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GPS Tracking and Time-Geography: Applications for Activity Modeling and Microsimulation, Final Report

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GPS Tracking and Time-Geography

Applications for Activity Modeling and Microsimulation

Final Report
FHWA-sponsored Peer Exchange and CSISS Specialist Meeting

10-11 October 2005

The Upham Hotel
Santa Barbara, California



Compiled by Kostas Goulias and Donald Janelle
from proceedings of the meeting

<http://www.csiss.org/events/meetings/time-geography/>

Center for Spatially Integrated Social Science
University of California, Santa Barbara



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GPS Tracking and Time-Geography Applications for Activity Modeling and Microsimulation

An FHWA-sponsored Peer Exchange and CSISS Specialist Meeting

10-11 October 2005
Santa Barbara, California

1. Background, Purpose, and Goals

After years of academic experimentation and testing, activity-based approaches to travel demand forecasting are slowly finding their way into practice as policy analysis tools. Many planning agencies in the United States have initiated exploratory projects that eventually will lead to wider use in policy analysis and transportation management. The spatial and temporal details of these new methods offer desirable and flexible techniques for transportation modeling practices and they also provide unprecedented detail in space and time. This detail (resolution) offers unique opportunities for travel behavior research, modeling, and travel-demand forecasting because we can now depict decision making processes at the level that decisions are made, i.e., for individuals, households, or groups of individuals.

Currently, many planning agencies are viewing activity and tour-based models as desirable and feasible techniques for their transportation modeling practices (e.g., New York Metropolitan Transportation Council - <http://www.nymtc.org/>, Portland Metro - <http://www.metro-region.org/>). Many other applications are emerging as shown by recent Transportation Research Board workshops designed for practitioners (see <http://www.trb-forecasting.org/activityBasedApproaches.html>). The development and implementation of activity, tour-based, and micro-simulation modeling approaches, however, require additional and more specialized data on travel activity patterns. For example, most activity-based approaches for travel demand forecasting require diary data (a detailed account of travel or activity) for individuals and possibly for entire households. A consistent movement of all these methods and

models is toward the use of finer resolution in time (e.g., second-by-second actions) and space (e.g., parcel-by-parcel and meter-by-meter positioning). In fact, many of these model components not only need detailed data about the movement of people in time and space but also a substantial amount of data to study cyclical behaviors and to perform statistical testing of hypotheses. They also need other secondary data that can be used as complementary sources in model building or “external” data to verify and validate the activity-based simulation models. Today, lack of sufficiently detailed data is inhibiting the development, testing and verification, and implementation of activity, tour-based, and micro-simulation modeling approaches.

Potentially valuable sources of data are may be derived from surveys that use geospatial technologies. These technologies may be used in an automated fashion with very little interaction with the surveyed person thus solving two thorny issues in data collection: cost and survey burden. The best known technology of this type is Geographic Positioning System (GPS – this is a system that uses GPS satellites that broadcast signals. These signals are read by GPS receivers that in turn compute their location on Earth in terms of longitude, latitude, and altitude at any given time of a day. With improvements in GPS hardware, we are now able to collect GPS data over longer periods. Devices of this type can be attached to vehicles or given to individuals for tracking their movements for much longer periods than typical surveys. They offer data that are not usually collected by travel surveys, such as the exact route followed by a traveler. In this way, geospatial technologies may also provide data to directly estimate components of activity-based models.

Some of the basic theoretical underpinnings of activity-based approaches are from time-geography (e.g., the movement of individuals and the constraints they face) and microeconomics (e.g., discrete choice by an individual). Many of these travel demand-forecasting systems require finer detail of information in time, space, and social context. One of these aspects, however, concerns the movement of persons in space and the temporal aspects of this movement. **Time geography**, within human geography, is concerned with daily, weekly, and seasonal rhythms of human behavior over space. The approach per Torsten Hägerstrand, one of the first proponents, claims that we all live in a conceptual bubble due to a variety of constraints (dictated by constraints imposed by physics and/or by society). This bubble is named the time-space prism. It took many years and some maturation in the development of Geographic Information

