Cross Cascades Corridor Analysis Project

Technical Memorandum No. 3
Work Program to Further Develop Statewide Forecast Model

Prepared by HDR, Inc. and Hunt Analytics
for the
Washington State Department of Transportation

This technical memorandum defines a technical work program to assist the Washington State Department of Transportation (WSDOT) in kicking off a long-range program to develop a statewide transportation forecast model. This work program draws from the technical work accomplished by WSDOT's Transportation Planning Office for its Cross-Cascades Corridor Analysis Project, which resulted in the development of a sketch planning statewide travel demand forecasting tool. This forecast tool, completed in June 2001, comprises 61 transportation analysis zones, including six zones that are external to Washington State, and provides a framework for a more comprehensive method for predicting future movements between the metropolitan areas of the state than is currently in use.

The intent of this work program is to identify the tasks, processes and data elements that are critical to building toward the development of an integrated land use and transportation model based on a set of original data focused on Washington State households and commercial establishments.

This technical memorandum is organized as follows:

	Page
Background	*3*
Model Approach	*3*
Current Model Capabilities	*4*
Desired Capabilities and Functions	*4*
Partners in the Model Development Process	*6*
Usability	*7*
Overall Work Program Requirements	*7*
Management Plan/Chartering Process	*7*
Needs Analysis, Model Specifications	*8*
Develop a Work Program that Responds to Needs Analysis	*8*
Technical Reviews	*9*
Policy and Internal Reviews	*9*
New Data Collection	*9*
Existing Data	*10*
Calibration and Testing	*10*
Documentation	*11*
Training	*11*

	Page
Specific Work Program	*11*
Identify Data Requirements and Key Variables	*12*
Develop Model Specifications	*12*
New Data Collection	*12*
Existing Data	*13*
Integrating Land Use and Transportation	*14*
Develop Modal Networks	*14*
Develop Zone System	*16*
Build and Estimate Model Components	*16*
Calibration and Testing	*17*
Documentation	*17*
Training	*17*
Estimated Budget	*17*
Recommended Schedule	*20*

Background

In 2001, the WSDOT Transportation Planning Office completed the development of a sketch planning statewide travel demand forecasting tool, which they refer to as the Cross-Cascades Corridor (CCC) model. This integrated land use-transportation model is capable of producing rudimentary interregional forecasts of transportation flows along the state's transportation systems (state highways, BNSF/Amtrak intercity rail routes, intercity bus routes, and air routes) in support of analyses of alternative transportation and economic development scenarios. The CCC model, which comprises 61 transportation analysis zones, including six external zones to the rest of the U.S., Canada and other international zones, provides a more comprehensive method for predicting future movements between the metropolitan regions of the State than is currently in use, and provides information for the movements to and from these metropolitan areas, as well as to and from, and within, the smaller urban areas and rural areas of Washington State.

This model allows the Transportation Planning Office to better answer questions about the impact of economic and transportation development initiatives on usage of the state's transportation systems. It ultimately produces trip generation, distribution and assignment by mode and facility, but it also has built into its framework the ability to represent the impact on the spatial distribution and magnitude of activities (e.g., population, employment, value of goods and services, secondary economic impacts, etc.) of infrastructure investments and economic development initiatives.

The CCC model can be further refined to provide even more accurate forecasts of statewide transportation movements and economic impacts. A number of states (including Oregon, Ohio, Colorado and Michigan) have embarked on a rigorous model development process using detailed data sets about household and commercial travel, extensive development and testing of co-efficient variables, and calibration processes.

The intent of this technical memorandum is to establish a work plan for the further development of this model by the Transportation Planning Office. The goal of the work plan is to identify the technical activities necessary to build a long range forecast model containing 2,000-3,000 analysis zones based on a robust data base of economic/land use information and both household and employer survey data. As with the current model, this work plan identifies the means to produce an integrated land use and transportation model that forecasts both long range (approximately 20-year horizons) and incremental year horizons (every three years).

