AMPLIFIED WORK PLAN for:

SHRP 2 C04 – IMPROVING OUR UNDERSTANDTING OF HOW HIGHWAY CONGESTION AND PRICING AFFECT TRAVEL DEMAND.

Prepared by PB / Parsons Brinckerhoff

March 2008

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This document is an amplified work plan for the SHRP 2 C04 project, providing a detailed description of how the research plan will be carried out by the PB led research team.

It is organized in the following manner:

- Summary of responsibilities - key team members
- Scope of work
- Schedule and work flow diagram
- Response to SHRP 2 comments on proposal (July 10, 2007)
- Final Budget (August 3, 2007)

1. Summary of Responsibilities - Key Team Members

Implementation of the work plan will be managed and directed by the following principals:

Robert M. Donnelly, PB – Project Manager

Peter Vovsha, PB – Principal Investigator 1

Hani Mahmassani, Northwestern University – Principal Investigator 2

Mark Bradley, – Principal Investigator 3

Figure 1 shows a matrix of responsibilities among the research team, with the role and level of effort for the key members of the team indicated for each task in each of the three phases of the research.

Figure 1: SHRP 2 C04: Summary - Responsibilities of Main Team Members (Hours of the main person + assistants)

Task	Robert Donnelly Project Manager	Peter Vovsha Principal Investigator 1	M. Bradley Principal Investigator 2	H. Mahmassani (Northwestern) Principal Investigator 3	K. Kockelman	T. Adler (RSG)	K. Small	David Brown-stone	Frank Koppel-man	John Bowman	Jean Wolf / Billy Bachman (GeoStats)
1. Choice framework	12	32 – **Lead**	12 – **Review / Input**	16 – **Review / Input**	2	8	2	2	2	3	
2. Examine data sets	8 - Coordination	28 **– Lead**	8	8	8	8	4	6	4	4	4
3. Coordination SHRP-NCHRP	8	16 – **Lead**	8 - **Review**	8 - **Review**	0	0	0	0	0		
4. Interim Report	24	32 – **Lead**	8 - **Review**	8 - **Review**	2	8	0	0	0		
5. Project plan (prepare data and specs)	60 – Coordination	220 - **Lead**	200 – **Co-lead / demand models**	200+412 – **Co-lead / network simulation**	72 – **Coordin-ation in obtaining datasets**	52+110 – **Data prepar-ation**	24 – **Model specification (reliability measures)**	40 – **Model specifica-tion (Time-of-day choice)**	24 - Review	32 – **Model specifica-ion (Daily pattern and long-term choices)**	
6. Mathematical description of choices / model estimation	48	160 – **First review / QC**	232 – **Lead / demand models**	232+500 – **Lead / route choice**	60- Review	24+48 – **Model Estimatio n (Value of Time)**	36 – Model Estimation review	40 – **Model Estimatio n (Time-of-day choice)**	36 - Review	120 – **Model Estimation (Daily pattern and long-term choices)**	70+200 GPS travel survey data analysis
7. Phase 2 Report	32 – Review / Report consolidation	80 – **Report consolidation**	80 – **Primary Input**	80+120 – **Primary Input**	16 - Review	16+4 Review	4	12	4	16	
8. Incorporation into practice	48 - Review	140 - **Lead**	40 – **Review / Input**	40+16 – **Review / Input**	24 - Review	8+8	8	8	8	8	
9. Network simulation	16	32 - Review	90 – **First review**	90+240 – **Lead**	0	0	0	0	0	0	
10. Draft Final Report	48 – Review / Report Consolidation	80 – **Lead / Report Consolidation**	32 – **Input (model estimation)**	32 – **Input (network simulation procedures)**	8	8+4	4	2	4	0	
11. Final Report	24 – Review / Report Consolidation	36 – **Lead / Report Consolidation**	8	8+8	4	2	2	0	2	0	

2. Scope of Work

Phase I: General Framework and Data Availability

Objective of the Research

As stated in the RFP: The objective of this research is to develop mathematical descriptions of the full range of highway user behavioral responses to congestion, travel time reliability, and pricing. The mathematical descriptions of behavior should be in a form that can be incorporated into various travel demand modeling systems in use or being developed. Examine network assignment practices needed to support models that simulate behavioral responses to congestion, travel time reliability, and pricing. Accomplishment of the project objective will require the following tasks.

Task 1: Identify a Choice Framework

General Task Scope of Work

As stated in the RFP: The work in this task is to identify a choice framework (parameters) faced by auto users, unconstrained by current models or data. The purpose of this exercise is to provide a baseline for the project. This task should result in a theoretical framework that posits the choice parameters and explanatory factors to be included in choice model specification, explaining highway user behavior under congestion and road pricing. A modeling environment is needed in which all the dimensions of behavioral response engendered by congestion and pricing can be analyzed, including especially:

. Change in time of travel
. Route change
. Willingness to pay tolls
. Mode change
. Trip generation choices or activity pattern generation choices
. Trip tour structuring

Technical Activities / Issues – per Proposed Research Plan

Behavioral Framework

As part of this task, the research team will analyze in depth and classify possible behavioral responses to congestion and pricing based on the vast body of already implemented research, as well as reported in before and after studies. This classification will be incorporated in the formulation of a comprehensive conceptual model of travel behavior that will serve as the starting point for the specification of model systems that could be estimated with the selected data sets.

The research team will focus primarily the estimation effort (in Task 6) on models of route and pre-route (toll vs. non-toll) choice, mode choice and time of day choice – integrating these dimensions as much as possible. For other types of models (destination choice, occupancy choice, trip/tour pattern choice, work location, car ownership, residential location, etc) we will also estimate and report at least one or two specifications of each in order to demonstrate how congestion and pricing effects can be integrated from the shorter term to these longer term choices.

Travel and Population Segmentation

Another long-term gap in understanding and modeling congestion and pricing is associated with poor segmentation of population and travel.

A variety of traveler and trip type dimensions are understood to be important. Traveler/trip segmentation may best address the following list:

- Income, age and gender.
- Household size and composition.
- Worker status.
- Travel purpose.
- Activity/schedule flexibility
- Trip frequency.
- Vehicle occupancy and travel party composition.
- Time-of-day
- Trip length / distance.
- Toll payment method.
- Situational context: time pressure vs. flexible time.

One of the most important outcomes of the proposed research will be to develop a deeper and more constructive understanding of how all these factors that comprise user heterogeneity work together with regard to different possible behavioral responses. In some cases, we expect that important factors will require full model segmentation since they are associated with distinctive behavioral mechanisms. In some other cases, different variables could be combined in the same utility expression with no full segmentation assuming that their impacts are complementary and compensatory. This will be determined in the course of work on Task 6.

Specific Impacts of Congestion

We believe that a deeper understanding of congestion impacts on travel behavior should include several additional aspects:

- Perceived highway travel time
- Different pattern of highway user behavior in presence of unpredictable travel times:
- Disequilibrium (lagged equilibrium) between travel demand and supply:

Perception of Toll Roads and Managed Lanes

The following specific pre-route factors (beyond travel time and cost) should be considered and estimated for all types of priced facilities:

- Reliability
- Safety

Understanding and modeling of the usage of HOV/HOT lanes must be routed in an understanding of the behavioral mechanisms associated with formation of carpools. For this research project, we plan to address this issue in depth. Operational classification of carpools for analysis and modeling will include the following dimensions:

- Formation mechanism (intra-household, inter-household planned, inter-household casual),
- Travel party composition (adults only, adults with children),
- Directionality (one-way vs. two-way),
- Carpool associated with joint participation in the same activity vs. pure travel arrangement (pick-up and/or drops-off).

Team Roles/Responsibilities for Work Scope

PB Americas: Management and **primary responsibility** for product with technical lead by Co-Principal Investigator, Peter Vovsha. His responsibility is to prepare a memorandum on Task 1.

Subconsultants:

Mark Bradley: Co-Principal Investigator - Meet with core project team, provide inputs and detailed review of the Memorandum prepared for Task 1.

Hani Mahmassani (Northwestern University) Co-Principal Investigator - Meet with core project team, provide inputs and detailed review of the Memorandum prepared for Task 1.

Kara Kockelman – Correspond with core project team, provide advice on the development of the memorandum on Task 1.

RSG, Tom Adler and Analyst - Meet with core project team, provide advise on the development of the memorandum on Task 1.

GeoStats – No activity.

Kenneth Small: Special Advisor - Meet with core project team, provide advise on the development of the memorandum on Task 1.

David Brownstone: Special Advisor - Correspond with core project team, provide advise on the development of the memorandum on Task 1.

Frank Koppleman: Special Advisor – No activity.

John Bowman – Correspond with core project team, provide advice on the development of the memorandum on Task 1

Task 2: Examine Available Data Sets

<u>General Task Scope of Work</u>

As stated in the RFP: The work in this task is to examine available data sets that might be used to gain the desired information. Determine if the data sets would need augmentation, and propose a method and budget to develop mathematical descriptions of the full range of behavioral responses to congestion, travel time reliability, and pricing. *See Special Note:*

> Special Note: Travel time reliability is included in this task because the same basic data is used to analyze travel response to one-time delay, repeated delay, and tolls. Prior work on willingness-to-pay has addressed both time savings and reliability issues as elements of willingness-to-pay.

Technical Activities / Issues – per Proposed Research Plan

Survey Types Considered

The following major types of surveys of individual behavior will be considered for use this research aimed the analysis of transportation pricing and congestion. The categories represent a combination of general methods and the purposes for which the surveys are done:

Type 1: General Comprehensive Household Interview Surveys - Revealed Preference (RP)

Type 2: Stated Preference (SP) Follow-on and Linked to Household Interview Surveys

Type 3: Managed Lane Studies - Combined Revealed Preference and Stated Preference (RP/SP)

Type 4: Regional Pricing Options and Area-Based Pricing - Combined Revealed Preference and Stated Preference (RP/SP)

Type 5: New Facilities with Tolling - Combined Revealed Preference and Stated Preference (RP/SP)

Type 6: Time of Day Tolling - Combined Revealed Preference and Stated Preference (RP/SP)

Type 7: Existing Facilities: Adding Tolls - Combined Revealed Preference and Stated Preference (RP/SP)

Even in each of these categories, there are variations in their structure, scope, and design. In view of the objectives of the study, there are advantages and disadvantages to be carefully evaluated. No one single survey type can provide a full basis for a comprehensive analysis of all impacts of congestion and pricing on travel behavior. Altogether, however, we anticipate that the set of existing, as well as planned concurrent surveys, can provide good coverage of the main travel dimensions of interest, and good empirical foundation for this research project

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Preliminary List of Available Surveys

The following major data sets are available and in most cases have already been intensively used by members of our team in their previous research – see **Table 2** (pp 4-14 through 4-17).

RP/SP Survey Integration

This project will provide a very timely opportunity to synthesize the evidence from as much of the recent data as possible as possible within a state-of-the-art model estimation framework.

It is critical to use both RP and SP data in order to get an accurate model of traveler responses to pricing. While SP data is typically necessary to estimate distributions across the population and provide detailed market segmentation information, it also has potential shortcomings. Research from the limited number of managed lane systems already in place has indicated that the willingness to pay estimates from RP data tend to be roughly twice as high as those from SP data from the same context. Reasons hypothesized for this are that travelers have inaccurate perceptions of the time that they actually save on the systems, as well as evidence possible "protest" responses against pricing options that may outlined in the SP exercises. Carefully pooled analysis of both types of data will be necessary to take advantage of the strengths and avoid the shortcomings of each. One very strong candidate data set in this regard will be the data from the MnPASS system in Minneapolis. Mark Bradley has published analysis results using the SP panel data, but as yet the trip data from the panel surveys have not been combined with objective data on HOT lane travel times and prices and general lane travel times in order to derive RP models. Another important data set for pooled analysis is the data from the Traffic Choices pricing experiment in the Seattle region. That experiment combines some of the best elements of SP research—an experimental design of prices that vary by time and space—with critical elements of RP data—objective GPS measurement of travel speeds, times and prices, along with responses that involve actual payment of money.

Transferability Aspect

Though transferability has not been explicitly included in the scope as stated in RFP, it is implied in many objectives as we understand them for the project. We believe that the fact that existing models developed for different regions are generally non-transferable, largely stems from the poor specification/segmentation of person, household, and situational variables, as well as the absence of such important explanatory variables as reliability. With a rich set of explanatory variables in the current research, we will be better position to investigate commonalities and differences of travel behavior across regions. It is currently a strong belief among many researchers that more elaborate models of travel behavior should be transferable and observed differences in travel behavior could be explained by variables and regional conditions within the same model structure. This project provides and ideal platform for a comprehensive testing of this hypothesis. We plan to specifically implement several statistical tests on transferability and report.

Data Sufficiency Evaluation

For this stage of the research, we plan to scrutinize the survey structure, scope, and available variables, and identify final data sets for the subsequent behavioral analysis and estimation. One very important component that would be taken into account is the existing or potential linkage of the survey to the regional / corridor travel model that would provide such important additional variables as trip travel time and cost for each alternative mode and time-of-day period, as well as zonal population, employment, and land-use data.

The following results and suggestion will be reported and discussed with the Panel:
Augmentation of existing data sets. Data sets are proposed to be used, what they contain and what augmentation is likely to be needed. If a chosen data set would need augmentation, a method and budget for this will be substantiated.

Potential new surveys. The existing data sets and travel dimensions that they cover will be evaluated with respect to the conceptual model and mathematical descriptions of the full range of behavioral responses to congestion, travel time reliability, and pricing. Potential gaps in the existing data sets that do not cover certain important dimensions of the conceptual model will be identified and the corresponding proposal for additional data collection effort will be developed.

Team Roles/Responsibilities for Work Scope

PB Americas: Management and **primary responsibility** for product with technical lead by Co-Principal Investigator, Peter Vovsha. His responsibility is to prepare a template for surveys, and consolidate list of available surveys with details on the data items, survey, scope, and usefulness for different choice dimensions. Bob Donnelly will assign different surveys for documentation to the corresponding team members.

Subconsultants:

Mark Bradley: Co-Principal Investigator – examine and document selected datasets, provide the necessary information for making decision about the survey usefulness.

Hani Mahmassani (Northwestern University) Co-Principal Investigator - – examine and document selected datasets, provide the necessary information for making decision about the survey usefulness..

Kara Kockelman – – examine and document selected datasets, provide the necessary information for making decision about the survey usefulness.

RSG, Tom Adler and Analyst - – examine and document selected datasets, provide the necessary information for making decision about the survey usefulness.

GeoStats – – examine and document selected datasets, provide the necessary information for making decision about the survey usefulness as related to GPS technology/data.

Kenneth Small: Special Advisor - – examine and document selected datasets, provide the necessary information for making decision about the survey usefulness..

David Brownstone: Special Advisor - – examine and document selected datasets, provide the necessary information for making decision about the survey usefulness..

Frank Koppleman: Special Advisor – – examine and document selected datasets, provide the necessary information for making decision about the survey usefulness..

John Bowman – – examine and document selected datasets, provide the necessary information for making decision about the survey usefulness.