Systems (GIS) for empirical studies to emerge that demonstrate the research value of mapping time-space paths of humans in a city. Many of the original ideas in time geography and the more recent GIS mapping of the time-space paths are used to develop a new generation of travel-demand forecasting models that explicitly quantify time-space prisms. GPS and GIS may be the technologies that make all this possible. For example, it is conceivable we can collect data for more than 12 months, leading to a full year of personal space-time prisms. In this way, we can look at where people travel on a regular basis compared to places visited infrequently, or only once over a long period of time. We can examine the time they travel in relationship to the locations frequent, and document shifts in their travel times. This new capability, combined with larger samples of traces, may also lead to better ways to conceptualize and analyze space-time prisms. GIS is only recently able to process and analyze these quantities of data. This type of data will be invaluable as travel-demand modeling shifts toward microsimulation. The most intriguing GPS dataset on household vehicle travel in the United States, so far, is the Commute Atlanta data, a FHWA-sponsored value pricing project, where 1-second GPS data over 12 months for 270 households with 487 vehicles were collected. Other long period GPS data have been collected in Borlange, Sweden (www.rattfart.com). Another potential source will be from another FHWA-sponsored value pricing project, conducted by the Puget Sound Regional Council in Seattle. The 1995 GPS data collected in the FHWA-sponsored project in Lexington, KY included 6-days of travel. More commonly, regional household travel surveys have limited their GPS data collection to 1 or 2 days, which limits their utility in understanding space-time prisms.

Using as motivation the recently collected large amounts of GPS data from a variety of studies in the United States and Europe, the Federal Highway Administration (FHWA) decided to fund a Peer Exchange meeting in Santa Barbara, CA. The intent of this Peer Exchange was to assemble experts to discuss potential approaches on using GPS vehicle traces for defining space-time paths and prisms to be used in activity modeling and microsimulation for transportation analysis. This Peer Exchange brought together travel demand forecasters, experts in travel behavior and GPS data collection, and geographers to discuss different approaches to analyzing space-time prisms for transportation forecasting needs. Invitees came from universities, State DOTs, MPOs, and consulting groups.

Goals of Peer Exchange:

The more specific goals of this Peer Exchange were to:

- a. Discuss methods and techniques for using the GPS data to be applied to activity modeling and microsimulation.
- b. Increase practitioner interest in the potential of GPS data for activity models.
- c. Encourage academics and their graduate students to pursue research activities with these datasets.
- d. Develop priorities for research that could be conducted using the Commute Atlanta dataset after it has been anonymized for public release.
- e. Develop priorities for research that could be conducting using other GPS data collected from other household travel/activity surveys.

2. Meeting Preparation and Format

Invited participants prepared and submitted short position statements related to one or more of the goals listed above. These statements were posted on the CSISS web site in advance of the meeting (15 September 2005). The Peer Exchange took place over one and one-half days (starting on the morning of 10 October and ending with lunch on 11 October). Presenters and participants from state DOTs, MPOs, consultants, and academics gave short presentations and discussed the variety of issues that emerged directly for the goals above. **Appendix A** of this report contains the agenda of the meeting. The presenters and the title of their presentations are listed below together with panelists and a contributor. The presentation outlines and related graphic displays are available in pdf format at <http://www.csiss.org/events/meetings/time-geography/participants.html>.

Participants and Presentation Titles:

- **Terry Bills, ESRI, GPS and Travel Behavior: A Few Research Questions**
- **Larry Blain, Puget Sound Regional Council of Governments, GPS-Assisted Data Collection to Support Transportation Planning**
- **Mark Bradley, Santa Barbara, Toward GPS Data Collection for Activity Based Models**
- **Keith Clarke, UCSB, Negative (or Anti-) Time: A Theoretical Approach of Potential Use in Time-space Trajectory Analysis and Modeling**
- **Helen Couclelis, UCSB, Activity Modeling with GPS Tracking Data: New Assumptions for the Age of ICT**
- **Mike Goodchild, UCSB, Potential of Dense-tracking Data**
- **Kostas Goulias, UCSB, Travel Data for Activity-based Travel Demand Forecasting Models**
- **Randy Guensler, Georgia Tech, Commute Atlanta Instrumented Vehicle Data**
- **Donald G. Janelle, UCSB, Synoptic Analysis of Space-time Activity Patterns**
- **Mei-Po Kwan, Ohio State University, Time-Geographic Methods for Analyzing GPS Data**
- **Mike McNally, University of California, Irvine, The Merging of Travel Forecasting and Traffic Management Data and Models**
- **Harvey Miller, University of Utah, High-resolution Measurement of Time Geographic Entities**
- **Elaine Murakami, FHWA, Bringing Geographers and Travel Demand/Activity Modelers together to Benefit from New GPS Travel Data Resources**
- **Val Noronha, UCSB, GPS and Travel Monitoring**
- **Ram Pendyala, University of South Florida, Collection and Analysis of GPS-based Travel Data for Understanding and Modeling Activity-travel Patterns in Time and Space**

- **Shih-Lung Shaw**, University of Tennessee, **Time Geography for Activity Modeling with GPS Tracking Data**

Panelists:

- **Ayalew Adamu**, CALTRANS
- **Gordon R. Garry**, Sacramento Area Council of Governments
- **Qingquan Li**, Wuhan University (China)
- **Mark Schlappi**, Maricopa Association of Governments (Phoenix)
- **William F. Yim**, Santa Barbara County Association of Governments

Contributor:

- **Richard Mudge**, DELCAN Transportation, provided access to the closed website of the Baltimore Metropolitan Area

3. Meeting Outcomes

After the presentations and related discussions, breakout groups were formed and each developed a set of issues to consider further. Four breakout groups produced two sets of outcomes.

The first outcome includes **summaries of issues** that require further scrutiny for facilitating GPS data collection and use. The two breakout groups developed detailed lists of key issues, topics, and opportunities, and listings of the types of barriers that need to be overcome prior to effective implementation. **Appendix B** contains detailed discussion outlines from each breakout group.

Subsequently, the issues identified in the first round of breakout groups were transformed into a finite set of **recommended research projects** for possible funding by public agencies and/or private enterprises. **Table 1** summarizes these potential projects and **Appendix C** provides additional details.

The overall consensus was also to advocate the recommended projects with public agencies, such as the California Department of Transportation as a state project and a project jointly funded with other states and to develop project statements that can be recommended by mechanisms such as the National Cooperative Highway Research Program and the new Strategic Highway Research Program. In addition, portions of these projects as individual tasks can also be considered by the University Transportation Centers.

Table 1. Recommended Research Initiatives

| Title | Objective | Duration | Funding Level |
|--|---|-------------------|---------------------------------------|
| Use of GPS Data to Enhance and Calibrate/Validate Travel Models | Identify and improve accuracy of existing four-step models, identify and enhance policy analysis capabilities of four-step models, define the role of GPS data in activity-based model design, development, and application | 2-3 years | \$500K + data collection costs |
| Driver Behavior Profiles for Validating Traffic Microsimulation Models | Demonstrate applicability of GPS data for developing profiles of driver behavior for validating traffic microsimulation models | 1.5-2 years | \$300K-\$400K |
| Integration of Time-Space Geography in Activity-Based Models | Develop definitions, measurements, and representations of time-space paths; identify the role of ICT in influencing action space; and integrate time-space paths into activity-based models | 2 years | \$350K + data collection costs |
| Anonymizing GPS data | Identify data needs, convene stakeholder groups to identify privacy risks, develop new techniques for anonymizing data, attempt to break protections, develop specific policy guidelines | 1 year | \$200K |
| Geographical Modeling Testbed | Develop an education and training tool, with appropriate data and information resources, that is useful for testing hypotheses, testing comparative model development, and developing new analytical techniques | 2 years | \$750K – \$1250K |
| Variability in Recurrent and Variety Seeking Activities across Space and Time | Determine to what degree recurrent and variety-seeking activities vary across households, space, and time, and identify the most important dimensions and measures to describe this variability | 1 year 5 Years | Scoping - \$50K to \$100K \$2,500K |
| <p>Note: These project recommendations are from the FHWA-sponsored Peer Exchange and CSISS Specialist Meeting “GPS Tracking and Time-Geography Applications for Activity Modeling and Microsimulation” in Santa Barbara CA, 10-11 October 2005. See http://www.csiss.org/events/meetings/time-geography for more information.</p> | | | |