Model Approach

The approach taken in development of the CCC model follows the Spatial Input-Output methodology, which combines the disciplines of land use analysis, economic analysis and transportation planning processes. This method was selected after review of five alternative methodologies -- Four-Step process; Spatial Input/Output model; Trip Table approach; Microsimulation; and Linear Program model – at a one-day workshop involving technical experts and forecasters from the State's RTPOs/MPOs and from

within WSDOT. Workshop participants rejected the trip table and linear program approaches as too simplistic, and believed that the microsimulation method was inappropriate for a statewide model system. As the Spatial Input-Output approach incorporates the Four-Step process, in addition to providing additional outputs on land use and economic effects, this approach to model development was selected for the CCC project.

The method uses an input-output (I-O) structure of the economy to simulate economic transactions between different industrial or household categories. The economic transactions to and from a zone are allocated to other zones based on prices (of goods and services) and transportation costs (of different modes and/or routings). The resulting zonal interactions generate transportation activity. In future years, transportation costs vary with changes in the demand and supply of transportation, therefore the spatial allocation of economic activity also evolves over time. Thus, the model is integrated with respect to land use and transportation. Specifically, in one year the model distributes household and economic activity across zones, uses links and nodes of a transportation network to connect the zones and model the transportation system, and calculates transportation flows on the network. The resulting travel costs and disutilities influence the zonal distribution of the household and economic activity components in future years.

Current Model Capabilities

The CCC model produces forecasts of average annual daily traffic (AADT) between origins and destinations on highway, railroad and air routes, and is capable of distinguishing those trips by trip purpose and trip generator (industry group). Moreover, the model can evaluate the effect of changing land use characteristics (new business development, employment additions or subtractions, etc.) and transportation network characteristics (speeds, new links, new modes, etc.) on these modal systems.

Other basic capabilities of the CCC model include:

- Production of outputs of economic and transportation characteristics and behaviors associated with ten industry groups and four household income groups.
- Production of transportation flows associated with each user mode.
- Uses an assignment process that reflects terminal costs – i.e., parking and freight handling costs.
- Uses the IMPLAN dataset/model produced for Washington State.

Desired Capabilities and Functions

The model will address the analysis needs described by WSDOT, recognizing the opportunities and constraints that are available. That is, the design of the model will be needs driven as established at a series of technical workshops identified in the work program.

During both the model development/testing and peer review process, a number of suggestions were generated for improvement in future modeling efforts. These are presented as incremental to the basic structure of the spatial I-O approach to building a

more robust dataset with which to complete a more highly developed statewide model. Each of the suggestions listed below would represent continuation of work already begun and completed in the CCC model – i.e., the work program would build upon what's already been done, and would continue to utilize the MEPLAN software which WSDOT has purchased, and would utilize the spatial I/O structure begun the CCC model project.

The model must be capable of completing forecasts and analyses for corridor planning and development purposes as well as for evaluating the statewide system to allow for assessments of how competing corridors and modes would react to different initiatives, projects or scenarios. For example, the model should be able to adequately evaluate the impacts of certain policy scenarios including, but not limited to, evaluating effects of: different transportation funding scenarios; different rates of economic growth; investments in alternative modes or non-state owned systems; various transportation demand management strategies, etc.

The major recommendations for future model development are summarized below. In addition to these major recommendations a number of other technical suggestions resulted from comments at modeling workshops and project team experience.