Task 3: Maintain Project Coordination Between SHRP 2 & NCHRP

General Task Scope of Work

As stated in the RFP: The work in this task is to maintain liaison through the SHRP 2 Senior Program Officer with on-going work in the National Cooperative Highway Research Program and the Federal Highway Administration. The results of SHRP 2 Project C04 should support and not duplicate other on-going work. *See Special Note:*

> Special Note: NCHRP Project 8-57, Improved Framework and Tools for Highway Pricing Decisions, has recently begun. This project will develop a decision-making framework that includes descriptions of methods and analytical tools for establishing pricing policies and predicting their impacts on travel behavior and congestion. Gaps in knowledge will be identified and improved methods and tools will be developed. This project clearly has similarities to SHRP

2 Project C04, but does not focus on in-depth mining of data sets for fundamental additions to knowledge of travel behavior with regard to congestion, travel time reliability, and pricing. Also, NCHRP Synthesis 38-03, Compilation of Public Opinions on Tolls and Road Pricing is in progress. The results of this synthesis will be a resource for SHRP 2 project C04. Proposers should budget for informational meetings, conference calls, and possible attendance at special workshops that may occur during the course of the study.

Technical Activities / Issues – per Proposed Research Plan

The work under research projects NCHRP 08-57 and SHRP 2, will be actively coordinated, in order to enhance these related efforts and avoid duplication. Such coordination will help ensure these tandem investigations arrive at mutually supportive, highly complementary specifications and recommendations. Any contradictions may confuse potential users and, potentially, diminish the credibility of the research efforts; such instances will be naturally avoided here, thanks to highly related roles of key team members.

Optimal coordination between these related projects, offering a maximization of product benefits, can be achieved by definition of the common and exclusive areas as shown in **Figure 2** below.

The primary focus of the NCHRP 08-57 project is on improvement of the general decision-making framework for highway pricing (exclusive part) with the recognition of applied forecasting models as important decision-supporting tools. The primary focus of the SHRP 2 project is on development of mathematical descriptions of the full range of highway user behavioral responses to congestion, travel time reliability, and pricing (exclusive part) with the subsequent incorporation into various travel demand modeling systems. The NCHRP 08-57 project has a more practical and immediate focus while the SHRP 2 project relates to more fundamental research issues of travel behavior, expecting to extend our capabilities, including developing methods that can be absorbed in practice

Both projects have in common a framework of applied model systems. Ideally, this common part should be coordinated in order to provide a link between the fundamentals of travel behavior established in SHRP 2, and the practical aspects of decision-making on pricing substantiated in NCHRP 08-57. If this were the case, the two projects would form a valuable and coherent body of research with a clear practical outcome. Additionally, close coordination of the two projects would reduce a possible duplication of effort for similar tasks. By avoiding redundant work in either, the work accomplished in both projects can be performed to maximum benefit. To specifically ensure the necessary integration of modeling frameworks developed in both projects we offer Dr. Peter Vovsha (PB), who is the Principal Investigator of NCHRP 08-57, to serve as a Co-Principal Investigator for SHRP 2 CO4, who would lead the Task 8 "Model specifications" / Phase III "Application frameworks".

Team Roles/Responsibilities for Work Scope

PB Americas: Management and **primary responsibility** for product with technical lead by Co-Principal Investigator, Peter Vovsha. He will be responsible for writing a memo describing details of the coordination between the two projects as well as incorporation of the finding of the NCHRP 08-57 project in the SHRP 2 CO4 work plan.

Subconsultants:

Mark Bradley: Co-Principal Investigator - Detailed review of the memo and inputs to the project coordination plan.

Hani Mahmassani (Northwestern University) Co-Principal Investigator - Detailed review of the memo and inputs to the project coordination plan.

Kara Kockelman – No activity.

RSG, Tom Adler and Analyst - No activity.

GeoStats – No activity.

Kenneth Small: Special Advisor – No activity.

David Brownstone: Special Advisor No activity.

Frank Koppleman: Special Advisor – No activity.

John Bowman – No activity.

Task 4: Phase I - Interim Report

General Task Scope of Work

As stated in the RFP: The work in this task is to prepare an Interim Report that includes the results of tasks 1 and 2. The report should contain a very specific plan for Phase II, including a description of proposed data sets, any restrictions on use of data, any missing data necessary to this project, methods to deal with missing data, and expected results. Phase II will not proceed until the Interim Report is approved and a notice is received that Phase II is authorized.

Technical Activities / Issues – per Proposed Research Plan

The implementation and results of the work done in Tasks 1 and 2 will be documented in the Phase I - Interim Report.

Prepare a report consisting of three principal components:

4.1 Formulation of a Modeling Framework (Task 1) to serve the project's research for improved modeling of travel behavioral response and system performance with respect to congestion and road pricing.

4.2 Development of a Detailed Data Set Inventory and Evaluation (per Task 2) of existing, as well as possible data sets concurrently under development, along with descriptions of supporting modeling infrastructure that can support the data development and statistical estimation to be done in this project.

4. 3 Prepare an Implementation Plan for Phase II that will prioritize and detail the specific survey, network and other data to be assembled, organized, and prepared in Task 5 , and the estimation methods and criteria to be used for the analysis and model testing to be done in Task 6. The plan will identify methods needed to fully prepare the data, account for missing information, biases, or other threats to their validity. Additionally, we plan to present and discuss with the Panel, a schedule for interim deliverables / technical memorandums that would relate to completion of certain meaningful steps in subsequent research Tasks 6, 8, and 9. These interim deliverables will facilitate the interaction between the research Team and Panel.

This report will be delivered no later than the fifth month of the contract. The Phase I - Interim Report will be reviewed by the project staff and panel, and panel feedback will influence the remaining project work, including the final products. The consultant team will meet with the SHRP 2 staff and project panel about one month after submission of the report to address comments and questions stemming from their review of the report.

Deliverables / Milestones:

- Interim Report submitted within 5 months.
- Meeting with SHRP 2 staff about one month later.
- Approval will be obtained prior to initiating Phase II - Task 5.

Team Roles/Responsibilities for Work Scope

PB Americas: Management and **primary responsibility** for Phase I products and report, with technical lead by Co-Principal Investigator, Peter Vovsha.

Subconsultants:

Mark Bradley: Co-Principal Investigator - Provide substantive inputs to the development and review of the Phase I / Interim report.

Hani Mahmassani (Northwestern University) Co-Principal Investigator - Provide substantive inputs to the development and review of the Phase I / Interim report.

Kara Kockelman – Provide review of the Phase I report.

RSG, Tom Adler and Analyst - Provide substantive inputs to the development and review of the Phase I report.

GeoStats – No activity.

Kenneth Small: Special Advisor - No activity.

David Brownstone: Special Advisor - No activity.

Frank Koppleman: Special Advisor – No activity.

John Bowman – No activity.

Phase II: Statistical Analysis and Model Estimation

Task 5: Execute Project Plan per Interim Report

General Task Scope of Work

As stated in the RFP: The work in this task is to execute the plan approved in the interim report.

Technical Activities / Issues – per Proposed Research Plan

A data consolidation plan would be finalized and executed in this task to create the necessary background and platform for the subsequent major research Task 6 of model estimation. While a great level of details will depends on the results and findings of Tasks 1-4, the following are anticipated as important steps of the plan:

Data Development

5.1. Acquire, Reconcile and Process Travel Behavior Survey Data Sets: Obtain the selected databases, the companion documentation, and bring them to a common categorization denominator (through correspondence tables) in terms of travel purposes, income groups, person and household characteristics, etc to the extend possible.

5.2. Acquire, Process and Merge Complementary Data: Obtain all identified complementary data necessary for the model estimation (level-of-service skims, zonal socio-economic and land-use data) from the regional agencies (MPOs, DOTs).

5.3. Obtain or Synthesize Reliability Measures (discussed in Task 6 below) in each survey framework; if necessary, coordinate with the local MPO / DOT in order to obtain traffic network data that could be used to synthesize indirect reliability measures (proxies) as discussed in Task 8 below.

5.4. Integrate Data Sets, organize them as a computerized database / warehouse, and prepare them for a combined statistical analysis and estimation. The prepared databases will be documented and made available for a wide community of researches and practitioners.

Model Specifications and Analysis Plan

5.5 Prepare Preliminary Model Specifications and Analysis Plan , consistent with the general model framework established in Task formats and coordinate them with the team (and panel) of NCHRP project 08-57. Though, the model specification details in terms of variables and utility expressions cannot be know before the estimation stage has been completed, the model specification formats in terms of choice alternatives can be specified and discussed in advance at this stage.

Team Roles/Responsibilities for Work Scope

PB Americas: Management and supporting responsibility for Task 5 technical activities and products, with technical direction and quality assurance by Co-Principal Investigator, Peter Vovsha. His task is to coordinate preparation of the data sets and model specifications for the estimation process.

Subconsultants:

Mark Bradley: Co-Principal Investigator **- Primary responsibility** for preparation of the data sets and model specifications for the estimation process.

Hani Mahmassani (Northwestern University): Co-Principal Investigator - **Primary responsibility** for preparation of the data sets and model specifications for the estimation process.

Kara Kockelman – Coordination of activities of advisors and obtaining datasets.

RSG, Tom Adler and Analyst – Supporting responsibility for travel survey data preparation.

GeoStats – No activity.

Kenneth Small: Special Advisor – Provide partial focused review and inputs to task technical activities and products; provide specifications for travel time reliability measures

David Brownstone: Special Advisor – Provide partial focused review and inputs to task technical activities and products; provide specifications for time-of-day choice models sensitive to congestion and pricing

Frank Koppleman: Special Advisor – Provide partial focused review and inputs to task technical activities and products.

John Bowman - Supporting (Mark Bradley) responsibility for travel survey data and demand side technical activities and products; provide specifications for daily activity pattern models and long-term choices sensitive to congestion and pricing

Task 6: Specify and Estimate Choice Models - Mathematical Descriptions of Highway User Choices Sensitive to Congestion, Travel Time Reliability, and Pricing

General Task Scope of Work

As stated in the RFP: The work in this task is to specify and estimate mathematical descriptions of highway user choice sensitive to congestion, travel time reliability, and pricing. This should lead to major contributions in one or more of the following priority research areas:

- Disaggregate measures of willingness to pay by user class and trip characteristics
- Distributions of values of time within individual user classes
- Contribution of trip time variability (reliability) to measures of willingness to pay

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Technical Activities / Issues – per Proposed Research Plan

In this task where the agreed-upon behavioral modeling framework (Task 1) and the available data sets (Task 2) we will be tied together, to (a) deepen our understanding of congestion- and pricing-related behavior through hypothesis testing, and (b) estimate models that can be used by a wide range of future practitioners in both project-specific and region-wide travel demand forecasting.

The work will include the following subtasks:

6.1 Detailed model specification and estimation plan

Extending the work from Task 5.5, the choice models that will be estimated will be specified in full econometric detail. For each model, this detailed specification may include a number of different behavioral hypotheses and associated model forms to be tested using the available data. The specification will also indicate how each model will be linked / integrated with other models to be estimated, for example with the use of expected utility ("logsum") variables from "lower level" models. For example, the total expected utility across all modes and pricing options can be specified to influence the choice of tour or trip destinations. To allow such linkages to be created, the detailed plan will specify any interdependencies between models and any implications on the exact order in which the models must be estimated. The plan will also consider available software for model estimation, and select a specific software option (or options) for each model.

6.2 Selection of data sets for each model

Which data sets are most appropriate for use in estimating each model will be decided in this subtask. This process will likely involve a sorting of eligible data sets into at least three categories: (a) those that are clearly appropriate and will definitely be used, (b) those that may be useful but whose contribution need to be tested empirically, and (c) those that would clearly not offer any additional value to the estimation over the data sets in categories (a) and (b). This subtask will add to the detailed model estimation plan from Subtask 1 a strategy for testing which data sets will be used in the final version of each model, as well as the statistical estimation strategy for combining data sets from different sources. Ideally, each model will be informed by Revealed Preference (RP) data sets on actual choice behavior, along with any data from any relevant and well-designed Stated Preference (SP) experiments.

6.3 Model estimation and hypothesis testing

The major subtask will be to carry out the estimation strategy as laid out in the detailed model estimation plan. Important data issues and decision points for each model will be laid out in advance, so that the estimation will proceed along a well-defined path. The work in this task will be done within the framework of both the academic and practical model estimation experience of the team, to envision and implement this process, as well as to deal with any unforeseen data or estimation issues that may arise.

There are three key issues that will be addressed as part of the model estimation work in this task:

The models will reflect the **heterogeneity of traveler responses** to congestion and pricing to the greatest extent possible. This includes both systematic market segmentation, and estimating the distribution of residual variation in response across the traveling population.

The models will explicitly capture two critical, interrelated aspects of behavior—the effects of **travel time variability and reliability** and the **choice of travel departure time**, in a manner that is both consistent with behavioral theory and applicable in project evaluation and forecasting.

The models will take advantage of **state-of-the-art econometric estimation and application techniques**, and will be estimated to be readily incorporated into the coming generation of activity-based travel demand microsimulation models. Advanced model estimation approached will be applied in this task, including investigation of Mixed logit methods. Random Coefficients (mixed) logit model estimation (already available in commercial software like ALOGIT or LIMDEP or BIOGEME), has become a practical tool for modeling choices related to road-pricing. The random coefficient logit form directly corresponds to the situation where VOT and underlying utility coefficients for travel time and cost are assumed randomly distributed, rather than deterministic.

6.4 Selection of final models for application

Once sufficient estimation has been done to thoroughly test the various hypotheses and data sets for all of the models included in the behavioral framework. the final, best specification(s) of each model to be used in the recommended application framework(s) will be decided upon. This subtask overlaps with Task 8 to some extent, as any revisions to the recommended application frameworks may require that we revisit the selection of which estimated models are best for application.

Team Roles/Responsibilities for Work Scope

PB Americas: Management and QC responsibility for Task 6 technical activities and products, with technical direction and quality assurance by Co-Principal Investigator, Peter Vovsha.

Subconsultants:

Mark Bradley: Co-Principal Investigator **- Primary responsibility** for estimation of the set of core demand models sensitive to congestion and pricing.

Hani Mahmassani (Northwestern University): Co-Principal Investigator **- Primary responsibility** for network data and simulation side technical activities and products as well as estimation of the set of route choice and related models sensitive to congestion and pricing.

Kara Kockelman – Provide substantive inputs to the development and review of task activities, and coordination with the Special Advisors team.

RSG, Tom Adler and Analyst – Supporting responsibility for travel survey data and demand side technical activities and products; estimation of the set of models to support value-of-time segmentation.

GeoStats – Supporting responsibility for GPS travel survey data and demand side technical activities and products.

Kenneth Small: Special Advisor – Provide partial focused review and inputs to task technical activities and products.

David Brownstone: Special Advisor – Provide partial focused review and inputs to task technical activities and products; estimation of the time-of-day choice model sensitive to congestion and pricing

Frank Koppleman: Special Advisor – Provide partial focused review and inputs to task technical activities and products.

John Bowman - Supporting (Mark Bradley) responsibility for travel survey data and demand side technical activities and products; estimation of the daily activity pattern and long-term choice models sensitive to congestion and pricing

Task 7: Phase II Report

General Task Scope of Work

As stated in the RFP: The work in this task is to prepare a Phase II Report that fully describes the methods and results. Submit the report for review and approval before proceeding to Phase III.

Technical Activities / Issues – per Proposed Research Plan

The implementation and results of the work done in Tasks 5 and 6 will be documented in a report that consists of three principal components:

7.1 Specific survey, network and other data assembled, organized, and prepared (based on Task 5).

7.2 Estimation methods and results of the analysis and model testing (based on Task 6).

7.3 Conclusions and Implications for Phase III – Findings of the Phase II work will be summarized and, along with a discussion of the general implications of the completed research for how the activities in then final phase of the project – aimed at transferable information for practicing planners – can most effectively be conducted.