Appendix A

Meeting Agenda

Agenda for the Meeting

GPS Tracking and Time-Geography Applications for Activity Modeling and Microsimulation

An FHWA-sponsored Peer Exchange and CSISS Specialist Meeting

10-11 October 2005

The Upham Hotel — Santa Barbara, California

Sunday 9 October 2005 Arrival in Santa Barbara

Monday 10 October *Garden Room*

8:30 **Welcome, Kostas Goulias and Don Janelle**

8:35 **Introductions**

8:45 **Background Issues and Objectives, Elaine Murakami**

9:00 *Session I* **GPS Transportation Data Collection**

- **Randy Guensler**, Georgia Tech, **Commute Atlanta Instrumented Vehicle Data**
- **Larry Blain**, Puget Sound Regional Council of Governments, **GPS-Assisted Data Collection to Support Transportation Planning**
- **Panel Discussion on Data Needs from State DOT / MPO Perspectives**
 - **Ayalew Adamu**, CALTRANS
 - **Gordon R. Garry**, Sacramento Area Council of Governments
 - **Mark Schlappi**, Maricopa Association of Governments (Phoenix)
 - **William F. Yim**, Santa Barbara County Association of Governments

10:15 *Coffee Break*

10:30-11:45 *Session II* **Time-Geography Perspectives on Activity Behavior and Transportation**

- **Shih-Lung Shaw**, University of Tennessee, **Time Geography for Activity Modeling with GPS Tracking Data**
- **Mei-Po Kwan**, Ohio State University, **Time-Geographic Methods for Analyzing GPS Data**
- **Harvey Miller**, University of Utah, **High-resolution Measurement of Time Geographic Entities**
- **Ram Pendyala**, University of South Florida, **Collection and Analysis of GPS-based Travel Data for Understanding and Modeling Activity-travel Patterns in Time and Space**

12:00 *Lunch in garden*

1:15 *Session III* **Activity Modeling – Integrating GPS Data and Time Geography**

- **Kostas Goulias, UCSB, Travel Data for Activity-based Travel Demand Forecasting Models**
- **Helen Couclelis, UCSB, Activity Modeling with GPS Tracking Data: New Assumptions for the Age of ICT**
- **Mark Bradley, Santa Barbara, Toward GPS Data Collection for Activity Based Models**
- **Keith Clarke, UCSB, Negative (or Anti-) Time: A Theoretical Approach of Potential Use in Time-space Trajectory Analysis and Modeling**

2:00 *Session IV GPS-based Data for System-wide Transportation Modeling and Analysis*

- **Terry Bills, ESRI, GPS and Travel Behavior: A Few Research Questions**
- **Mike McNally, University of California, Irvine, The Merging of Travel Forecasting and Traffic Management Data and Models**
- **Val Noronha, UCSB, GPS and Travel Monitoring**
- **Donald G. Janelle, UCSB, Synoptic Analysis of Space-time Activity Patterns**
- **Mike Goodchild, UCSB, Potential of Dense-tracking Data**

2:45 *Framing Key Issues*

A Plenary Discussion, Mike Goodchild, UCSB, moderator

3:15 *Coffee Break*

3:30 *Breakout Sessions*

5:30 Plans for Tuesday

5:40 Wine and cheese, compliments of The Upham Hotel

6:30 Dinner – Opal Restaurant, 1325 State Street

Tuesday 11 October

6:00 – 8:30 Hike in Santa Ynez Mountains – optional

9:00 *Plenary Review of Breakout Sessions* Coach House [see results in Appendix B]