1. **Improve Calibration of Existing Model.** The current version of the CCC model was "assembled" rather than calibrated. The resources and schedule available for the CCC model allowed the technical teams to complete only a limited amount of the kind of calibration that is typically accomplished in development of a statewide model. Further work in calibrating the existing model would provide robust (and reliable) forecasts for the Cross-Cascades Corridor, while building credibility with corridor MPOs and policy makers. Additionally, this calibration step will provide valuable insight regarding the spatial economy of the state and its relationship to statewide transport demand that would be useful in further model development.
2. **Incorporate Representation of Land Markets.** Introducing space (floor space and land) and the associated prices in the economy/land use element of the model will permit more accurate evaluation of industry and household location possibilities, especially around metropolitan areas. Surrogate measures of land use can be substituted as a means of avoiding extensive new data collection.
3. **Allow for Elastic Economic Relationships.** This involves allowing the technical coefficients in the input/output model to vary with prices and utility. The initial assumption in the model design was that the interrelationship between different factors was constant across the state. In calibration, it became apparent that there are important differences between areas of the state. For instance, in the Seattle area there is substantially more industrial production per capita. The assumption that employee productivity is equal across the state (constant employees/$ by factor) and that labor participation was essentially equal (constant employees/household by household category) led the model to generate an unrealistic east-to-west commuting pattern.

4. **Focused Washington Data.** The CCC model was constructed with national data on person travel. In the calibration exercise, it was found that these data are not completely appropriate for Washington State. Additional supplementary primary data collection regarding the travel of people and goods in Washington would improve the model performance and credibility. For example, more specific data on commuting trip patterns (i.e., a household O-D survey) could be used to calibrate the travel model *and* could help to establish the variability of some technical coefficients as described above. Also, an Establishment Survey, which surveys selected business about their transport activity over a representative period, would be helpful in better understanding small goods movement and service trips.
5. **Increase Spatial Resolution.** After reviewing early model runs it appears that overall intercity trip lengths on the highway system are too long. This appears to trace back to the large size of the zones used in the model. For the purposes of statewide corridor modeling, 300 to 400 zones would provide a sufficient level of accuracy, however, this development program will focus on a more highly developed model such as that used by the Michigan Department of Transportation, which uses more than 3,000 analysis zones.
6. **Expanding Model Scope.** The CCC model should be expanded to include all of Washington State at the same level of detail, and include border regions of neighboring states and provinces. The number of external zones should also be increased. A broader model would allow the assessment some trip allocations that could not be considered in the present structure of the CCC model. For instance, it is not possible to evaluate rail freight impacts of changes to the BNSF Cross-Cascade routes because the important alternative through the Columbia Gorge was not included in the CCC model.

Partners in the Model Development Process

The initial CCC model development effort was reviewed and overseen by many stakeholders with interest in travel demand forecasting within Washington State. Interested parties from MPOs/RTPOs, WSDOT Region offices, WSDOT Modal Offices, Washington State Department of Revenue, academia, and other experts, attended four technical workshops and a Peer Review Session. These workshops and sessions provided enormous benefit to the model development process, with respect to the technical questions, suggestions and comments made, and in understanding the value of the forecast model throughout WSDOT. It's essential that the outreach effort initiated in the *Cross-Cascades Corridor Analysis Project* be continued and expanded if the model development process is to meet its potential as a versatile, effective and efficient analytical tool.

Both technical experts and institutional and policy leaders are necessary partners in the model development process. Each of these audiences needs a different kind of outreach strategy. The technical experts typically prefer a series of workshops, peer reviews, and technical reports in order to feel engaged and to have opportunities to provide meaningful input. The institutional and policy leaders and officials, who need to appreciate how the

model can assist in evaluating the effects of their policies and mandates, would benefit more from chartering sessions, agency coordination meetings, briefings to Legislative leaders, the Transportation Commission, and the Executive Management team.