This report will be delivered no later than the 11th month after the start of Phase II. It will be reviewed by the project staff and panel feedback will influence the remaining project work, including the final products. The consultant team will meet with the SHRP 2 staff and project panel about one month after submission of the report to address comments and questions stemming from their review of the report.

Deliverables / Milestones:

- Phase II Report submitted within 11 months of the beginning of Phase II.
- Meeting with SHRP 2 staff about one month later.
- Approval will be obtained prior to initiating Phase III - Task 8.

Team Roles/Responsibilities for Work Scope

PB Americas: Management responsibility for Task 7 products and Phase 2 report consolidation, with technical lead by Co-Principal Investigator, Peter Vovsha.

Subconsultants:

Mark Bradley: Co-Principal Investigator - **Provide primary inputs to the development** and review of the Phase II report, with respect to travel surveys and demand analysis.

Hani Mahmassani (Northwestern University) Co-Principal Investigator **- Provide primary inputs to the development** and review of the Phase II report, with respect to networks and simulation analysis

RSG, Tom Adler and Analyst - Provide substantive review of the Phase II report.

Kara Kockelman – Provide substantive review of the Phase II report.

GeoStats – No activity.

Kenneth Small: Special Advisor – Provide partial focused review the Phase II report.

David Brownstone: Special Advisor – Provide partial focused review and inputs for the Phase II report.

Frank Koppleman: Special Advisor -Provide partial focused review and inputs for the Phase II report.

John Bowman - Provide partial focused review and inputs for the Phase II report.

Phase III: Application Framework

Task 8: Incorporation into Current or Developing Practice

General Task Scope of Work

As stated in the RFP: In order to be useful to practicing planners and engineers, the results of this project must be presented in a way that can be incorporated into current or developing practice. Phase III will describe model specifications, with recommendations for implementation at the corridor/project and the regional planning levels. This project will not implement or calibrate models but describe how to integrate the mathematical descriptions developed in Project C04 with the broader set of models in use or being developed. See Special Notes 3 and 4. This Phase will address at least:

- Corridor or project level model structures and needs
- Regional model structure-trip-based versus activity/tour-based
- Integrating the route choice model with the regional model
- Land-use effects of changes in accessibility

See Special Notes:

> Special Note: NCHRP Project 8-57, Improved Framework and Tools for Highway Pricing Decisions, has recently begun. This project will develop a decision-making framework that includes descriptions of methods and analytical tools for establishing pricing policies and predicting their impacts on travel behavior and congestion. Gaps in knowledge will be identified and improved methods and tools will be developed. This project clearly has similarities to SHRP 2 Project C04, but does not focus on in-depth mining of data sets for fundamental additions to knowledge of travel behavior with regard to congestion, travel time reliability, and pricing. Also, NCHRP Synthesis 38-03, Compilation of Public Opinions on Tolls and Road Pricing is in progress. The results of this synthesis will be a resource for SHRP 2 project C04. Proposers should budget for informational meetings, conference calls, and possible attendance at special workshops that may occur during the course of the study.
>
> Special Note: Before beginning Phase III, coordinate with the SHRP 2 Senior Program Officer to determine the interim results of NCHRP 8-57, so that SHRP 2 efforts will enhance, not duplicate, work undertaken by NCHRP.

Technical Activities / Issues – per Proposed Research Plan

Operational Model System Frameworks

Phase III will describe model specifications, with recommendations for implementation at the corridor/project level and the regional planning levels. This project will not implement or calibrate new operational models, but it will describe how to integrate the developed mathematical descriptions within the broader set of models in use or being developed, and in consideration of the synergy between this work and NCHRP 08-57 project.

This phase will address the following principal model types, considered along three principal dimensions:

By demand modeling scale:

- Regional transportation demand models including the following two major types:
  - Conventional trip-based aggregate 4-step models
  - Activity/tour-based microsimulation models
- Corridor or project-level model structure

By network simulation technique:

- Conventional static assignment procedures based on a simplified deterministic route choice and link volume-delay functions.
- Dynamic traffic assignment and/or meso or micro-simulation, which provide a more realistic representation of congestion, queues, and probabilistic route choice.

By inclusion of land-use effects of changes in accessibility:

- Pure transportation models
- Integrated land-use and transportation models

All types of applied models will be covered, including advanced models and conventional ones. It has long been recognized that advanced models (in particular, activity-based) represent a more complete framework for modeling congestion and pricing. However, conventional trip-based 4-step models can also be modified to better reflect the behavioral responses to congestion, travel time reliability, and price. While effort will be made to incorporate realistic sensitivity to pricing in different types of models, advanced models provide a superior framework for pricing studies. Special attention will be given to ensuring consistency between the demand/behavior and network/simulation sides, in terms of model structure and specification, segmentation, and overall algorithm design. This includes ways to ensure VOT compatibility in mode choice and multi-class assignment procedures, through judicious combination of different travel segments by vehicle classes.

In general, the choice of model framework that an entity might use for a particular study depends on numerous objective factors, such as project scale, as well as subjective factors, such as the quality of a region's existing models and data sets. Regional or state-wide travel models tend to offer a comprehensive framework for behavioral prediction; more detailed simulations of corridor or facility-level traffic are also increasingly relied upon in practice. In addition, a new generation of simulation-based, dynamic, micro assignment tools provides attractive new platforms that bridge the gap between coarse regional models and more detailed corridor-level tools.

Regional vs. Corridor

Since most DOTs and MPOs have regional travel models in place, albeit with widely varying levels of representational detail and methodological sophistication, this will be considered as the basic framework within which to provide improved responsiveness to congestion, pricing and reliability. This framework will also be the basis against which to identify gaps in current or future ability to meet the analysis needs related to these questions, as well as a starting point towards an evolution that provides a more complete and conceptually, theoretically and methodologically sound approach to address these phenomena. Thus, possible impacts of congestion, reliability, and pricing across all choice dimensions (from short-term route choice to possible long-term land-use impacts) will be analyzed and recommendations will be made about the manner in which to incorporate them in regional models, to the extent possible.

An important level within which to conduct analyses of pricing, reliability and congestion is at the corridor level, using a *Corridor Network Simulation Model*. While not intended as a substitute to regional models, a corridor network model can be a very effective complementary tool to achieve a more detailed level of analysis. Corridor-specific models are useful for a detailed analysis of route choice level decisions under congestion, and specifically for a better representation of facility-level choices between managed lanes and general-purpose lanes, queuing, simulation of toll plazas, etc. In the current project framework, we will make a special effort to ensure that the new behavioral models developed for route choice (especially in the context of managed and free lane alternatives) as well as reliability measures will be compatible with operational corridor-level models, as these may provide the fastest route to implementation in practice.

Activity-Based vs. Conventional 4-Step

A regional model can have either a conventional (e.g., 4-step) structure or a more advanced (e.g., activity-based) behavioral structure. Each can be combined with either static (capacity-restrained) traffic assignment or more advanced (dynamic) simulation. .

Possible improvements for conventional models that will be reviewed and considered in this task for possible incorporation of the results of this research are likely to include the following:

- *Added travel and demographic segmentation*, for more flexible choice patterns and greater response heterogeneity,
- Better incorporation of *time-of-day choice and peak-spreading* in the model structure,
- Greater *consistency between the demand side* (specifically trip distribution, mode choice, and peak spreading) *and network simulation* with respect to the VOT segmentation and equilibrium feedbacks.
- Incorporation of simplified measures of *reliability and perceived highway time* in traffic assignment, mode choice and trip distribution (through mode choice logsums used in the impedance function).
- Incorporation of *accessibility measures* sensitive to congestion, reliability, and pricing in trip generation model to account for induced / suppressed demand.
- Incorporation of a *pre-route choice model (toll vs. non-toll)* as part of mode choice nested hierarchy.

Although characterized by a significantly higher degree of complexity**,** *activity/tour-based models* represent the most promising way to address highway congestion and pricing in a fully integrated fashion. Currently, there are four such models developed and applied by U.S. MPOs (for the County of San Francisco, the New York metro area, Columbus, Ohio region, and Sacramento area). Five other such models are at different stages of development (for Atlanta, Denver, the entire San Francisco Bay Area, Lake Tahoe, and the State of Ohio). The members of the team conducted development and application of most activity-based models in U.S. [*Vovsha, et al, 2005*].

In this task, we will evaluate and document standard techniques of using travel times and toll skims (with possible addition of reliability measures) as variables throughout the conventional modeling procedure.

A substantial focus of the work will, however, be on activity-based models which offer a wide range of other options relevant to road congestion and pricing. The rationale for emphasis includes:

- Tour-based structure ensures much more realistic sensitivities of mode and time-of-day choice through consideration of entire tour chains and entire individual daily patterns. And their emphasis of activities as the driving force behind observed travel choices offers a much more comprehensive considerations of transportation and pricing policy options (such as flex-time, work/leisure substitution).

- Microsimulation: Perhaps most importantly for the evolution of practice, activity-based models are being implemented via microsimulation. Microsimulation allows virtually unlimited segmentation, to better reflect heterogeneity in travelers and the multitude of choice alternatives. Such models can even incorporate situational variables (like time pressure on a person who is late for some important activity), which can be important determinants of willingness to pay. This is especially appealing if the activity-based model is integrated with the dynamic assignment / traffic micro-simulation.

There are a number of additional reasons why this seems an obvious choice over traditional 4-step models or other possible frameworks:

- It appears to be the likely *future state-of-the-practice*, with most large MPO's in the US already implemented such models, in the process of developing them, or with plans to develop them.
- The demand microsimulation framework allows very good representation of *heterogeneity of response to pricing*, with the possibility of drawing the willingness to pay for each predicted person/trip from a relevant distribution.
- The microsimulation framework is ideal for application of *non-closed choice models* with complicated parameterized disturbance terms;
- Activity-based models are the only models that currently include realistic representation of *departure time choice* in the context of activity schedule constraints.
- The best activity-based models include *behaviorally consistent integration of models* at all levels of the system, from trip-level models up through tour-level models (trip-chaining), up through activity/tour generation, and even influencing longer term decisions such as auto ownership and location of workplace.

Activity-based microsimulation framework allows for an immediate incorporation in this research project of most of the advanced behavioral models. In particular, the following model components will be specifically considered with regard to inclusion in operational models:

- Incorporation of various measures of *reliability and perceived highway time* in traffic assignment, mode choice, destination choice, as well as upper level choices.
- *Pre-route selection* (tolled or non-tolled) within the nested mode, tour, and destination choice structure.
- Improved *time-of-day choice* models for better assessment of peak-spreading associated with congestion pricing
- Incorporation of *accessibility measures* sensitive to congestion, reliability, and pricing in daily activity pattern models to account for restructure of daily patterns.
- Incorporation of choice of person *mobility attributes* in view of congestion and pricing (car ownership, transponder, transit pass, long-term parking arrangements, etc).
- Incorporation of *long-term impacts* on usual workplace and school location.

The work in this task will include developing and reporting guidance with respect to how the project results can be incorporated in three important areas:

- Land-Use Effects in Integrated Models
- Model Improvement by Incorporation of the Project Results
- Operational Proxies for Reliability

Land-Use Effects in Integrated Models

The proposed inclusion of more detailed measures such as perceived highway time, reliability, and costs would make the lower-level travel models (in particular, route choice and mode choice) more realistic. This in itself would provide a valuable contribution to all other upper-level models though mode choice logsums and accessibility measures even in the same model structure. As part of this general improvement and better portraying of congestion and pricing impacts, land use models would benefit that are based on *transportation accessibility measures that would be significantly improved*. Along with this general improvement, there are also several specific features associated with more advanced land-use models where additional levels and lines of integration are expected.

Activity-based microsimulation models are also ideally suited for integration with the newest generation of land-use simulation models, such as UrbanSIM and PECAS. In this task, we will determine what measures of travel accessibility are used as inputs to those models, and ensure that the methodology that is developed will provide compatible measures that are fully sensitive to congestion pricing.

Model Improvement by Incorporation of the Project Results

Practical guidance will be developed for the incorporation of the project results in different types of operational models. The important considerations in this regard relate to the structural details of the model, and possible enhancements if the existing model is missing an important feature. We expect that incorporating model components developed in the course of this project will require certain structural enhancements from most of the existing models (no just "plug and play"!).

A checklist of nine major modeling features relevant to the modeling of road pricing is presented in the **Table 5** below, and for each of the features its importance in the context of the project, and two extreme (minimal and most advanced) structures that can support it are shown

TABLE 1. MODEL FEATURES RELEVANT TO ROAD-PRICING (POTENTIAL TRAVELER'S RESPONSES)

Feature Important	for/if:	Minimal Most	advanced
Network route choice with reliability	Always	Static assignment	Dynamic assignment / micro-simulation
Payment type	Several toll collection technologies applied	Multi-class assignment	AB model (payment type choice)
Toll / non-toll road (pre-route) choice	Always	Static assignment or binary choice	Trip mode choice sub-nest
Car occupancy / carpool formation	HOV discounts, HOT lanes	4-step model (mode choice sub-nest)	AB model (joint travel)
Mode	Transit alternative	4-step model (trip mode)	AB model (tour & trip mode)
Time-of-day T	OD-specific or variable tolls	4-step model (peak spreading)	AB model (tour scheduling)
Trip distribution / destination choice	Large-scale projects and policies	4-step model (trip distribution)	AB model (destination choice)
Trip generation / activity pattern	Large-scale projects and policies	4-step model (trip generation)	AB model (activity pattern)
Residential choice, land use	Large-scale projects and policies / long term	Integrated LU & 4-step transportation model	Integrated LU & AB transportation model

The guidance will walk the user through the model structure components, explain what the necessary general model enhancements are, and then explain how advanced model components that specifically address congestion, reliability, and pricing could be incorporated.

Operational Proxies for Reliability

Special emphasis will be placed on the incorporation of reliability in all types of operational models, not necessarily the advanced ones. This however, requires application of certain proxies, since the direct measures of reliability might not be supported on the supply side, particularly in application. The framework of conventional static assignments and 4-step models is especially restrictive in this regard, but most MPOs and DOTs still use these types of models, and even the more advanced activity/tour-based models in practice are still based on conventional static assignments. For this reason, various operational proxies for travel time reliability will be explored – see **Table 6**. These reliability measures can be provided on the supply (network simulation) side even with simplified static assignment tools.

TABLE 2. INSTRUMENTAL PROXIES FOR TRAVEL TIME RELIABILITY

Core measure	Link attribute scaling factors*	OD-skim contraction
Volume over Capacity (V/C) ratio	Number of lanes	Average weighted by distance (mean or 50th, 60th, 70th, 80th percentile)
	Road type	
	Network location (bottleneck)	
Delay compared to free-flow condition	Number of lanes	Sum weighted by distance
	Road type	
	Network location (bottleneck)	
* Accounts for probability and impact of accidents and traffic instability		

Additionally traffic mix, and specifically percent of heavy trucks, will be explored. In general the current research will rely on the previously implemented research synthesis on travel time variability. This will provide additional instrumental proxies of reliability for operational models.

The suggested methods for indirect measurement of reliability and its inclusion in travel models will be explored and compared to the direct measures of reliability as used in the extensive research implemented in the University of California at Irvine by K. Small and D. Brownstone, as well as the NCHRP Project 7-15 that outlines measurement issues of reliability on the network/supply side).

Team Roles/Responsibilities for Work Scope

PB Americas: Management and **primary responsibility** for Task 8 technical activities and products, with technical direction and quality assurance by Co-Principal Investigator, Peter Vovsha. He is responsible for the memorandum on the incorporation of the estimated demand models in practice.

