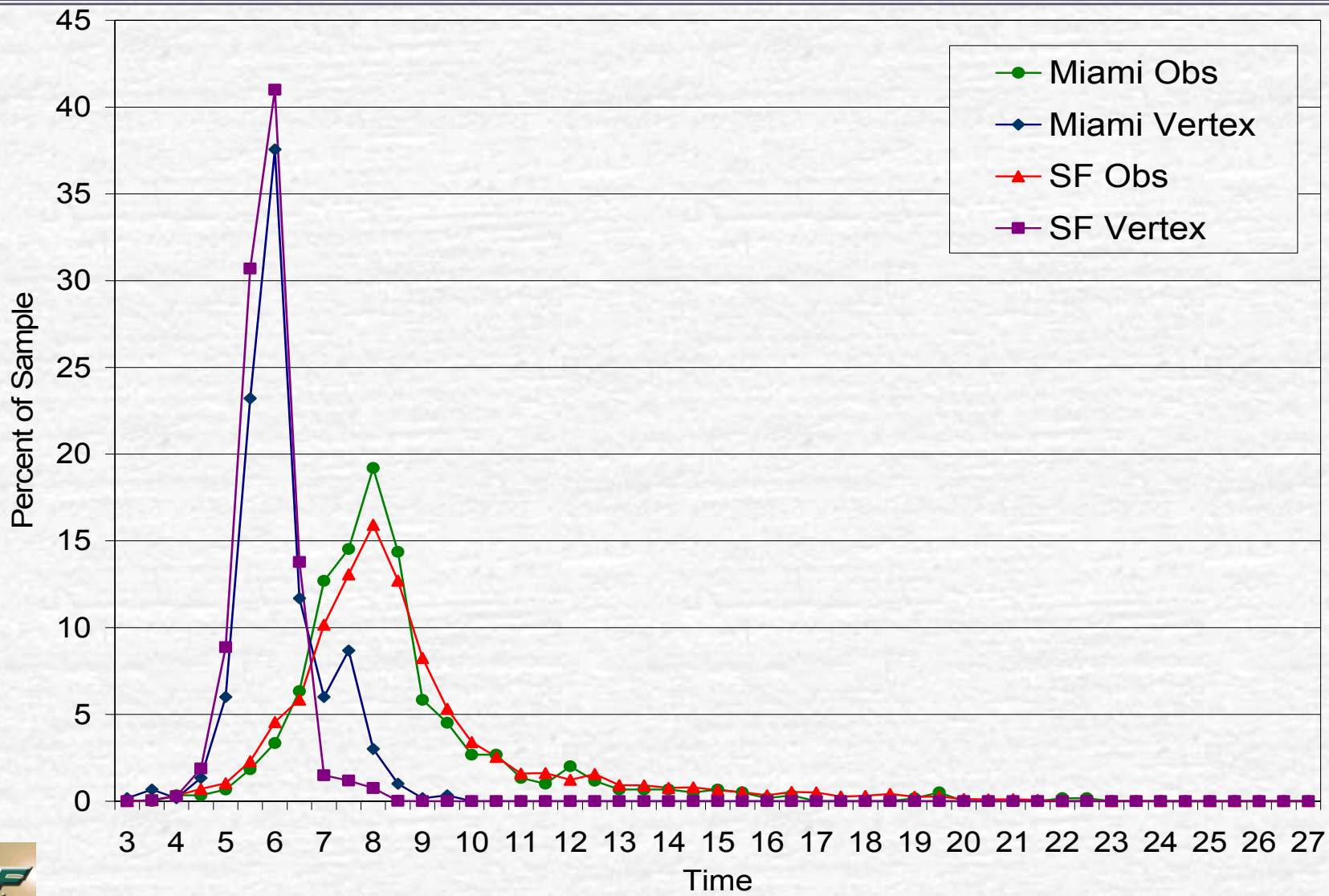
Prism-Constrained Activity-Travel Simulator



- Define open and blocked periods for each individual
- PCATS incorporates time-space constraints
  - Mode availability
  - Modal speed
  - Time available
  - Range of destinations
- Structure of PCATS