Usability

Another critical element in the acceptance of the statewide forecast model development process is in providing opportunities for stakeholders and others to use the model and/or to see the value of the model's capabilities as it develops. In addition to discussing the goals of the model development process and demonstrating its functionality with a wide and diverse range of audiences, it would be useful to:

- Develop a demo of the model's processes and results and place it on the WSDOT web site.
- Improve the interface between WSDOT's GIS and the model to make it more accessible to analysts working on land use and economic analysis matters.
- Ensure that the model is capable of monitoring progress in meeting WSDOT's Performance Measures, including some of those described in the *Measures, Markers and Mileposts* report distributed by Secretary MacDonald.
- Code the model to allow it to produce information that's useful for management systems and STIP investment processes.
- Work directly with economists working in other State agencies that deal with IMPLAN data and develop employment forecasts and/or are involved in economic development initiatives throughout the State.
- Enhance training opportunities for use of the model and its databases.

I. Overall Work Program Requirements

The following tasks are essential to any work program as they help set the direction of the model development process, including validation of model structure, processes and functions, and usage in transportation analysis activities within the WSDOT. In Section II of this technical memorandum, a more specific program of work tasks is provided to support the development of an appropriate statewide forecasting tool[1] that draws on available techniques as required. In this Section, tasks IB and IC below are intended to help determine what is needed at this time.

A. **Management Plan, Process Chartering**. The success of the model development process will be directly related to the ability to manage the resources available to the work program and to keep the teams engaged with analytical tasks and deliverables so that the schedule is met. The management plan must include detailed information about each of the work program activities, including

[1] It is anticipated at this time that the model will draw on what has already been done for the CCC model, including integrated treatment of land use and transportation with approximately 3,000 zones, as well as land and space markets.

resources budgeted, personnel assignments and responsibilities, required work products, scheduled progress and public meetings, and the relationship of each task to the larger product. An essential element of the management plan is the convening of a Chartering Process Meeting, which includes all of the critical leaders of the project, who together review the work program, schedule and budget, and make commitments to meet either the original work program requirements, or modifications to that work program as discussed at the Chartering Meeting.

B. Needs Analysis, Model Specifications. As with the first two workshops that were convened for the *Cross-Cascades Corridor Analysis Project* (in January and February 2001), the functionality and specifications of the model must be refined recognizing the opportunities and constraints that exist regarding staff, resources, available technical skills, schedule, and the goals of the Executive Management team. The discussion regarding functionality relates to both WSDOT's purpose in developing a forecast model, as well as the ability for different staff and/or divisions within the WSDOT to have the skill to run the model. Ideally, the definition of the model team's purpose should come from the Executive Management team at WSDOT – who would identify the range of analyses it believes are critical and would identify a champion in Executive Management to direct a team that carries out the model development project.

The discussion of the desired specifications of the model is a highly technical one (e.g., discussions about integration with MPO and neighboring jurisdiction's models, about level of detail, development and maintenance of data base, etc.), relating to the level of precision that can be attained with the model within the limitations imposed by budget, schedule, and the questions anticipated to be asked of the model development team.

WSDOT will need to convene meetings with critical stakeholders within the department, other state agencies, and with other technical stakeholders at MPOs, RTPOs, academic institutions, and other outside experts. These stakeholders should come together as a Technical Advisory Committee (TAC). The intent of this process is to review the proper data sources, discuss goals for the model, and come to conclusions about the versatility, application and other attributes and functions of the model software/database that are to be developed.

It's likely that several other workshops will be required after the model development process is initiated. These first workshops are designed to assist the core team in getting the project underway.

C. Develop a Specific Work Program for Meeting Needs Identified in Task IB. After one or more workshops to determine the model's specifications (Task IB), the planning team would develop a preliminary work program of assignments, schedule and resources to meet the desired goals of the model. Both the

Executive Management team designee and representatives of the TAC will carefully review the work program. After approval by these reviewers, the work program will commence.

D. Technical Reviews. The highly technical nature of this program requires a well-organized series of reviews of each step of the model development process. The TAC needs to have multiple opportunities to review progress at each critical milestone of the process (including scoping out the data collection activities, reviewing the quality of the data that is collected, and understanding how the data will be further evaluated and utilized in the model). The actual number of TAC meetings and the work associated with each milestone will be dependent on the requirements that emerge from the Specific Work Program.