Subconsultants:

Mark Bradley: Co-Principal Investigator – supporting responsibility and substantive inputs to the development and review of task activities / memorandum

Hani Mahmassani (Northwestern University): Co-Principal Investigator – supporting responsibility and substantive inputs to the development and review of task activities / memorandum

Kara Kockelman – Provide substantive inputs to the development and review of task activities, and coordination with the Special Advisors team.

RSG, Tom Adler and Analyst – Provide partial focused review and inputs to task technical activities and products.

GeoStats – No activity.

Kenneth Small: Special Advisor – Provide partial focused review and inputs to task technical activities and products.

David Brownstone: Special Advisor – Provide partial focused review and inputs to task technical activities and products.

Frank Koppleman: Special Advisor – Provide partial focused review and inputs to task technical activities and products.

John Bowman - Provide partial focused review and inputs to task technical activities and products.

Task 9: Network Simulation (DTA and Micro)

General Task Scope of Work

As stated in the RFP: The work in this task is to review currently available dynamic assignment and microsimu1ation models, with specific attention to the level of granularity needed to simulate highway user responses to congestion, travel time reliability, and pricing. Investigate coverage limitations (network size-regional versus corridor). This task will address at least the:

- Integration of the disaggregate response models with the network loading models
- Consideration of priced route choice within the network versus definition within the demand model (as in mode choice)
- Appropriateness of available dynamic/microsimu1ation network models
- What development is needed if current offerings are insufficient

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Technical Activities / Issues – per Proposed Research Plan

Network Assignment Models, Algorithms and Simulation Tools

Previous studies addressing user heterogeneity in the context of static traffic equilibrium assignment for the evaluation of road pricing schemes can be classified into two categories. The first category is the multi-class approach, in which the entire feasible VOT range is divided into several predetermined intervals according to a discrete VOT distribution, path travel attributes (e.g. monetary cost), or some socio-economic characteristics (such as different income levels). Examples of these include the work of *Florian, 1998* and *Yang et al, 2002*. The second category, which has remained mostly in the realm of theoretical research, recognizes the VOT to be continuously distributed across the population of trips. For example, *Leurent, 1993* proposed that a cost versus time equilibrium is achieved when every trip-maker, with own VOT, chooses a path that minimizes his/her own generalized cost. The method of successive average (MSA) was adapted to solve for the cost versus time equilibrium with the consideration of elastic demand in a static assignment model. In a seminal paper, *Dial, 1997* proposed the static bi-criterion user equilibrium traffic assignment model with continuous VOT to predict path choice and associated total arc flows. This model can be reduced to a variational inequality (VI) problem and solved by existing VI algorithms, such as the generalized Frank-Wolfe algorithm. Dial's approach, based on a restricted simplified decomposition framework, assigned every trip to a path with the minimum generalized cost with respect to that trip-maker's VOT, resulting in a large, possibly infinite, number of trip classes in a simultaneous equilibrium. Whereas Leurent's cost versus time (CVT) equilibrium model considered elastic demand and only one criterion, i.e., travel time, to be flow dependent; Dial's model assumed fixed demand and allowed both criteria to be flow dependent. *Marcotte & Zhu, 1997* and *Marcotte, 1999* considered the problem of determining an equilibrium state resulting from the interaction of infinitely many classes of customers, differentiated by a continuously distributed class-specific parameter.

Only the first category (multi-class) has been used (only to a limited extent) in practice, though the continuous approach is more general and affords more flexibility in terms of behavioral modeling. The more common approach in practice is to ignore heterogeneity altogether; static (capacity-restrained) user equilibrium assignment incorporates tolls as a link attribute, strictly additive along the route. Assignment then is performed on the basis of a generalized cost (or time) which combines travel time and toll into a single scalar by multiplying the toll by a constant value of time; shortest path calculations in the assignment procedure are then based on this generalized cost instead of the original time attribute.

Any differentiation of tolls (by vehicle type, occupancy, or time of day) in current practice, using commercially available (static assignment) software, requires a multi-class assignment with a full segmentation of trip (origin-destination) tables. This frequently leads to an impractically large number of trip tables, and lack of convergence in the assignment process, especially when users are segmented by VOT. Certain ad-hoc modifications of the link performance functions may be applied to approximate distance-based, time-based, or even congestion-dependent pricing forms. However, the latter two types start pushing the boundaries of applicability of user equilibrium principles underlying the static assignment process. Static assignment models cannot accommodate other pricing forms (such as a daily user charge, entrance-exit-based charges, or discounts and exemptions). It is also well recognized that static assignment is unsuitable to model network performance for time-varying demand and to capture the effect of operational strategies that entail queuing (e.g. associated with toll collection), and that affect the variability of travel times through the network.

It is now well recognized in the transportation modeling community that evaluation of tolls and pricing schemes in congested metropolitan context requires: (1) consideration of time-variation (within day) of traffic demand and during peak-periods, which calls for a dynamic analysis of the demand and flows in the network; (2) adoption of a network-level perspective, rather than individual facility, because of the need to consider traffic distribution across paths in a network in response to prices; (3) realistic representation of congestion phenomena and queuing; (4) representation of operational aspects associated with measures that combine lane/facility access and pricing e.g. HOT lanes; and (5) consistent representation of user responses to prices in the short, medium and long terms.

The limitations of static assignment models in this regard are beyond the ability of "quick fixes" to provide reasonable tools for the evaluation of pricing schemes. Nonetheless, some guidance to practice in the near-term might be beneficial in certain regards, for example:
Formulating a standard practice for multi-class assignment to address traveler heterogeneity (e.g., vehicle type, occupancy, and VOT); and

Developing a set of best practices for network coding rules, toll-equivalent representation of volume-delay functions and treatment of toll plaza delays.

Dynamic traffic assignment techniques provide a natural approach to meet the above requirements for the evaluation of pricing schemes. In particular, simulation-based DTA methods, in which the traffic network performance is captured through the simulation of vehicular flows through the network links and junctions, provides realistic depiction of the time-varying evolution of traffic patterns, congestion, travel times and delays in all parts of the network. Furthermore, particle-based (traveler or vehicle) simulation, in which individual travelers and/or vehicles are represented and moved through the network, offers considerable flexibility to retain a disaggregate modeling approach for behavioral modeling (on the demand/activity side) all the way through the assignment process. Such micro-assignment models may actually simulate the flow of traffic at different resolutions— microscopic or mesoscopic. In the former, all driving maneuvers are modeled (lane changing, car following, etc.), a level of detail which is not warranted for operational planning and pricing applications. In the latter, individual particles are tracked and moved according to speeds consistent with macroscopic relations, subject to various queuing and processing rules reflecting the prevailing traffic controls at junctions.

Recognizing the need for mesoscopic simulation-based micro-assignment tools, FHWA released about three years ago the first such tool for use by MPO's and state agencies, DYNASMART-P, developed at the University of Maryland by a member of the team assembled for the present proposal. Recent improvements in the software have allowed application to very large networks, such as those of the Southern California Area Government (SCAG) with over 68,000 links and up to 3 million vehicles in the network at any given time, and that of the Baltimore Metropolitan Region, which includes about 50,000 links, and is in actual use by the Baltimore Metropolitan Council staff. However, the version released by FHWA is limited in terms of the pricing schemes that may be evaluated as well as in terms of allowing only a single VOT. More recently developments by Dr. Mahmassani's group at the University of Maryland have led to: (1) consideration of virtually any type of pricing scheme, including those based on real-time sensing of traffic conditions (state-dependent, both reactive and anticipatory); (2) a novel algorithm to find a bi-criterion (time, cost) dynamic traffic assignment with user heterogeneity represented by a continuously-distributed VOT; (3) explicit consideration of travel time reliability in the user response function; and (4) incorporation of higher-order choice dimensions, including mode choice and departure time choice in the response of users, which can be equilibrated as well. The latter capability was illustrated in a recent evaluation for FHWA of the impacts of integrated corridor management programs in the CHART corridor network between Washington, DC and Baltimore [*Zhou et al., 2007*].

Micro-assignment techniques, coupled with meso-level modeling of traffic interactions, allow representation of a much wider variety of vehicle and traveler types than traditional assignment. While commercially/publicly available software may not be ready for large-scale detailed micro-assignment with heterogeneous users, research and test versions suggest that this gap is rapidly being closed. However, while the algorithmic and software aspects may see significant advances, the behavioral underpinnings for capturing users' responses to pricing remain incomplete, especially regarding evolution of users' attitudes, preferences and behavior over time.

There appears to be growing acceptance of DTA tools by the practicing community, and increasingly by user agencies, notwithstanding some of the confusion that may result from the growing number of commercial offerings with competing claims and sometimes inconsistent terminology. As such, simulation-based DTA has emerged as the platform of choice for the evaluation of tolling schemes, and for delivering and translating advances in behavioral modeling into integrated tools for producing practical results and forecasts. In addition to some of the above-noted real-world applications of DYNASMART-P, several other applications are underway using a variety of DTA-like tools. For example, team members [*Kockelman et al, 2005*; and *Boyles et al, 2006*] have demonstrated the use of TransCAD's dynamic assignment approximator for the Dallas-Ft. Worth network, as compared to microscopic assignment by a (research) package called VISTA, using over 50,000 links along with tolls (and homogeneous user assumptions). This research resolved important questions involving demand profiling/smoothing and comparisons of assignment results obtained with different methods. In addition, Citilabs' new version of CUBE Voyager contains a dynamic assignment module, which will be examined under this research project. Other entries in this category include DYNAMEQ, intended as a companion to EMME-2. Furthermore, developers of traffic microsimulation software (AIMSUN, VISSIM) are adding modules for mesoscopic simulation with assignment. However, as noted previously, applicability to pricing evaluation remains limited by the inability to include a large number of user classes in a practical multiclass procedure; for this reason, the advance noted earlier in terms of bi-criterion assignment with continuous VOT distribution is especially promising.

It is difficult to point to near-term improvements for dynamic assignment without consideration of specific software and capabilities. Advances in the underlying methodology are likely to include the following:

- Incorporating endogenous pricing mechanisms whereby prices are set according to prevailing traffic conditions (this has already been demonstrated in DYNASMART-P)
- Addressing major vehicle types (auto, commercials, trucks), vehicle occupancy (single, 2, and 3+), and VOT segments that correspond to the categories defined in the demand models.
- More effective and seamless integration with "upstream" demand/activity models.

Integration of Demand Model and Network Simulation

Ways to integrate Activity-Based models and DTA through activity scheduling / rescheduling procedures will be specifically explored. An example framework for achieving individual level integration between the AB model and DTA is suggested in **Figure 7**. While conceptual schemes for inter-relating behavior and network models can be formulated, actual integration at an operational level entails considerable challenges, and judicious modeling and software decisions to enable such integration.

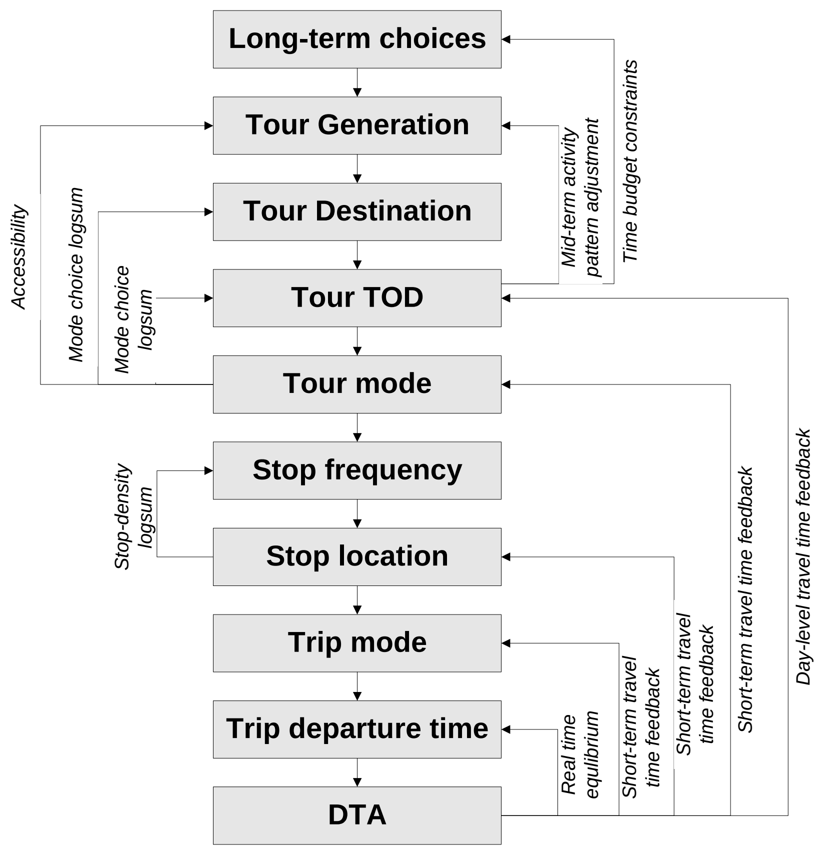


FIGURE 7. INTEGRATION OF AB AND DTA MODELS

The key notion in integrated models is to achieve compatible and mutually consistent levels of analysis detail between the demand side on one hand, and network modeling on the other. Integrated models must retain the richness carried by the individual model components, and not lose information (e.g. through aggregation) in the various transfers of information that take place within a model framework. For example, after generating an activity pattern in a tour-generation disaggregate process, assigning these outcomes in a trip-based static assignment loses much of the information provided in the behavioral model.

Integrated modeling of behavior and network performance for the evaluation of pricing schemes is best achieved by consistent and mutually compatible representation of the decision-making entities in the network. In other words, the fact that individual particles are represented in micro-assignment techniques provides a natural integrating mechanism with the demand side. Hence, particle-based, or disaggregate DTA, as reflected in models such as DYNASMART-P, is a central element in developing integrated approaches. An important mechanism provided in DYNASMART-P since its early inception, is to allow the loading of entire trip chains onto the network instead of just individual trips. This capability was illustrated for a relatively small network [*Abdelghany & Mahmassani, 2003*] in an integrated model of trip timing and activity sequencing that is solved to equilibrium consistently with a dynamic assignment of the resulting choices. For the evaluation of pricing schemes and reliability-improving measures, incorporation of short term adjustments in trip timing is a critical capability.

Heterogeneity of Users in Traffic Network Assignment and Simulation

Accounting for heterogeneity of road users at the network simulation (route choice) stage follows directly from the manner in which user heterogeneity is reflected in the general choice context. As explained previously, we account for different VOT across users either through explicit segmentation or by applying probabilistic distributions in order to eliminate significant aggregation biases associated with using the average VOT. However, because different shortest path trees must be calculated for different VOT, the computational burden of introducing VOT classes in the network assignment stage can be significant, and may effectively preclude practicality for real-size regional networks. Furthermore, a large number of classes will lead to significant and non-trivial difficulties in finding a convergent solution to the equilibration problem.

Recent advances in the algorithms for finding bi-criterion paths in large-scale networks open a way to effectively account for heterogeneity of road users in both static and dynamic assignment frameworks. This is based on the fact that for each OD pair there is always only a limited subset of so called "extreme efficient" paths in the bi-criterion space "time × cost" for the entire range of VOT. A path is considered "extreme efficient" if it is Pareto-optimal and also lying on the boundary of the convex hull of points corresponding to the time and cost skims for the Pareto-optimal paths. With a reasonable assumption regarding the VOT distribution of users, approximate route choice probabilities can be calculated in a computationally effective way even for large dynamic traffic assignment applications – see [*Mahmassani et al, 2005*].