9:30 *Small-group Planning Sessions*

- The objective is to initiate drafts of “Scope of Work” for research projects that integrate transportation tracking data, time geography, and activity modeling.
- Groups may convene in the Coach House, the Board Room, or in the garden area

11:15 *Plenary Reports from Planning Sessions* Coach House [see results in Appendix C]

11:45 *Summation and Plans*, Kostas Goulias

12:00 *Lunch – on your own in Santa Barbara*

Appendix B

Issues Identified by Breakout Groups on GPS Data Collection and Use

GPS Data Collection and Use: Key Topics, Opportunities, and Barriers

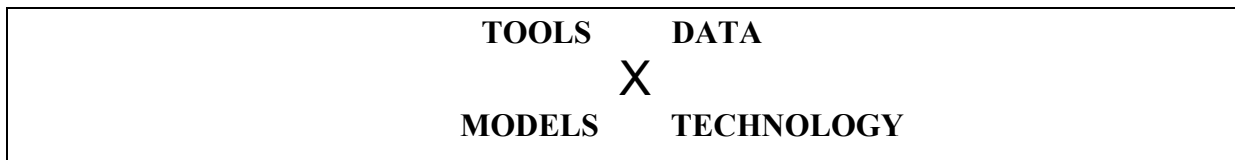
Group A: *T. Bills, L. Blain, H. Couclelis, M. Goodchild, K. Goulias, M. McNally, R. Pendyala, V. Noronha, S. Shaw*

R. Pendyala chaired the group discussion and prepared this summary outline.

Objective and Charge

- **Objective**
 - Using GPS data to define space-time paths and prisms for activity modeling and microsimulation
- **Charge**
 - Identify key topics – compile a list
 - What is needed to make progress?
 - Action items
 - What are the barriers to progress?

Structure/Framework



What Are Some Applications?

- **Probe vehicles to measure link speeds by location and time of day, including arterials**
 - Speed-flow relationships utilized in models
 - Recurrent congestion (identify bottlenecks)
- **Real-time monitoring of system**
 - Incident detection (non-recurrent congestion)
 - Emergency vehicle routing
- **Calibration/validation of 4-step and activity-based models**
 - GPS travel paths (vehicle traces) provide...
 - Speeds and travel times by time of day
 - Trip length distributions
 - O-D patterns (attraction-based trip patterns)
 - Traffic counts (full coverage)
- **Development/calibration of traffic microsimulation models**
 - Driver behavior – response to incidents, (mis)information, parking search behavior
 - Patterns of driving behavior (speed, acceleration, braking)
 - Conditions/movements at intersections, etc.
- **Emergency evacuation/disaster management**
 - Location of people by time of day (including location on network)

- **Transportation policy analysis/formulation in real time (endogeneity of policy implementation)**
 - Dynamic road pricing
 - Dynamic reverse lanes/lane closures/directional restrictions
 - Yield management (e.g., dynamic parking pricing)
- **Speed management**
- **Person-based GPS data applications**
 - Add multimodal dimension – mode choice (transit, bicycle, walk)
 - Transit access and egress paths

Data Issues and Action Items

- **Communications links – on-board processors, receivers, transmitters**
- **Standards for data structures/formats**
- **Data handling and reduction systems**
 - On-board and on-site
- **Seamless data fusion (different pieces of information from different devices)**
- **Who is custodian/keeper/archiver of data?**
- **Data residing in private vs. public sector agencies**
 - Insurance companies, mapping companies, GPS manufacturers
 - Review patents in area of GPS technology and data processors
- **Desire for real-time GPS data**
 - Incentives to get people to agree to transmit data
 - Establish public/private partnerships (institutional structures)
- **Legal/ethical use of data**

Tools and Models: Moving Towards Activity-Based Approaches

- **Matching GPS data with supporting trip characteristics data – Build an effective interface**
- **Simplify data collection process (intelligence in software)**
- **Measurement and analysis of time-space paths**
- **What characterizes/defines a time-space path?**
 - Deterministic vs. random components
- **Model validity by spatial resolution**
 - TAZ → Person
 - Measures of validation by level of spatial resolution/aggregation
- **Time-space prism definition to account for interactions and ICT use**