E. Policy and Internal Process Reviews Leading to an Implementation Plan. Directing the model development process to be relevant and useful to WSDOT's internal needs can be an even more complicated process than the technical review process discussed in Section ID. That is, the department already uses a wide variety of tools to assist in its strategic planning, policy review and investment decision-making that have a proven track record – so there may be some reluctance to begin using a new set of tools until there is confidence in their accuracy and usability. Gaining credibility may require use of the model in limited ways and should include comparisons of model output with the results of other technical tools (e.g., comparing future state highway forecasts produced by HPMS with those produced by the model). It would be risky to attempt to use the model to answer extremely complex questions that have short time lines before there is wide acceptance of the model. Developing and implementing a strategy for use of the model should be under the direction of the Executive Manager overseeing the process, who needs to have a relatively detailed understanding of the model's functionality as well as the progress being made by the model development team.

F. New Data Collection. One of the primary means of expanding the capability and comprehensiveness of the CCC model is the incorporation of new data about land use and land availability, economic activities, production and consumption behavior, travel patterns, transportation options and services, transportation demands, and economic and demographic information related to users of the system. From these data, the model can better determine origin-destination patterns, sensitivities and thresholds of individuals and commercial establishments to changes in operating costs and/or new access and markets. The more significant data collection efforts will be a household diary survey and a commercial establishment survey, coupled with information provided in data that was collected for the CCC model effort and other available data sources.

It's anticipated that collecting the new data will take up to 18 months and will absorb a large percentage of the model development program's resources.

While much of this new data can be collected at any time, it's recommended that the data collection effort not commence until after direction is provided for the entire model development program during discussions in the Needs Analysis/Model Specifications tasks.

Characteristics of the new data collection activities are presented in Section IIC.

G. **Existing Data**. There is still an enormous amount of information provided in data sets collected for the CCC effort (see Table II.1) that will be evaluated and incorporated into the next stage of model development. In large part, further review and use of this data will be related to the different geographic areas that will be used in the expanded model. That is, the data collected for the CCC effort has been generalized into the 61-analysis zone format used for the CCC model; as the model grows to several thousand analysis zones, the data will need to be refined to fit the expanded zone format. In addition, similar data will need to be collected for the bordering states of Oregon and Idaho.

While this data has been assembled by Transportation Planning Office (TPO) staff and is ready to be reviewed, it is recommended that further evaluation of these data not commence until the Needs Analysis/Model Specifications tasks (see Task IB above) are completed. During the Needs Analysis task the team will identify the number of zones and begin to layout the zonal boundaries, which will form the geographic area relevant to the data reduction/analysis exercises.

A necessary set of data that has not been collected but is available to the TPO staff is in the area of land use and land availability. This information is available from local tax assessor records and supports the development of a land market and "Developer" model. It is also recommended that this data collection exercise not begin until the Needs Analysis task assist TPO staff in understanding what level of model development is desired by stakeholders.

H. **Calibration and Testing.** Initially, the calibration process compares model output with observed values for various aspects of the system, including traffic flow volumes at particular locations on state highways[2], employment and population totals by category and zone, and prices for land and/or floorspace, as appropriate. Parameters in the model are adjusted until the model produces reasonable outputs. Targets for future comparisons can be based on other forecast databases, such as Reebie Associates freight data set, the National Personal Transportation Survey, the USDOT's Commodity Flow Forecasts, and other economic and transportation forecasts. In some cases, calibration targets may be based on "reasonable outputs", such as those derived from 'goodness of fit testing', screenline data, and other variables identified in other statewide models and in FHWA databases.

[2] In the case of WSDOT calibration process, the WSDOT Travel Delay Methodology is another tool that can be used to identify existing, as well as future, traffic volume information.