The parametric shortest path bi-criterion parametric optimum path finding algorithm developed by Mahmassani et al (2005) forms the backbone of a simulation-based dynamic assignment procedure that has been developed and tested by [*Lu, Mahmassani and Zhou, 2006*], is the one that will serve as the foundation for the work in this task. The framework of this algorithm provides a very general solution approach to heterogeneity not only in terms of VOT, but also in terms of value of reliability (e.g. in the specification of *Small et al, 2005* for route and departure time choice. As such, *Lu and Mahmassani, 2007* have extended the framework to incorporate: (1) other choice dimensions, e.g. departure time; and (2) sensitivity to additional attributes, e.g. reliability and schedule delay (in a non-additive generalized cost structure).

The study team will test the feasibility and attempt to demonstrate that the integration of advanced behavioral model constructs, that include the key short and medium term choice dimensions of users in response to dynamic pricing, congestion and unreliability of travel time, with the network performance modeling side is within reach using the simulation-based dynamic traffic assignment platforms that have started to appear in practice. Because the bottleneck in applying the findings from behavioral models to forecasting the impact of pricing and other operational measures in actual networks lies on the network modeling side, and its ability to handle very large networks with detailed time-varying link attributes, the study team's research will be directed toward pushing the boundaries on the extent of realism that can be captured within state-of-the-art dynamic network modeling platforms.

Because of the objective to develop operational tools that could be used in practice as soon as possible, the development on the network side will consider integration within existing frameworks that have a base of application to real networks. The interest that several agencies have for evaluation of pricing and other intelligent management strategies provides an opportunity for complementing the set of tools available to these agencies through the use of simulation-based dynamic modeling techniques. These may be used either as stand-alone or in coordination with the existing model system in use at these agencies.

Team Roles/Responsibilities for Work Scope

PB Americas: Management of Task 9 technical activities and products, with technical direction and quality assurance by Co-Principal Investigator, Peter Vovsha.

Subconsultants:

Mark Bradley: Co-Principal Investigator – supporting responsibility and substantive inputs to the development / review of task activities and memorandum.

Hani Mahmassani (Northwestern University): – **Primary for Task 9** technical activities and products. He is responsible for the memorandum describing the proposed network simulation procedures, algorithms, and software platforms.

Kara Kockelman – No activity.

RSG, Tom Adler and Analyst – No activity.

GeoStats – No activity.

Kenneth Small: Special Advisor – No activity.

David Brownstone: Special Advisor – No activity.

Frank Koppleman: Special Advisor – No activity.

John Bowman - No activity.

Task 10: Draft Final Report

General Task Scope of Work

As stated in the RFP: The work in this task is to prepare a Project Draft Final Report and submit for review and approval.

Technical Activities / Issues – per Proposed Research Plan

The implementation and results of the work done in Tasks 8 and 9 will be documented in the draft of the Final Report, along with overviews of the Phase I and II two prior reports. The final report will consist of three principal components:

10.1 Model Specifications and Recommendations for Practitioners (based on Task 8) – documentation of the considerations and activities undertaken in this task to develop the model specifications and recommendations for practitioners.

10.2 Review and Specification of Advanced Network Simulation Methods (based on Task 9) effective in the analysis of the interaction of road pricing and congestion, including DTA and other network microsimulation methods.

10.3 Conclusions and Recommendations - model specifications and recommendations for incorporation of methods developed in the research that can be incorporated in practice, addressing regional and corridor planning level analysis of road pricing and congestion, and methods to extend the range possible impacts that can be estimated, from the very short-term to the long-term. This section may be seen as the main product of the SHRP 2 C04 project, and will be written in such a way that it can be separately distributed or summarized.

The report will be delivered no later than the 7th month after the start of Phase III. It will be reviewed by the project staff and panel feedback. The consultant team will meet with the SHRP 2 staff and project panel about one month after submission of the report to address comments and questions stemming from their review of the report.

Deliverables / Milestones:

- Final Report submitted within 7 months of the beginning of Phase III.
- Meeting with SHRP 2 staff about one month later.

Team Roles/Responsibilities for Work Scope

PB Americas: Management and **primary responsibility** for Task 10 technical activities and product, a draft Final Report.

Subconsultants:

Mark Bradley: Co-Principal Investigator - Provide substantive inputs to the development and review of the draft Final Project report; primary responsibility for summarizing the core demand model estimation results.

Hani Mahmassani (Northwestern University) Co-Principal Investigator - Provide substantive inputs to the development and review of the draft Final Project report; primary responsibility for summarizing the recommended network simulation models and procedures.

RSG, Tom Adler and Analyst - Provide substantive review of the draft Final Project report.

Kara Kockelman – Provide substantive review of the draft Final Project report.

GeoStats – No activity.

Kenneth Small: Special Advisor – No activity.

David Brownstone: Special Advisor – Provide partial focused review and inputs for the draft Final Project report.

Frank Koppleman: Special Advisor -Provide partial focused review and inputs for the draft Final Project report.

John Bowman - No activity.

Task 11: Final Report

General Task Scope of Work

As stated in the RFP: The work in this task is to make modifications to the Draft Final Report requested by reviewers and submit a Final Report.

Technical Activities / Issues – per Proposed Research Plan

Based on the meeting with and comments received from the project staff and panel, the consultant team will finalize the final report making modifications as requested The report will be delivered no later than with 2 months after obtaining these comments, and with the 10 months after the start of Phase III.

Deliverables / Milestones:

- Final Report submitted 2 months later, 10 months after beginning Phase III

Team Roles/Responsibilities for Work Scope

PB Americas: Management and **primary responsibility** for Task 11 product, a revised Final Report.

Subconsultants:

Mark Bradley: Co-Principal Investigator - Provide responses to the Panl Comments to the draft Final Project report.

Hani Mahmassani (Northwestern University) Co-Principal Investigator - Provide responses to the Panl Comments to the draft Final Project report.

RSG, Tom Adler and Analyst - Provide review of the final Final Project report.

Kara Kockelman – Provide review of the final Final Project report.

GeoStats – No activity.

Kenneth Small: Special Advisor – Provide review of the final Final Project report.

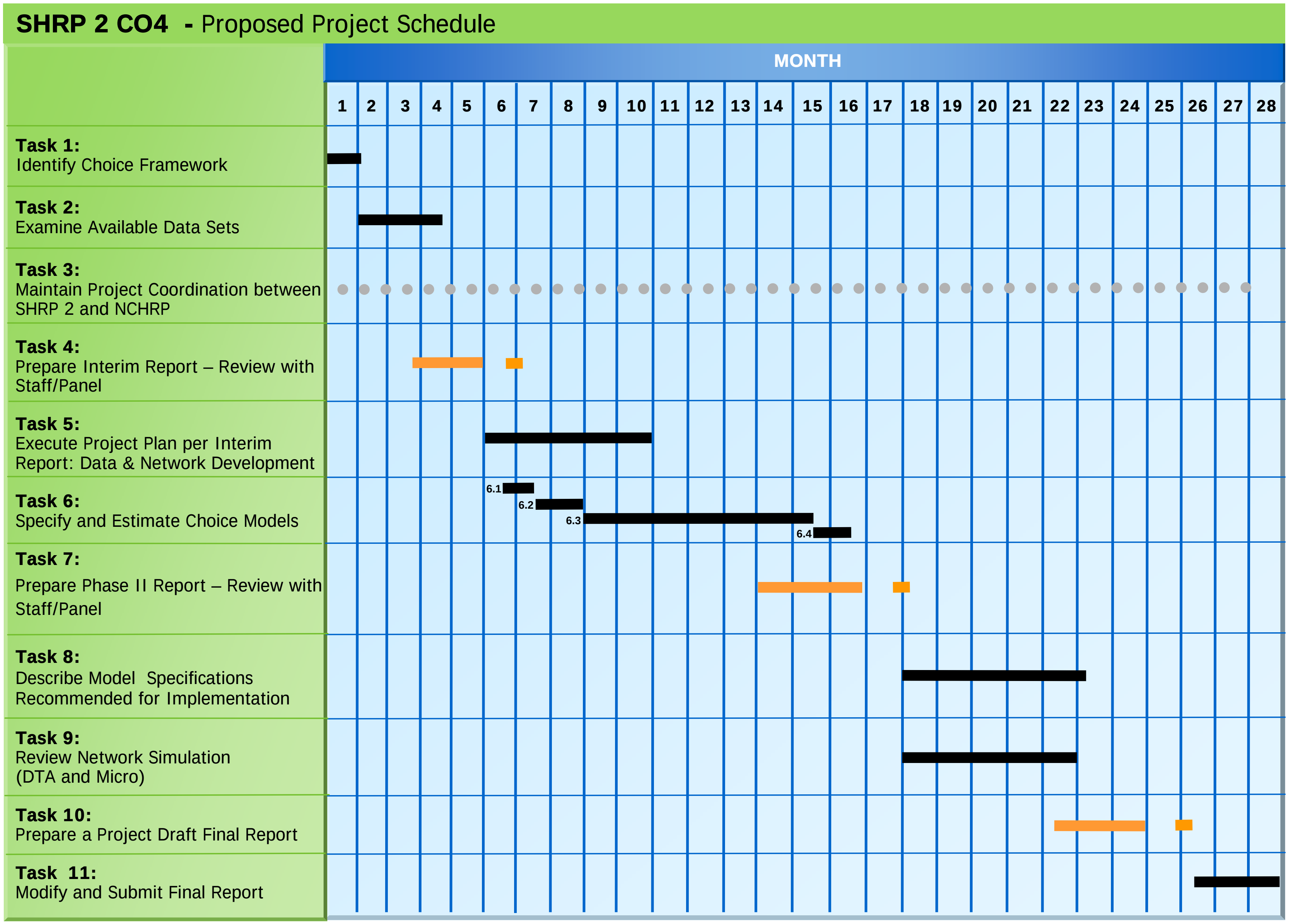
David Brownstone: Special Advisor – No activity

Frank Koppleman: Special Advisor – Provide review of the final Final Project report.

John Bowman - No activity.

3. Schedule and Work Flow Diagram

3. Schedule and Work Flow Diagram



4. Response to SHRP2 Comments on Proposal (July 10, 2007)

Parsons Brinckerhoff
Spring Park Technology Center
465 Spring Park Place
Herndon, VA 20170-5227
703-742-5700
Fax: 703-742-5800

July 10, 2007

Mr. Steve Andrle
Senior Program Officer
Transportation Research Board of the National Academy of Sciences
500 Fifth Street, NW
Washington, DC 20001

Subject: SHRP 2, Capacity Project C04,
Improving Our Understanding of How Highway Congestion and Pricing Affect Travel Demand

Dear Mr. Andrle:

We are very pleased by the selection of our proposal for this important and timely research project. The members of our team are excited about this opportunity to advance the analysis, modeling and understanding of the interactions between highway congestion and pricing with travel demand. We have come to this project with a great number of constructive ideas and clear directions for improvement of modeling tools and decision making frameworks of road pricing and view this project as a real opportunity for a significant breakthrough in travel demand modeling to support transportation planning and decision-making. We very much look forward to getting started and working on this effort with the SRHP staff and panel.

Below are responses to several issues outlined in your letter (for your convenience the original question/request is repeated in italics):

1. ***Confirm the accuracy and completeness of the information shown on the enclosed copy of the summary sheet from your proposal..***

   We can confirm the accuracy of the Summary Sheet, with the following amendments having been made:

   There is an amendment to be made to the proposing Administrative Officer. The new contact information is as follows:

   Mr. Jeffrey B. Gaber
   Vice President
   (703) 742-5837
   gaber@pbworld.com

Mr. Gaber is located in PB's office in Herndon, VA in the Washington DC area:

PB
Spring Park Technology Center
465 Spring Park Place
Herndon, VA 20170

Clarification: Mark Bradley has not obtained his PhD.

Change in Title: Robert Donnelly – to Senior Planning Manager

Contact information for Prof. Hani Mahmassani has also been updated.

Please see Attachment 1.

2. *General Comments and Recommendations*

No response required.

3. *Suggested Modification to the Research Plan (Attachment 2)*

1. The SHRP 2 Oversight Committee and Expert Task Group is concerned that your proposal does not include a DBE or plan to include one. Please indicate how you plan to address this deficiency.

PB agrees with the goal to include DBE firms in SHRP research and would like to modify our research plan and budget in this project to that end. We have identified GeoStats LP, Atlanta, GA as a subconsultant we would like to add to the team, and have begun discussion with Jean Wolf, to determine how GeoStats can participate most effectively in this project. Based on very positive prior work experiences that members of our team have had with GeoStats, and from these discussion with Jean, we are convinced that GeoStats will add substantial value to the research plan in Task 2 and 6 and are committed to making modifications to assigned responsibilities and the budget to do so, with approximately 2-3% of the total project amount redirected to GeoStats. Specific tasks to be assigned to GeoStats include:

Task 2: Examinations of Available Data Sets

- Update list of available datasets to include GPS-enhanced travel surveys and GPS-based travel time/congestion studies.

Task 6: Specify and Estimate Mathematical Descriptions of Highway User Choices

- Review / mine / analyze existing GPS data from our household travel surveys for statistics on true travel times, trip departure times, routes, and other variables of interest
- Review / mine / analyze existing GPS data from our travel time studies (and other datasets if available) for information regarding travel time variability and reliability

GeoStats is a fully certified DBE with the State of Georgia.

Please see Attachment 2.

2.. Please provide assurance that Robert Donnelly, Peter Vovsha, Mark Bradley, and Hani Mahmassani will be available for the project at all levels.

PB management understands that the success of this project depends squarely on the timely and full provision of these key individuals as proposed in our research plan. PB is committed to assigning Robert Donnelly and Dr. Peter Vovsha with PB, as well to enter agreements with the principal subconsultants – Professor Hani Mahmassani and Mark Bradley – at the level of effort and according to the schedule outlined in our proposal, with only minor adjustments required per the addition of GeoStats to the team.

3. Please describe the role that University of Maryland personnel will play in Phase 2..

Hani S. Mahmassani has been named the William A. Patterson Distinguished Chair in Transportation at Northwestern University, with a primary appointment in the Department of Civil and Environmental Engineering. By the start of this contract he will be affiliated with Northwestern's Transportation Center, an interdisciplinary research center in the McCormick School of Engineering and Applied Sciences. PB will develop and enter a direct contact with the Northwestern University, for the same scope of work, level of effort and budget presented in our proposal for Prof Mahmassani and a graduate assistant.

Please see Attachment 3.

4. Provide Assurances that if proprietary software is used to develop results or products, the use by others of such results or products will not be sensitive to or restricted by proprietary software.

It is not anticipated that this project will result in the development or upgrade of proprietary software.

5. If project funds are used to upgrade proprietary software for the purposes of conducting this research, describe how those upgrades will be made available to other users.

It is not anticipated that this project will result in the development or upgrade of proprietary software. We would only claim non-exclusive rights to data or software used or developed by the consultant as funded by this research, however, the academic members of the team would have the rights to publish findings of their research without approval. Data obtained for use in this project from third parties, such as MPO's, State DOT's, etc. would retain the rights and restrictions claimed by such third parties.

6. Please describe how you will protect key staff from the demands of other work so they can complete this project on schedule.

To ensure the availability of the PB staff proposed, we will continuously monitor the level their commitments to other projects and plan our staffing for new pursuits in a way that protects their level of effort proposed for this assignment.