GPS Data and Time-Space Geography for Activity-Based Modeling

- **A multidimensional taxonomy (matrix) of GPS data use**
 - Planning and policy applications vs. research uses
 - Model development, calibration, and validation
 - Real-time (continuous monitoring) vs. static snapshot
 - Immediate payoff vs. longer-term applications
- **Proof of concept**
 - Transportation planning applications supported by GPS data – demonstrate worth of investment in data collection

- Information feedback to respondents – demonstrate worth of transmitting/sharing data
- **Institutional partnerships and incentive structures**

Project Ideas

- **Use of GPS data to calibrate/validate models (four-step and activity-based models)**
- **Driver behavior modeling to validate traffic microsimulation models**
- **Data fusion**
- **Dynamic real-time policy implementation**
- **Influence of ICT on time-space geography**

GPS Data Collection and Use: Key Topics, Research Uses, Impediments, Action Items, and Projects

Group B: *A. Adamu, M. Bradley, G. Garry, R. Guensler, D. Janelle, M-P Kwan, H. Miller, E. Murakami, R. Schlappi, W. Yim*

H. Miller chaired the group discussion.

R. Guensler prepared this summary outline.

Key Topics

- **Research needs**
 - What questions do we want to answer?
 - Generation of research hypotheses
 - Data needed to test hypotheses
 - Unit of analysis for data collection
 - Development of valid sampling plans
 - Avoiding self selection bias
 - Validity, consistency, transferability
- **Privacy**
- **Funding sources**
- **Identification and participation of stakeholders (theory to practice)**
- **Technology**
 - Person-based technology development
 - Instrumentation costs
- **Data retention and warehousing**

Research Uses

- **Verify existing travel demand models**
 - Congested speeds
 - VDF curves
 - Trip tables
 - HBW splits
 - Etc.
- **Develop methods to use data to falsify elements of activity-based models**
- **Propagation of adjustments in scheduling and activities through the system**
 - Social network effects
- **Manage urban systems**
 - Pushing demand out of the peak = pushing demand out of desired schedule into alternative schedule
 - Traveler response to incentives and programs
 - Consequences of change (economic, social, cultural)
- **Identify potential time based solutions to transportation problems**
 - Operating hours
 - Scheduling
 - Meetings
 - Private/public entity involvement
- **Congestion monitoring and mitigation**

- Identifying when and where congestion really occurs
- Expanding understanding of conditions under which congestion develops
- Identifying precursors to congestion
- Predicting congestion based upon monitored data
- Feedback to control systems to relieve congestion
- Identification of infrastructure improvements
- **Latent demand**
 - Long term monitoring
 - Monitoring changes in trip-making and route choice as a function of changes in land use and transportation infrastructure
 - Effects on trip-making and route choice associated with providing enhanced traveler information to the traveling public
- **Development of traffic management systems**
 - Replacement of high-cost monitoring technologies
 - Deployment in new areas (low volume roads and exurban/rural)
 - Operations management research
- **Identification of discontinuities in roadway performance characteristics**
 - Significant differences in performance on similar roadways
 - Infrastructure impacts on capacity and performance
 - Phase transitions
 - Impact on HCM concepts
- **Impact of performance variability (reliability) on route choice**
 - Day-to-day variability in travel time and other performance characteristics
 - Impacts by trip purpose
- **Time-tolerance in mode choice decision making**
 - Panel data (cluster sampling around transit service)
 - Personal and vehicle monitoring
 - Schedule pressures
 - Transit reliability effects
 - Accessibility to activity centers
- **Recurrent activity patterns vs. travel variability**
 - Home, work, school, day care, etc. vs. new and unique locations
 - Factors affecting the addition of new locations to recurrent activity
 - Learning of new routes
 - Constraints on variety seeking activity
- **Integration of other data streams into GPS research**
 - Satellite remote sensing
 - Video
 - Land use
 - Surveys
 - Counts
- **Challenges in using real time data vs. archived data**
- **Determining stakeholder benefits**
 - Agencies, companies, persons, etc.
 - Cost-benefit analysis for various uses
 - Proof of concept work
 - Case study development