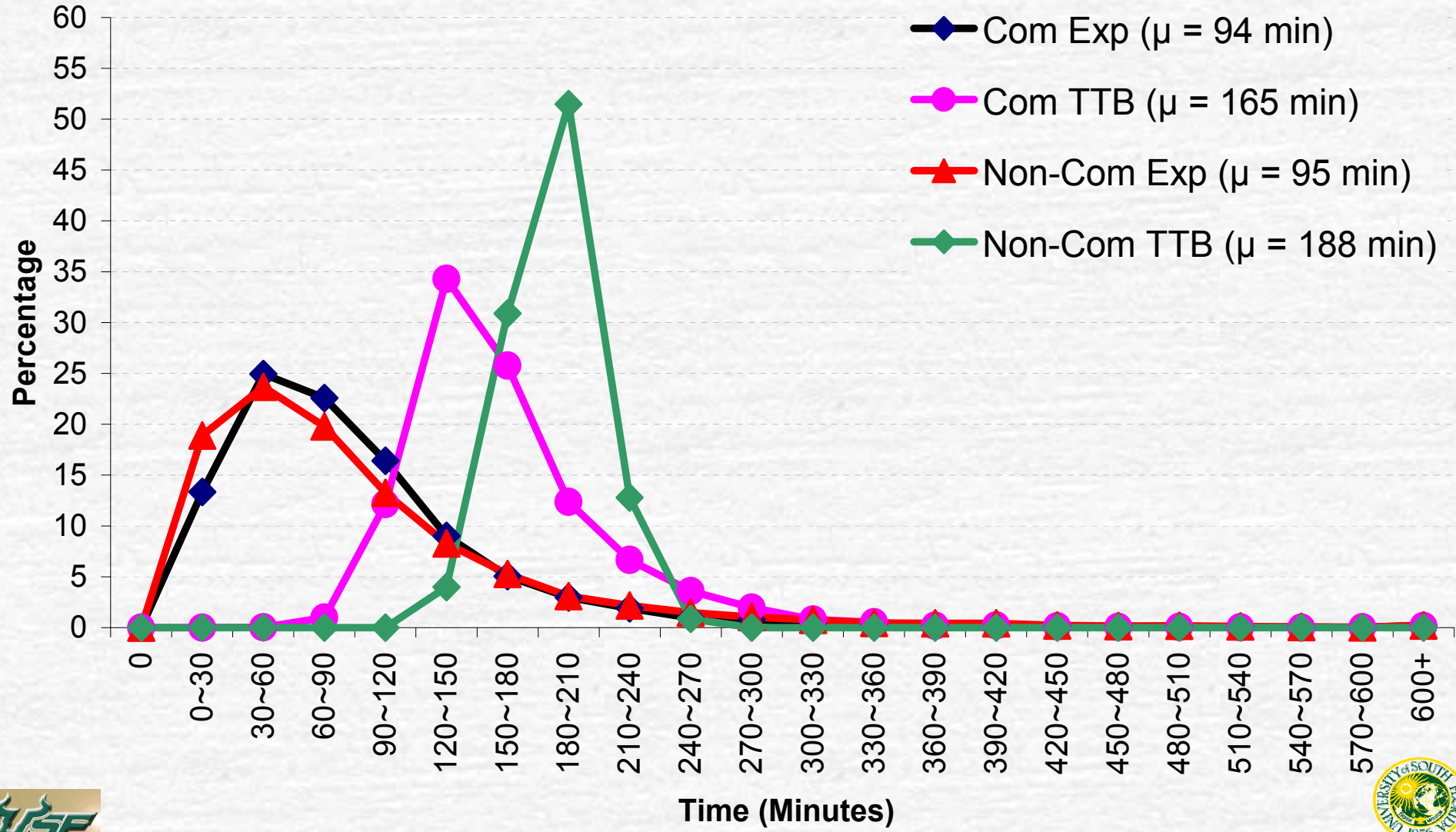
Sample Distributions:

Origin Vertex – Morning Prism



Sample Distributions:

Obs Travel Time vs Frontier Distributions



International Comparisons

Survey area	Commuters			Non-commuters		
	Expendi-ture (min)	Budget (min)	r	Expendi-ture (min)	Budget (min)	r
USA	94	165	.558	95	188	.501
Swiss	101	187	.556	115	250	.464
India	73	141	.521	51	84	.617

GPS Data and Time-Space Geography

- Accurate temporal and spatial attributes for all activities and trips
- Construct time-space paths of activity-travel participation on (actual) modal networks
- Automated geocoding of all activity/trip locations
- Multiday and multiweek data on time-space paths due to reduced survey burden
  - Explore variations and planning time horizons

Collecting GPS Data on Time-Space Paths

- Passive vs. active data collection protocol
  - What does the respondent need to provide?
- Secondary data collection
  - What needs to be collected and how?
- Temporal resolution of data collection
- Sampling issues
  - One person vs. All persons vs. One vehicle vs. All vehicles
  - Sample size: Is a smaller sample size sufficient because of greater accuracy and/or multiday data?
- Understanding limitations of GPS data

Analyzing GPS-based Travel Data

- Management, synthesis, and visualization of data in GIS platforms
- Construction of time-space paths/prisms
- Linking/matching/merging secondary data
  - Land use, network, census, commercial databases
- Route choice behavior and network analysis (supply variables)
- Comparison of actual vs. "optimal" time-space path
  - Develop/refine behavioral paradigm (not utility maximization)
  - Positive utility of travel?

Using GPS Data in Activity-Based Model Development

- Define/identify constraints and opportunities
  - Time-space constraints → Generate choice sets (activity type, destination, mode, time of day)
- Incorporate interactions and interdependencies
  - Household time-space paths → Interperson interactions (vehicle and task allocation, joint activity engagement)
  - Multiday time-space paths → Interday dependency (history dependency and future anticipation/planning)
- Inform model linkages and specification

Challenges and Opportunities

- Tools and resources for collection, analysis, synthesis, and visualization of time-space geography
- Identify wider range of applications
  - ICT, mobility, accessibility, and social equity analysis
  - Network performance assessment (supply analysis) – application to disaster planning
  - Built environment, travel behavior, and physical activity
  - Land use planning – locate activity opportunities within time-space paths
  - Transportation security and safety applications (locations of people and vehicles by time of day)

Challenges and Opportunities (continued)

- Identify wider range of applications (continued)
  - Driver behavior and vehicle acceleration/speed profiles → vehicle emissions analysis
  - Comprehensive microsimulation of land use – travel demand – traffic (network) continuum