7. *What other management controls and oversight systems are in place to ensure the project stays on task and within budget?*

A fully developed cost budget and schedule represents the most directly stated and clearest definition of the project manager's goal—the balanced interdependent relationship of scope, schedule and budget. The utilization of Oracle, PB's accounting system provides bi-weekly cost controlling reports to track spending against budget. This fully developed schedule and cost monitoring system will allow the project manager to track progress. It will also allow the project manager to readily determine the effect of changes on any variable in the project equation, the consequent effect on the other variables, and therefore the overall effect on the contract. If a condition has changed, the project manager can then consider whether the client should be notified.

4. *Forward a copy of your completed representations and certifications form.*

A copy of the approved completed representations and certifications form is enclosed.

Please see Attachment 4.

5. *Forward a copy of your current approved indirect cost rate agreement.*

A copy of the approved indirect cost rate is enclosed.

Please see Attachment 5.

6. *Forward a copy of your travel policy statement.*

A copy of my travel policy statement is enclosed.

Please see Attachment 6.

Thank you very much again for the selection of our team and the opportunity to work on this important research project.

Sincerely yours,

Jeffrey B. Gaber
Vice President
PB Americas, Inc.

Copy: Robert Donnelly, PB
Shannon Aguero, PB

Attachments:

(1) Summary Page – As Amended
(2) GeoStats: Accomplishments and Qualifications; DBE Certification with GDOT
(3) Announcement: Northwestern University - Hani S. Mahmassani named William A. Patterson Distinguished Chair in Transportation
(4) PB: Representations and Certifications form
(5) PB: Indirect cost rate agreement
(6) PB: Travel policy

100 YEARS

ATTACHMENT 1: Summary Page – As Amended

Summary Page

SHRP 2 Project C04

"Improving Our Understanding of How Highway Congestion and Pricing Affect Travel Demand"

Proposing Agency	PB Americas, Inc.(PB) One Penn Plaza New York, NY 10119 (212) 465-5200
Person Submitting Proposal	Robert Donnelly, Project Manager (PB) Senior Planning Manager (212) 464-5115 donnelly@pbworld.com
Proposal Written by	Robert Donnelly, Project Manager (PB) Dr. Peter Vovsha, Co-Principal Investigator (PB) Prof. Hani Mahmassani, Co-Principal Investigator Dr. Mark Bradley, Co-Principal Investigator
Proposal Date	May 3, 2007
Principal Investigator 1	Dr. Peter Vovsha Principal Consultant (212) 464-5511 vovsha@pbworld.com
Principal Investigator 2	Mark Bradley (MBRC) Consultant (805) 564-3908 mark_bradley@cox.net
Principal Investigator 3	Prof. Hani Mahmassani Professor (301) 524-3536 masmah@gmail.com
Administrative Officer	Jeff Gaber Vice President 703 742-5837 gaber@pbworld.com
Proposed Contract Period	28 months
Total Contract Amount	$1,000,000
Fixed-Fee Portion (%)	8.0 percent

100 YEARS

ATTACHMENT 2: GeoStats: Accomplishments and Qualifications: DBE Certification with GDOT

GeoStats Company Background and History

GeoStats LP, a woman-owned business[1] based in Atlanta, Georgia, is transportation consulting firm that specializes in the collection, processing, analysis, and reporting of travel/driver behavior and system performance data. GeoStats utilizes emerging technologies, such as the Global Positioning System (GPS) and Geographic Information Systems (GIS), to serve a wide range of information needs regarding transportation system users and the system's operational performance.

The company is lead by Dr. Jean Wolf, who has a Ph.D. in Civil Engineering from the Georgia Institute of Technology (Georgia Tech) and whose research specialty is GPS data collection and user interface design. (Prior to starting GeoStats, Dr. Wolf spent ten years at United Parcel Service as an industrial and system engineer, responsible for implementing many technology solutions.) Dr. William Bachman specializes in the analysis and reporting of transportation data and serves as the company Vice President. (Before joining GeoStats, Dr. Bachman worked as a Research Scientist at the GIS Center at Georgia Tech). Dr. Marcelo Oliveira specializes in the data processing and analysis and serves as Technology Architect for the company. GeoStats also employs transportation planners and engineers, software engineers, and GIS analysts.

Established in 2000, GeoStats quickly became as a leader and innovator in its field. GeoStats analyzes and evaluates traveler behavior and transportation systems using GPS-based data collection, permanent ITS monitored data, archived historical data, and transportation model forecasts. The firm has dedicated itself to the research and development of integrated software and hardware solutions that identify and quantify travel and the underlying traveler / driver behavior and system performance characteristics imbedded within GPS datasets. Operating in an ever-advancing world, GeoStats brings state-of-the-art techniques to meet real world needs in transportation operations and regional planning applications.

GeoStats services and products have been used extensively in travel behavior studies, vehicle and physical activity studies, and transportation system performance evaluations – all of which require the capability to collect and interpret second-by-second travel and traffic data. Clients of GeoStats include metropolitan planning organizations, state and federal departments of transportation and health, universities and colleges, federal armed forces, and private companies.

GeoStats Areas of Expertise:

- Household Travel Surveys – GPS Subcomponents
- GPS-based Travel Time, Speed and Delay Studies
- Mobility / Physical Activity Data Collection and Analysis
- ITS Database Design, Analysis, and Applications Development
- Data Mining for Travel Behavior and Performance Evaluation
- Transportation Planning / Travel Demand Forecasting

The next two sections provide more details for the first two areas.

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[1] GeoStats is a Georgia DOT certified DBE / WBE. GeoStats is also certified as a HUBZone small business concern.

GPS-enhanced Household Travel Surveys

GeoStats has led the implementation of GPS in household travel surveys across the United States, starting with the first use of GPS to derive adjustment weights for trips (California Statewide, 2001 - 2002). Since then, GeoStats has continued its improve the state-of-the-practice in GPS-enhanced travel surveys, with regional or statewide studies conducted in:

- Pittsburgh (2001)
- Atlanta (2001-2002)
- Laredo (2002)
- St Louis (2002)
- London (Pilot study 2002)
- Longview / Tyler (2003)
- Kansas City (2004)
- Portland (Pilot study - 2005)
- Reno (2005)
- Washington DC (2006-2008)
- Chicago (2007-2008)
- Baltimore (2007-2008)
- Oregon Continuous (2008 – 2011)

In the 13 studies conducted since 2000 (including California statewide), GeoStats has collected more than 15 million GPS data points representing more than 21,000 trips. In addition, GeoStats has mined GPS datasets collected in other long-term GPS studies; these datasets contained more than 130 million GPS points within which GeoStats identified close to 107,000 trips. Most recently, GeoStats is involved in year-long GPS-augments to regional studies being conducted in Washington DC, Chicago, and Baltimore.

GeoStats has developed its own GPS data logging equipment that is optimized for travel survey data collection at a second-by-second rate. GeoStats also continues to stay abreast of the latest GPS data logging technologies and performs technology assessments on all relevant products at least twice a year. GeoStats uses a combination of retired police officers and package courier services to get GPS equipment delivered to and picked up from study households quickly with respect to the travel dates scheduled, providing data for processing and analysis in a timely manner.

To efficiently and effectively handle large quantities of GPS data collected in these studies, GeoStats has developed TIAS (Trip Identification and Analysis System), the first software for processing GPS point data into trips and allowing direct GPS to CATI trip comparisons that result in the identification of unreported trips. This unique and proprietary system has allowed GeoStats to generate a variety of other GPS-based travel survey data augments, including geospatial datasets that can be used for time use analyses; route choice behavior analyses; travel time, speed, and delay analyses; and VMT/trip rate analyses by trip purpose.

GeoStats has also developed software that supports the use of GPS in travel surveys to replace traditional diary methods; this process known as GPS-based prompted recall was tested in Portland in 2005. This methodology could result in more accurate information with reduced respondent burden. Although it may it infeasible to implement this method as the only method for large-scale surveys due to the costs associated with the equipment and deployment of the equipment, it may highly effective when used with targeted populations or as an optional data collection mode.

Travel Time, Speed, and Delay Studies

GeoStats has been performing travel time, delay, and speed studies using GPS and GIS technologies since 2000. In fact, GeoStats is currently involved in GPS/GIS-based traffic measurement studies in four states in the Southeast. GeoStats has broad experience in the implementation of web-based GPS and GIS applications for project management, status monitoring, data handling, and results reporting.

Here are a few examples of recent work in this area:

- GeoStats designed the Atlanta Regional Commission's congestion monitoring network and collected supporting GPS probe vehicle data from 2005 through 2007.
- GeoStats has been monitoring the traffic flow of Atlanta arterials slated for signal timing improvements since 2004 as part of the Metro-Atlanta Signal Timing Project sponsored by GA DOT. More than 3000 GPS-equipped probe vehicle runs were collected, processed, analyzed and reported under his direction. Analysis of the data revealed travel time and fuel savings as a result of any implemented improvements. Additionally, data for individual intersections and road segments was processed to identify the extent, duration, and intensity of congestion.
- GeoStats provided field data collection, processing and summarization services in support of the GA SR 400 Preliminary Managed Lanes Traffic and Revenue Study, conducted by HNTB for the Georgia. As part of this study GeoStats conducted a travel time study using GPS and TravTime™ software as well as a vehicle occupancy study using GPS, digital voice recorders and TravTime™. GeoStats also performed an origin-destination survey of users of the SR 400 toll-booth plaza (both cash users as well as cruise card holders) and assisted with a stated-preference survey of residents located in the GA 400 corridor.
- GeoStats designed and developed commercial software (TravTime™) for evaluating speeds, travel times and delays as indicated by GPS probe vehicle data. The software uses HCM methods for generating LOS estimates and generates reports, maps and charts. Currently, the application is being used in approximately 25 cities throughout the US.

The following table contains a longer list of projects in which GeoStats has been tasked with collecting second-by-second GPS data and then performing analyses on network/system performance. In our most recent studies, we have been asked to collect ground truth data and then analyze traffic data provided by other third party data providers.

Client & Project	**Project Type**	**Location**	**Month / Year**	**Approximate Miles of Data**
Sirius Satellite Radio	Traffic data auditing	Los Angeles	August 2007	9000
Sirius Satellite Radio	Traffic data auditing	Washington DC	April 2007	11,000
AirSAGE	Traffic data calibration	Salt Lake City, Minneapolis, Milwaukee, Washington DC, Los Angeles	December 2006 – May 2007	~23,000
GA DOT Cellint	Traffic data auditing	Alpharetta, GA	March 2007	4000
GA DOT SR 400	Performance Evaluation	Alpharetta, GA	January 2007	1500
GA DOT Metro Atlanta Signal Timing	Signal Timing Evaluation	Atlanta	October 2004-present	12,000
Atlanta Midtown Signal Timing	Signal Timing Evaluation	Atlanta	May 2006 – May 2007	7000
Atlanta Regional Commission CMS Update 05	Performance Evaluation	Atlanta	September 2005 – May 2006	4000
Atlanta Regional Commission CMP Update 06	Performance Evaluation	Atlanta	September 2006 – May 2007	3000
CHNCGA CMS 2006	Performance Evaluation	Chattanooga	January 2006	analysis only
Atlanta Regional Commission HOV Lane Speed Study	Performance Evaluation	Atlanta	2003	1500

JEAN WOLF, PH.D.

PRESIDENT

Since starting GeoStats in 2000, Dr. Wolf has led all GPS-enhanced travel surveys and physical activity studies conducted by the firm (numbering fifteen to date). Dr. Wolf has extensive project management, technology, and logistics experience, which makes her uniquely qualified to run complex GPS studies that depend upon the integration of numerous processes and data flows to produce highly detailed and accurate GPS deliverables. Dr. Wolf is a member of the TRB Travel Survey Methods Committee, the TRB Urban Transportation Data and Information Systems Committee, and the International Association of Travel Behavior Research (IATBR), all of which serve to keep her on the leading edge of travel survey methodologies and technologies.

EDUCATION

2000: Ph.D., Transportation / Civil Engineering, Georgia Institute of Technology

1996: M.S., Transportation / Civil Engineering, Georgia Institute of Technology

1987-1989: Graduate Studies, Operations Research, University of Maryland

1985: B.S., Statistics & Computer Science, University of Central Florida

KEY QUALIFICATIONS

- 22 years of experience in logistics and technology, first at UPS (1985-1995), then at the Georgia Institute of Technology (1995-2000), and continuing at GeoStats (2000 – present)
- Member, TRB Committee on Urban Transportation Data & Information Systems, 1999-present
- Member, TRB Committee on Travel Survey Methods, 2003-present
- Member, Institute of Transportation Engineers, 1995-present
- Member, Institute of Navigation, 1999-present
- Member, ITS Georgia, 1996-present

PROJECT EXPERIENCE (SELECTED, GEOSTATS)

- Project Director (2005-2007). Metropolitan Washington Council of Governments (MWCOG) Household Travel Survey GPS Study. In the fall of 2006, GeoStats conducted an extensive GPS augment to the MWCOG household travel survey pretest, deploying GPS equipment to more than 170 households in the region. This work continues with the full study, where more than 800 households will be deployed with GPS devices for up to three vehicles in each household for their assigned travel day. These deployments will be conducted from February 2007 – January 2008 and most recent plans include extending the data collection period for one day past the assigned travel day. GeoStats provided 100 GPS data loggers for this study, and is handling the deployment, data collection, and data processing aspects of the study, including GPS to CATI trip comparisons and the generation of trip rates and VMT by trip purpose.
- Project Director (2005-2007). Chicago Metropolitan Agency for Planning (CMAP) Household Travel Survey GPS Study. GeoStats is currently deploying GPS equipment to 500 households participating in the Chicago Regional Travel Inventory, with deployments scheduled from March 2007 through January 2008. GeoStats provided 50 GPS data loggers for this study, and is handling the deployment, data collection, and data processing aspects of the study, including GPS to CATI trip comparisons and GPS-based prompted recall followups with households in which unreported trips were detected.
- Project Director (2006). United Kingdom National Travel Survey Technology Assessment (2006). GeoStats has recently been awarded a technology assessment study for the UK National Travel Survey. The research team is led by Peter Bonsall from the The Institute for Transport Studies, University of Leeds, and includes the market research firm responsible for conducting their continuous national travel survey – The National Centre for Social Research. In this research effort, GeoStats will be responsible for inventory all technologies used in travel surveys, including GPS loggers, cell phones, and internet-based surveys. The UK Department for

Transport (DfT) will use the results of this study to consider appropriate technologies for implementation in their national survey.

- Project Director (2005). Reno Household Travel Survey GPS Study. In the fall of 2005, NuStats and GeoStats were hired by Washoe County (Reno, Neveda) to conduct a household travel survey with a GPS augment. For this study, which is the most recent CATI/GPS study in the US, GeoStats provided 60 in-vehicle GeoLoggers that were deployed to 150 households over the 10-week survey period (each household had up to three household vehicles instrumented with the GPS data logger for the duration of the assigned travel day). After collecting the CATI and GPS data for each household, comparisons in reported and measured trip rates by vehicle were conducted. Follow-up interviews were conducted for all GPS measured trips that were not reported to determine the reason for not reporting as well as the trip purpose.
- Project Director (2004-2005). Continuous Survey for Monitoring Household and Travel Decisions in Oregon – GPS Pilot Study – Oregon DOT / PB Consult. This one year pilot study was intended to evaluate three different survey methods for the upcoming continuous statewide survey. These methods include traditional CATI methods only, CATI with GPS validation, and GPS only with CATI prompted recall. GeoStats is response for the GPS components of the second and third method. GeoStats implemented a GPS-based prompted recall feedback loop to Data Source's call center so that telephone interviewers could contact study participants within a few days after their assigned travel day to collect trip details based on the processed GPS data.