- **Metadata development**
- **Traveler information effects**
- *Simulation model development and calibration*

Impediments

- **Funding**
- **Researchers and proponents may appear self-serving**
- **Staffing and training**
- **Costs**
 - Equipment
 - Service
 - Data Analysis
- **Staff expertise and fragmentation of staff in various divisions**

Action Items

- **Education and training**
 - Education of decision makers
 - Mainstream GIS training (organizations are getting flatter)
 - GIS as a tool, not as subject of study itself
 - Skill set maintenance via continuing education
 - Formal programs in land use, transportation, geography
- **Privacy survey**
 - Identification of public opinion on use of information and level of detail
- **Proof of concept case studies for education and benefit estimation purposes**
 - Proving to decision makers that we get better answers (that they also like)
 - MPOs need to know that this is a good investment
 - Demonstrate that costs are worthwhile
 - Benchmarking and side-by-side comparisons
- **Avoid advocacy perception**
 - Development of a professional research forum
 - Objective peer reviews
 - Identify downsides and risks
- **Funding**
- **Data**
 - Enhance data quality and lower data cost (both are improving)
 - Metadata development
 - Integrate with project management
 - Integrate into business process of MPO
 - GIS/GPS need to be a line-item in the budget
 - Repeatedly called for in past professional forums
- **Develop reliable resource estimates**
 - New modeling and data collection vs. current demands
- **Parallel research tracks**
 - Planning
 - Engineering/design
 - Environment
 - Etc.

- **Develop nexus between models**
 - Demand models
 - Mobility models
 - Simulation models
 - Environmental models
- **Information sharing**
 - Establishment of professional forum
 - TMIP-type program with combined funding
 - AMPO modeling committee approach
- **Focus information and recommendations to policy makers**
 - Explain why we need the data
 - Quantify the benefits and to whom they accrue (staff/divisions)
 - Show how the public will benefit
 - Quantify current fragmented spending on multiple projects
 - Identify offsetting expenditure reductions
 - Determine and argue for staffing needs
 - Importance of research
- **Assess impact of uncertainty in this field** (enhanced modeling and mobility tracking) on policy outcomes and potential impact on institutional resistance to changes in status quo
- **Facilitate effective communication** between land use planners, transportation planners, transportation engineers, GIS experts, and IT staff within organizations (reorganize agency structures)
- **Facilitate effective communications** between stakeholders and modify agency hierarchy when necessary to ensure Federal, State, regional, and local agency staff and resources are dedicated to proposition that good solid GIS systems and dense GPS data can be used effectively in transportation planning and operations
- **Pilot studies** to examine specific benefits and to compare results across regions

Projects

- **Anonymizing data**
- **Congestion monitoring and mitigation on specific corridors**
- **Development of adequate sampling plans**
 - Strata and duration of monitoring
- **Develop GIS-coded city for training future modelers**
 - parcel level data, demand model, simulation model, and example mobility database
- **Variability in recurrent and variety seeking activities across regions**
- **Verifying 4-step models and activity-based (time-space paths) models**
- **Evaluation of driver behavior**
 - Parking seeking
 - In-vehicle information systems response
- **Use of real-time data for monitoring and operations response**

Appendix C

Recommended Research Initiatives

Recommended Research from Group A

Report from R. Pendyala)

Topic I: Use of GPS Data to Enhance and Calibrate/Validate Travel Models

2 to 3 Years - \$500,000 + data collection cost

Objectives:

- Identify how accuracy of existing four-step models can be improved for both regional and local applications
- Identify how four-step models can be enhanced with regard to policy analysis capabilities
- What is the role of GPS data in activity-based model design and development and in application?