Recent Papers / Presentations (selected)

Wolf, J. (2006). Applications of New Technologies in Travel Surveys. Travel Survey Methods; Quality and Future Directions, Chapter 29, pp. 531-544, Elsevier, UK.

Bradley, M., J. Wolf, and S. Bricka (2005). Using GPS Data to Investigate and Adjust for Household Diary Data Non-Response. Presented at the Transportation Planning Applications Conference, Portland, Oregon, April.

Wolf, J. (2004). "Defining GPS and GPS Capabilities," in D. Hensher, K. Button, K. Haynes, and P. Stopher (editors), Handbook on Transport Geography and Spatial Systems, Elsevier (Handbook No. 5, Chapter 20).

Wolf, J., S. Schönfelder , U. Samaga, M. Oliveira and K.W. Axhausen (2004). 80 weeks of GPS-traces: Approaches to Enriching Trip Information, Transportation Research Record 1970, PP. 46-54.

Zmud, J. and J. Wolf (2003). Identifying the Correlates of Trip Misreporting: Results from the California Statewide Household Travel Survey GPS Study. Presented at International Conference on Travel Behaviour Research, Lucerne, Switzerland, August.

Steer Davies Gleave and GeoStats (2003). The Use of GPS to Improve Travel Data, Study Report. Prepared for the DTLR New Horizons Programme, London Department for Transport.

Wolf, J., M. Oliveira, and M. Thompson (2003). The Impact of Trip Underreporting on VMT and Travel Time Estimates: Preliminary Findings from the California Statewide Household Travel Survey GPS Study. Transportation Research Record No. 1854, pp. 189-198.

Wolf, J., M. Loechl, M. Thompson, and C. Arce (2003). Trip Rate Analysis in GPS-Enhanced Personal Travel Surveys. Transport Survey Quality and Innovation, Chapter 28, pp. 483-498. Elsevier, UK.

Wolf, J., R. Guensler, and W. Bachman. (2001). Elimination of the Travel Diary: An Experiment to Derive Trip Purpose from GPS Travel Data. TRR 1768, Transportation Research Board, pp.125-134.

Wolf, J. (2000), "Using GPS Data Loggers to Replace Travel Diaries in the Collection of Travel Data," Dissertation, Georgia Institute of Technology, School of Civil and Environmental Engineering, Atlanta, Georgia.

WILLIAM H. BACHMAN, PHD

VICE PRESIDENT

Dr. Bachman has twelve years of experience in transportation engineering / planning with a focus in geographic information systems (GIS), modeling, and software development. He spent five years as a research scientist at the Georgia Tech GIS Center where he lead several transportation research projects. He is now a partner at GeoStats and directs consulting and software development efforts. He is a member of the Spatial Data and Information Science TRB committee and an active member of several transportation-related professional organizations. He currently leads projects regarding GPS, GIS, ITS and transportation planning. His most recent projects are related to evaluating transportation system performance through GPS and ITS data analysis.

EDUCATION

1997: PhD., Civil and Environmental Engineering, Georgia Institute of Technology
1994: M.S., Transportation Engineering, Georgia Institute of Technology
1989: B.S., Environmental Design, University of Georgia

KEY QUALIFICATIONS

- 11 years experience in developing innovative and effective GIS, ITS, GPS solutions for the collection, analysis, and evaluation of transportation system performance
- Designed commercial software product (TravTime™) that is used for the analysis and reporting of GPS travel time and speed studies
- Taught several transportation and GIS courses at the Georgia Institute of Technology from 1997-2002 (GIS-Transportation, Advanced GIS, Transportation Planning, Highway Design, Geomatics).

PROFESSIONAL ORGANIZATIONS

- Member, TRB Committee on Spatial Data and Information Science (2005-2008)
- Board Member, ITS Georgia (2005-2007)
- Activities Director, ITS Georgia (2004-2006)
- Member, Institute of Transportation Engineers
- Member, Urban and Regional Information Systems Association

RECENT PROJECT EXPERIENCE (SELECTED)

Atlanta Congestion Monitoring Process (2005-2007)

- Collected GPS travel time data for selected corridors and integrated GPS data from other projects. Data was processed and facilities ranked based on delay and other factors. GeoStats also developed measures of reliability based on travel time variability and crash data.

CHNGA Transportation Planning Organization CMS (2005-2006)

- Processed GPS travel time data for the 2005 CMS update and evaluated the routes system and field data for suitability in supporting a regional speed study. Travel times, speeds, and delays were directly translated to the regional travel demand model network for comparison with baseline assumptions.

Metro-Atlanta Signal Timing Effectiveness Study (2005-2006)

- Directed system performance evaluations for a major signal timing effort in Atlanta. 60+ congested arterials identified in the past CMS are undergoing signal timing improvements over the next two years. GeoStats is using GPS travel time and delay runs and custom software to evaluate traffic flow impacts.

Georgia Statewide ITS Architecture GIS Support (2004-2005)

- Dr. Bachman and GeoStats participated on a consultant team that developed the statewide ITS architecture for Georgia. During this effort, the team visited several regions in the state to identify ITS elements and future ITS projects. The resulting architecture will serve as the foundation for all future ITS efforts in the state of Georgia.

GDOT NaviGAtor ITS Data Analysis (2003-2004)

- Led the analysis of all archived traffic data collected from the video-detection system on Georgia freeways. Based on this analysis, mitigation strategies that estimate highway speeds, volumes, and vehicle occupancies were defined. This project allows GDOT to generate a number of historical reports from a system that generates 30 million observations per day.

Atlanta CMS Update (2002), GIS-T Database Design.

- Dr. Bachman was responsible for the conceptual design of a GIS-CMS in this Atlanta Regional Commission project. The GIS-CMS describes how an interagency transportation information system can be integrated into a fully connected database that can be used to support CMS and other planning activities. The design joins previously disparate databases such as planning models, inventory databases, and ITS data.

GA 400 Tollway Service Area Analysis (2002)

- As part of an effort to evaluate policies for the use of excess toll revenue, Dr. Bachman used a data-driven approach to define regional transportation facilities that are used by regular tollbooth users. A variety of customer service area, accessibility, and mobility measures were generated and coordinated to form a basis for identifying locations for transportation investments. This also included the use of heavily traveled arterials by cruise card holders.

Atlanta Congestion Management System Update (2001), HOV Speed Study

- Dr. Bachman was contracted by GeoStats to conduct a speed study of the Atlanta area HOV lanes. Probe vehicles using GPS were used to evaluate average HOV speeds during morning, afternoon, and off-peak time periods. Dr. Bachman conducted all data processing and analysis tasks for this work, including matching the GPS data to the travel demand forecasting model links for use in the regional travel-demand forecasting model.

Recent Papers / Presentations (selected)

- Bachman (2006), “Operations and Congestion Vision for SDIS”, Spatial Data and Information Science Committee Workshop, TRB, Washington, DC
- Wolf and Bachman (2004). “Using GPS for GIS Data Collection”, TRB Workshop, Washington, DC
- Bachman (2003). “Transit Schedule Adherence Using Passive GPS and GIS”, AASHTO GIS-T Symposium Proceedings, Colorado Springs, CO.

MARCELO OLIVEIRA, PH.D., E.I.T.

TECHNOLOGY ARCHTECT

Dr. Marcelo Oliveira has extensive experience in GIS, GPS, and the custom integration of advanced technology for transportation. He has experience in GIS-based application development, traffic engineering, ITS development, and archived data user services. He possesses strong Transportation Engineering, GIS and DBMS skills that allow him to develop effective technology solutions for a wide range of transportation research and analysis needs.

EDUCATION

2002: Ph.D., Civil Engineering, Georgia Institute of Technology

2001: M.S., Civil Engineering, Georgia Institute of Technology

1997: M.S., Transportation Engineering, Federal University of Rio de Janeiro, Rio de Janeiro, Brazil.

1995: B.S., Civil Engineering, Federal University of Ceará, Fortaleza, Brazil

KEY QUALIFICATIONS

- 5 years of experience in designing Tablet PC and web-based user interfaces for the collection and display of transportation survey data
- 14 years of experience in developing applications (Pascal, Delphi, Perl, VB, VB.NET, C#) and analyzing data for transportation engineering, transit, traffic engineering and signal timing applications.
- 10 years of experience in developing and implementing GIS (ArcGIS, ArcView, ARC/INFO, TransCAD, Maptitude, UMN MapServer, JTS) and database (MySQL, MS Access, SQL Server 2000, PostgreSQL/PostGIS) driven transportation data reduction and visualization tools.

REGISTRATION CERTIFICATION

- 06/25/2002/EIT/GA EIT020928.

PROFESSIONAL ORGANIZATIONS

- Friend, TRB Committee on Spatial Data and Information Science (2005-2008)
- Friend, TRB Sub-committee on Archived Data User Services (ADUS)
- Friend, TRB Committee on Urban Transportation Data and Information Systems
- Member, American Society of Civil Engineers (ASCE)

RECENT PROJECT EXPERIENCE (SELECTED)

Technology Architect and Project Manager, 2005-2006. North Central Texas Council of Governments (NCTCOG) System-Wide Boarding and Alighting Study. GeoStats has conducted a system-wide boarding and alighting study using RideCount software and Palm/GPS devices. Data collection was managed remotely through a project website that allowed field manager to post data online and auditors to download raw data and post final audited version. Online data reports, charts and maps were available to the client trough dedicated project websites.

Technology Architect, 2005. Cobb Community Transit (CCT) Transit Planning Study. GeoStats has conducted a system-wide boarding and alighting study using their RideCount software and Palm/GPS devices, an onboard study and 100% bus stop inventory. Online data reports, charts and maps were available to the client trough dedicated project websites.

Technology Architect and Leading Developer, 2004-Present. TravTime™, GeoStats' Travel Time Software Tool. Dr. Oliveira was responsible for designing and being the lead developer of TravTime™. TravTime™ analyzes road network performance as measured by GPS probe vehicles, and is used for conducting GPS-based travel time, speed, and delay studies.

Leading Developer, 2004. Zurich Travel Time Study As part of an effort to evaluate regional travel times in Zurich, Switzerland, Dr. Oliveira developed analysis tools that matched thousands of GPS-based travel time runs to a digital road network. Summary performance measures were developed for each link in the network that was traversed during the data collection. The system processed almost 700 hours of second-by-second GPS data during 1700+ travel-time runs.

Project Engineer, 2003-2004. GDOT Archived Data Mitigation Strategies. All of the archived traffic data collected from the video-detection system on Georgia freeways was evaluated for accuracy and consistency. Based on this analysis, mitigation strategies that estimate highway speeds, volumes, and vehicle occupancies were defined. This project allows GDOT to generate a number of historical reports from a system that generates 30 million observations per day.

Technology Architect, 2003. Wilmington External Origin-Destination Survey – City of Wilmington. Responsible for Tablet PC survey instrument design and development including real-time geocoding capabilities using map interface, provision of two custom-programmed Tablet PCs, fielding of all roadside surveys, and data processing / database delivery.

Technology Architect, 2002-Today. TIAS, GeoStats' Trip Identification and Analysis System. As GeoStats' Technology Architect, Dr. Oliveira lead the migration of the company's GPS data processing software from prototype system developed in year one to database-driven, client-server production system that allows multiple analysts to animate GPS data, to insert / delete trip ends, and to import and match CATI trips to GPS trips. The modules in this system became the foundation of other GeoStats software applications.

Technology Architect, 2002. South Coast (CA) Air Basin Weekend/Weekday Activity Analysis, California Air Resources Board / Sonoma Technologies (2002). GeoStats deployed GPS data loggers to 70 households in the South Coast Region to collect 10 consecutive days of detailed travel data during the summer of 2002. With these data, GeoStats performed a weekend /weekday vehicle activity analysis across the regional network

Graduate Research Assistant, SWS Radar System, 1999-2002. Georgia Tech and GTRI. Conducted research on the impacts of a radar-based in-vehicle warning system on vehicular safety. As part f this effort, developed software to collect, reduce and analyze radar detector activity data. Also developed and implemented a microscopic simulation model to analyze the effects of the warning system's market penetration level on safety.

Recent Papers/Presentations (Selected)

Oliveira and Bachman (2006), Monitored Vehicles vs. Probe Vehicles for Estimating Arterial System Performance, Presented at the North America Travel Monitoring Exposition and Conference, TRB, Minneapolis, MN.

Wolf, J., Oliveira, M., Troped, P., Mathews, C., Cromley, E., Melly, S. (2006) Mode and Activity Identification Using GPS and Accelerometer Data, TRB 85th Annual Meeting Compendium of Papers CD-ROM, TRB, Washington DC.

Wolf, J., M. Oliveira, and M. Thompson (2003). The Impact of Trip Underreporting on VMT and Travel Time Estimates: Preliminary Findings from the California Statewide Household Travel Survey GPS Study. Transportation Research Record No. 1854, pp. 189-198.

Stiefer, P., Coe, D., Wolf, J., and M. Oliveira (2003). Investigating the Impact of Driving Activity on Weekends Ozone Levels Using GIS/GPS Technology. Published on CD-ROM of the Proceedings of ERISA 2003 Conference Proceedings.

Leonard II, J. D.; Oliveira, M. G. S., *Towards an Area Wide Service Measure*, Proceedings of the 4th International Symposium on Highway Capacity, Transportation Circular E-C018, Transportation Research Board, June 27-July 1, Maui, Hawaii, 2000, pp 17-25.

Department of Transportation

State of Georgia
#2 Capitol Square, S.W.
Atlanta, Georgia 30334-1002

HAROLD E. LINNENKOHL
COMMISSIONER
(404) 656-5206

DAVID E. STUDSTILL, JR., P.E.
CHIEF ENGINEER
(404) 656-5277

BUDDY GRATTON, P.E.
DEPUTY COMMISSIONER
(404) 656-5212

EARL L. MAHFUZ
TREASURER
(404) 656-5224

June 27, 2007

To Whom It May Concern:

This letter is in response to the DBE certification status of **Geostats LP**. This firm is currently still certified as a Georgia Uniform Certification Program DBE participant. Their file is currently in the process of being reviewed for their recertification. Once a firm is certified with the Georgia Department of Transportation in the DBE program, they retain their certification until such time as they are notified of decertification and consequently removed from the DBE monthly directory. You may continue to use this firm until the completion of any current projects as well as use them for any upcoming projects if you choose to do so.

If you need additional information regarding their certification status please do not hesitate to give me a call at (404) 656-5324.

Sincerely

Yolanda Colzie

Yolanda Colzie
Administrative Assistant
Georgia Department of Transportation
Equal Opportunity Division, DBE Program

ATTACHMENT 3: Announcement: Northwestern University - Hani S. Mahmassani named William A. Patterson Distinguished Chair in Transportation

Donnelly, Bob

From: Diana Marek [d-marek@northwestern.edu]

Sent: Wednesday, June 27, 2007 9:51 AM

Subject: Mahmassani named Patterson Chair Professor of Transportation

The Transportation Center at Northwestern University is pleased to announce that Prof. Hani S. Mahmassani has been named the William A. Patterson Distinguished Chair in Transportation and will be joining Northwestern University in September. Official press release follows. For additional information see: **http://www.transportation.northwestern.edu/news/2007/mahmassani-bio.html**

Hani S. Mahmassani named William A. Patterson Distinguished Chair in Transportation

Hani S. Mahmassani has been named the William A. Patterson Distinguished Chair in Transportation at Northwestern University, with a primary appointment in the Department of Civil and Environmental Engineering. He will be affiliated with Northwestern s Transportation Center, an interdisciplinary research center in the McCormick School of Engineering and Applied Sciences.

"Hani Mahmassani is recognized around the globe as a leader in transportation research," said Joseph Schofer, interim director of the Transportation Center. "Bringing him to Northwestern, with our 50-year tradition of excellence in this field and our already strong faculty, will advance our programs to another level."

Since 2002 Dr. Mahmassani was the first holder of the Charles Irish Sr. Chair in Civil and Environmental Engineering at the University of Maryland, where he was the founding director of the Maryland Transportation Initiative, a cross-disciplinary institute for transportation systems research and education. Before joining the University of Maryland, he was on the faculty at the University of Texas at Austin for 20 years, where he was most recently the A. Abou-Ayyash Centennial Professor in Transportation Engineering, professor of management science and information systems, and director of the Advanced Institute for Transportation Infrastructure Engineering and Management.

The editor-in-chief of *Transportation Science*, Mahmassani is also the associate editor of *Transportation Research C: Emerging Technologies* and of *IEEE Transactions on Intelligent Transportation Systems.*

His research areas include multimodal transportation systems analysis, planning and operations, dynamic network modeling and optimization, transit network planning and design, dynamics of user behavior and telematics, telecommunication-transportation interactions, large-scale human infrastructure systems, and real-time operation of logistics and distribution systems.

Mahmassani received his PhD from the Massachusetts Institute of Technology in transportation systems in 1982 and his MS in transportation engineering in 1978 from Purdue University. He holds a BS in civil engineering from the University of Houston.

At Northwestern Dr. Mahmassani will also have a courtesy appointment in the Department of Managerial Economics and Decision Sciences of the Kellogg School of Management, and he will be an affiliate of the Infrastructure Technology Institute.

The William A. Patterson Endowment and Chair was established in 1978 as the intellectual focal point for transportation research and education at Northwestern University. The late Frank A. Spencer, Northwestern professor and noted aviation expert, provided the leadership gift of $100,000 to help establish the chair, which was named in honor of the late William A. Patterson, a central figure in the nation s air transport industry for more than four decades. Patterson served as president and chairman of United Airlines from 1934 until his retirement in 1966. Patterson was also a life trustee of Northwestern and was instrumental in the establishment and strategic leadership of its Transportation Center. Marvin Manheim was named the first Patterson Professor in 1979 and served in that position until his death in 2000.

Diana F. Marek
Assistant Director
Transportation Center
Celebrating 50 Years of Excellence 1954-2004
Northwestern University
600 Foster St.
Evanston, Il 60208-4055
847-491-2280
d-marek@northwestern.edu
http://www.transportation.northwestern.edu/

5. Final Budget (August 3, 2007)

PB Americas Inc.
One Penn Plaza
New York, NY 10119
(212) 465-5000
Fax: (212) 465-5595

August 3, 2007

Joyce A. Tillman, Contract Manager
Office of Contracts and Grants
The National Academies
National Academy of Sciences
500 5th Street, NW
Washington, DC 20001

Subject: SHRPII C04 – Revised and Additional Pricing Information

Dear Ms. Tillman,

A revised budget is being transmitted as **Exhibit 1**, with revisions and additional information provided in response to the following points you raised in your request of July 28, 2007:

1. *The labor rates are loaded and as a result the indirect cost rate and the budgeted amount for indirect cost is not shown. Therefore I cannot verify if the indirect rate shown in your rate agreement is the rate that is used in the budget.*
    - The indirect rate used is PB's FY 2007 FAR Overhead Rate of 154.7%, applied to direct labor costs.
    - As shown in the revised budget the total amount for indirect costs is $136,960.

2. *The maximum fixed fee is 7%. Your proposal Summary Sheet shows a fixed fee of 8%. There also needs to be a line item in the budget to show the amount of fixed fee that is proposed for this contract.*
    - A fixed fee of 7% has been applied to PB direct labor and indirect costs in the revised budget
    - As shown in the revised budget the total amount for the fixed fee is $24,419.

3. *Travel and Other Expenses need to be broken down and identified.*
    - Travel expenses have been estimated on trip-by-trip basis, by individual, and location as shown in **Exhibit 2**
    - Total Travel expenses are estimated to be $33,860.
    - Other Direct Expenses are estimated to be $14,272, broken down as follows:

Printing $2,854
Copying 1,998
Mail/Delivery 4,282
Teleconference 2,283
Meeting (non-Travel) 1,570
Other 1,284
$14,272

4. *Please also indicate your willingness to fix the indirect cost rate for the period of the contract. The total funds available for this project were made known in the RFP. There will be no funding available at the end of the contract for adjustments in indirect rates.*

- We understand and accept that the terms of the contract with NAS that will require us fix the indirect cost rate, and that it will not be adjusted either upwards or downwards for the period of the contract.

In addition to addressing the points above, the budget in Exhibit 1 also reflects several other revisions to the estimated budget provided in our research plan and cost proposal:

- GeoStats, a DBE firm, has been added to the team as a subconsultant, with an estimated budget amount of $24,867.
- Adjustments to hours and budget for other members of the team were made accordingly, in Task 2 and 6 on which GeoStats will assist.
- It was determined that the incorrect direct labor rates for Bill Davidson and Rick Donnelly had been used in the proposal estimate; these have been corrected.

The total Contract Amount remains $1,000,000.

Cordially,

____
Robert M. Donnelly, Project Manager, PB

ATTACHMENTS: Exhibits 1 and 2

Copy: Steve Andrle, NAS; Jeff Gaber, TomDefeis, David Vanaman, Shannon Agurero, PB

Exhibit 1: Section 10.0 Itemized Budget - Revised 8/3/07

Part 1: Estimated Hours by Key Research Team Member

Member	Mid-Point Rates *	Estimated Hours Phase I Task 1	Task 2	Task 3	Task 4	Subtotal Phase I	Phase II Task 5	Task 6	Task 7	Subtotal Phase II	Phase III Task 8	Task 9	Task 10	Task 11	Subtotal Phase III	Total Project	% of Time Over Contract
Robert Donnelly**	216.75	12	8	8	24	52	60	48	32	140	48	16	48	24	136	328	7%
Peter Vovsha	209.51	32	28	16	32	108	220	160	80	460	140	36	80	36	292	860	18%
Bill Davidson	255.77	4	4			8	8	4		12	4		4	4	12	32	1%
Richard Donnelly	167.58				8	8	12	8	4	24		16			16	48	1%
Joel Freedman	163.71		8			8	72	32		104	48	8		4	60	172	4%
Rosella Picado	130.93		8			8	240	40	16	296	16		16		32	336	7%
Surabhi Gupta	86.61					0	180	200		380			8		8	388	8%
Subtotal: PB		**48**	**56**	**24**	**64**	**192**	**792**	**492**	**132**	**1,416**	**256**	**76**	**156**	**68**	**556**	**2,164**	
Hani Mahmassani	180.00	16	8	8	8	40	200	200	80	480	40	90	32	8	170	690	14%
Research Assistants	60.00					0	412	440	120	972	40	240		8	288	1,260	26%
Mark Bradley	190.00	12	8	8	8	36	160	500	120	780	16	8	12	8	44	860	18%
Kara Kockelman	180.00	2	8		2	12	72	60	16	148	24		8	4	36	196	4%
Tom Adler	270.00	8	8		8	24	52	24	16	92	8		8	2	18	134	3%
Analyst	90.00					0	110	48	4	162	8		4		12	174	4%
Kenneth Small	290.00	2	4			6	30	30	4	64	4			2	6	76	2%
David Brownstone	250.00	2	6			8	40	40	12	92	8		2		10	110	2%
Frank Koppleman	295.40	2	4			6	24	35	4	63	8		4	2	14	83	2%
Jean Wolf	132.89		2			2		30		30					0	32	1%
Billy Bachman	121.82		2			2		40		40							
Technical: GeoStats	70.43							200		200							
John Bowman	190.00	2	4			6	32	100	16	148	8				8	162	3%
Subtotal: Subconsultants		**46**	**54**	**16**	**26**	**142**	**1,132**	**1,747**	**392**	**3,271**	**164**	**338**	**70**	**34**	**606**	**3,777**	
Total: PB Team		**94**	**110**	**40**	**90**	**334**	**1,924**	**2,239**	**524**	**4,687**	**420**	**414**	**226**	**102**	**1,162**	**5,941**	

Part 2: Budget by Research Team (Firm or Individual)

Firm (or Individual)	Estimated Amount ($'s) Phase I Task 1	Task 2	Task 3	Task 4	Subtotal Phase I	Phase II Task 5	Task 6	Task 7	Subtotal Phase II	Phase III Task 8	Task 9	Task 10	Task 11	Subtotal Phase I	Total Project	Total with Expenses
PB	10,328	10,980	5,086	13,247	39,642	121,955	74,087	26,462	222,503	50,711	15,001	30,975	14,422	111,110	373,255	386,551
H. Mahmassani / NWU	2,880	1,440	1,440	1,440	7,200	60,720	62,400	21,600	144,720	9,600	30,600	5,760	1,920	47,880	199,800	210,086
Mark Bradley RC (w/ J. Bowman)	2,660	2,280	1,520	1,520	7,980	36,480	114,000	25,840	176,320	4,560	1,520	2,280	1,520	9,880	194,180	204,861
University of Texas, Kockelman	360	1,440	0	360	2,160	12,960	10,800	2,880	26,640	4,320	0	1,440	720	6,480	35,280	40,029
Resource Systems Group	2,160	2,160	0	2,160	6,480	23,940	10,800	4,680	39,420	2,880	0	2,520	540	5,940	51,840	53,677
Kenneth Small	580	1,160	0	0	1,740	8,700	8,700	1,160	18,560	1,160	0	0	580	1,740	22,040	24,750
David Brownstone	500	1,500	0	0	2,000	10,000	10,000	3,000	23,000	2,000	0	500	0	2,500	27,500	30,292
Frank Koppleman	591	1,182	0	0	1,772	7,090	10,339	1,182	18,610	2,363	0	1,182	591	4,136	24,518	24,886
GeoStats	0	509	0	0	509	0	22,946	0	22,946	0	0	0	0	0	23,455	24,867
Subtotal - Services	**20,059**	**22,651**	**8,046**	**18,727**	**69,483**	**281,844**	**324,072**	**86,803**	**692,720**	**77,594**	**47,121**	**44,657**	**20,293**	**189,666**	**951,869**	**1,000,000**
Travel Expenses					4,340				21,580					7,940	33,860	
Other Expenses:					1,042				10,386					2,844	14,272	
Total Amount					**$ 74,865**				**$ 724,686**					**$ 200,449**	**$ 1,000,000**	**$ 1,000,000**

** Rates are based on:*

1. Estimated project Mid-Point Direct Labor Costs (FY2006 with 4% escalation)
2. Indirect Costs: FY2007 FAR Overhead Rate of 154.7%, applied to PB Labor Costs
3. Fixed Fee: 7%, applied to PB Labor Costs plus Indirect Costs

PB:	**Direct Labor Costs**	**136,960**
	Indirect Costs	**211,877**
	Fixed Fee Amount	**24,419**
		373,255

Exhibit 2: Estimates of Travel Costs

Estimated Unit Costs

Per Diem local expenses	In DC:	In NYC
Lodging	150	200
Other	60	80

Estimated Costs per Trip - by Type

From	Project Team Member	Air+Other Travel To: DC	Air+Other Travel To: NYC	DC 1-day	DC 2-day	NYC 1-day	NYC 2-day
NY	Donnelly, Vovsha	400		430	640	n/a	n/a
NH	Adler	500	500	710	920	780	1060
CA	Bradley, Small, Blackstone	700	700	910	1120	980	1260
GA	Jean Wolf	500	500	710	920	780	1060
TX	Kara Kockelman	600	600	810	1020	880	1160
Ch	Hani Mahmassani	500	500	710	920	780	1060

Estimated Travel Expense by Individual by Phase

From	Project Team Member	# of Trips by Type DC 1-day	DC 2-day	NYC 1-day	NYC 2-day	Total Estimated Travel Expenses - **Phase I** DC 1-day	DC 2-day	NYC 1-day	NYC 2-day	
NY	Donnelly		1			0	640			640
NY	Vovsha		1			0	640			640
CA	Bradley		1			0	1,120	0	0	1,120
CA	Brownstone					0	0	0	0	0
CA	Small					0	0	0	0	0
NH	Adler					0	0	0	0	0
GA	Jean Wolf					0	0	0	0	0
TX	Kara Kockelman		1			0	1,020	0	0	1,020
Ch	Hani Mahmassani		1			0	920	0	0	920
										4,340

From	Project Team Member	# of Trips by Type DC 1-day	DC 2-day	NYC 1-day	NYC 2-day	Total Estimated Travel Expenses - **Phase 2** DC 1-day	DC 2-day	NYC 1-day	NYC 2-day	
NY	Donnelly	2	2			860	1,280			2,140
NY	Vovsha		2			860	1,280			2,140
CA	Bradley		2	1	2	0	2,240	980	2,520	5,740
CA	Brownstone				1	0	0	0	1,260	1,260
CA	Small				1	0	0	0	1,260	1,260
NH	Adler				1	0	0	0	1,060	1,060
GA	Jean Wolf				1	0	0	0	1,060	1,060
TX	Kara Kockelman		1		1	0	1,020	0	1,160	2,180
Ch	Hani Mahmassani		2	1	2	0	1,840	780	2,120	4,740
										21,580

From	Project Team Member	# of Trips by Type DC 1-day	DC 2-day	NYC 1-day	NYC 2-day	Total Estimated Travel Expenses - **Phase 3** DC 1-day	DC 2-day	NYC 1-day	NYC 2-day	
NY	Donnelly	1	1			430	640			1,070
NY	Vovsha	1	1			430	640			1,070
CA	Bradley	1	1			910	0	0	0	910
CA	Brownstone		1			0	1,120	0	0	1,120
CA	Small		1			0	1,120	0	0	1,120
NH	Adler					0	0	0	0	0
GA	Jean Wolf					0	0	0	0	0
TX	Kara Kockelman		1			0	1,020	0	0	1,020
Ch	Hani Mahmassani	1	1			710	920	0	0	1,630
										7,940

From	Project Team Member	# of Trips by Type DC 1-day	DC 2-day	NYC 1-day	NYC 2-day	Total Estimated Travel Expenses - **Total Project** DC 1-day	DC 2-day	NYC 1-day	NYC 2-day	
NY	Donnelly	3	4	0	0	1,290	2,560	0	0	3,850
NY	Vovsha	1	4	0	0	1,290	2,560	0	0	3,850
CA	Bradley	1	4	1	2	910	3,360	980	2,520	7,770
CA	Brownstone	0	1	0	1	0	1,120	0	1,260	2,380
CA	Small	0	1	0	1	0	1,120	0	1,260	2,380
NH	Adler	0	0	0	1	0	0	0	1,060	1,060
GA	Jean Wolf	0	0	0	1	0	0	0	1,060	1,060
TX	Kara Kockelman	0	3	0	1	0	3,060	0	1,160	4,220
Ch	Hani Mahmassani	1	4	1	2	710	3,680	780	2,120	7,290
										33,860

Summary by Firm	
PB	7,700
H. Mahmassani / NWU	7,290
Mark Bradley RC (w/ J. Bowman)	7,770
University of Texas, Kockelman	4,220
Resource Systems Group	1,060
Kenneth Small	2,380
David Brownstone	2,380
Frank Koppleman	0
GeoStats	1,060
	33,860