Tasks/Phases:

- Pilot study:
 - Use speed-flow relationships/link speed measurements in four-step model – check improvement (Atlanta)
- Identify policies of interest to MPO's in the context of four-step models
 - Transit user behavior
 - flex work hours
 - telecommuting
 - time of day pricing, peak spreading
- Analyze GPS data for:
 - driver/traveler response to incidents, information, policies
 - time-space patterns (potentially feedback into four-step models)

Topic II: Driver Behavior Profiles for Validating Traffic Microsimulation Models

1.5 to 2 Years, \$300,000 - \$400,000

Objective:

- Demonstrate applicability of GPS data for developing driver behavior profiles for validating traffic microsimulation models

Tasks:

- Develop driver and vehicular movement profiles using GPS data
- Data fusion of driver/vehicular movement profiles with loop detector data, real-time aerial videos, and any other types of field sensors
- Identify vehicular movement parameters that can be used in traffic microsimulation models

Topic III: Integration of Time-Space Geography in Activity-Based Models

2 Years, \$350,000 + data collection costs

Objectives:

- Definition/measurement/representation of time-space paths
- Role of ICT in influencing action space
- Integration of time-space paths into activity-based models

Tasks:

- Design and administer GPS data collection experiment that integrates ICT use patterns
- Determine how to analyze activity profiles corresponding to time-space paths/patterns (timing, sequencing, multitasking, substitution, coupling)
- Develop operational measures of time-space prism constraints for use in activity-based models

Recommended Research from Group B

Report from R. Guensler

Topic IV: Anonymizing GPS Data

1 Year - \$200,000.00

Background:

Privacy issues must be addressed before public release of GPS mobility data

Goal:

Identify data needs, convene stakeholder groups to identify privacy risks, develop new techniques for anonymizing data, attempt to break protections, develop specific policy guidelines

Researcher and MPO Meeting

- Census approach
- What data do we need at what resolution for what purposes?
- Will these require different levels and/or methods of anonymization

General Stakeholder Meeting

- Discussion of locational privacy issues
- Risk identification
- Prototype examples
- Masking technique examples
- Data fusion examples
- What pieces of data are necessary to identify an individual
 - e.g., home and work locations at specific resolution

Develop anonymizing techniques

- Peer review of results

Develop hacking techniques (break the protections)

- Peer review of results

With stakeholders, based upon the results, develop specific policy guidelines

Topic V: Geographic Modeling Testbed

2 Years - \$750,000.00 to \$1,250,000.00

Background: New analytical techniques require new training methods for practitioners and students

Goal: Develop an education and training tool that is useful for testing hypotheses, testing comparative model development, and developing new analytical techniques

Develop the underlying GIS data for a city

- Self contained city (or subset of a city coded to reflect self-containment)
- Identify a smaller city that can be used as the basis (e.g., Boise)
 - Potential to collect GPS and additional data
- Land use
 - Parcel-level land use with employment
 - Historic data
- Diary data
- Transportation infrastructure
- Transit network

3-D visualization

Modeling networks

- Coded 4-step model example
- Simulation model example (operations modeling of freeways and arterials)
- Base GPS traces on real data
 - Anonymization and adjustment

Peer review of data and models included

- Make sure that we are not forcing the data to fit pre-conceived causal relationships

Topic VI: Variability in Recurrent and Variety Seeking Activities across Space and Time

Scoping - \$50,000.00 - \$100,000.00

5 Years - \$2,500,000.00

Goal: Determine to what degree recurrent and variety-seeking activities vary across households, space, and time and what are the most important dimensions and measures to describe this variability

Scoping study

Develop a sampling plan that addresses

- Regional effects (sample within multiple regions)
 - Rural, suburban, urban characteristics
 - Weather characteristics
- Household strata and land development
- Transit accessibility
- Effects of changes in transportation infrastructure and land use environments
 - Pre- and post-improvements (e.g. I-15 improvement in SLC)
- Time effects (longer term monitoring or repeated monitoring)
 - Long term monitoring to examine disruptions
 - Instrumentation deployment time periods
- GPS plus travel diaries

Exploratory analysis of new data at different spatial and temporal scales

Identification of emergent patterns and responses in recurrent and variety seeking travel to changes in the system and effects of control variables identified above