I. **Documentation**. Professional practice in the development of complex exercises such as model development require careful and detailed documentation of the model's functionality, the data that drives it, the parameters and co-efficients built with those data, how the model is constructed, how the software works, the results of calibration and scenario analysis, and other stages of the development process. The documentation should be detailed enough that the model is accessible to other professionals who have not been involved in the model development effort. The context for the model development needs to also be provided in order to keep practitioners focused on the purpose of the model as defined by the Executive Management team. Ideally, the documentation should comprise the following:

- **Description of Model Documentation** - A summary description of the model components, key data sources, and assumptions should be developed after model completion. This documentation would include a detailed User's Manual.
- **Workshop Notes and Expert Reviewers Recommendations** – The comments, concerns, and suggestions of experts who participate in workshops and other venues should be documented.
- **Website** – A model overview and selected key data inputs/outputs should be made accessible to the public on the WSDOT website page for this project, to publicize the capabilities and usage of the model.

J. **Training.** Another aspect of the success of WSDOT's statewide forecast model is its accessibility to a larger number of professionals completing economic and transportation analyses for the State. That is, providing instruction in use and maintenance of the model to more staff from different divisions in WSDOT and other State agencies will lead to both higher acceptance of the model and improved model performance and applicability. A well thought out instruction document and training curriculum is an essential element of any work program.

II. Specific Work Program for Continued Model Development

The following work program describes the specific analytic activities and model production tasks that would occur under Task IC above for development of a state-of-the-art statewide forecast analysis model. That is, this section describes the activities that would occur after a work program has been established in Task ID.

Development of a state-of-the-art model will require a dedicated and well-staffed program that extends beyond a three-year time frame, particularly in completion of a comprehensive calibration and testing program, and, if desired, construction of an advanced land use/transportation model which accounts for land use constraints, and more specifically, changes in use of available square footage and new square footage.

A. **Identify Data Requirements and Obtain Data.** A well-organized scope of activities related to the collection and analysis of the required data for the model will be one of the primary results of the work program development task (Task ID). This data set will include both existing data available from various sources and new data collected in surveys done as part of the work. The surveys to be done include a household travel survey (minimum of 2,000 households); an establishment survey (minimum 2,000 establishments) that is designed to obtain information on goods movement and service provision; and if desired, land availability/square footage information.

   The scope of new data collection will be related to the desired key variables that emerge from the work program and the extent and coverage of existing data.

B. **Develop Model Specifications.** A Model Specification Plan will be developed to outline the key flows and interactions within the Spatial Input-Output model structure. Flows are categories of economic transactions, which generate trips that need to be accommodated by the transportation network. The flows used in the model will represent households of several types and a handful of industry sectors (or commodities). The Model Specification Plan will define the interactions within the model, including the nature of interactions between factors, whether these interactions are assumed fixed or price elastic in the model, exogenously generated (imports) and demanded (exports) activity, and other non-economically generated activity (e.g., retired and unemployed households). Other elements of the Model Specification Plan will include selection of the analysis "day" (e.g., weekday/weekend, season, etc.) and conversion to peak period.

C. **New Data Collection.** A relatively large effort will be required to collect new original data for an expanded and calibrated integrated land use/transportation model of 3,000 zones. The principal areas of new data are: Household travel diary information; Commercial Establishment travel diary information; and where existing data sets need to be supplemented by new surveys or other data collection instruments.

   The *Household Travel* information will be collected in a two-day travel diary kept by a minimum of 2,000 households throughout the State[3]. Included in the information collected from these diaries will be information about household size, demographics, income, and other variables. A supplemental component of this survey is a long-distance survey, which focuses on travel to destinations more than 50 miles from home. Such travel is undertaken relatively infrequently and, thus, is likely to be included in only a small number of interviews in a standard household survey. Since such travel represents a substantial component of the vehicle-miles of travel (VMT) in a statewide context, it is appropriate to target such travel in the sampling process for a portion of the survey.

[3] This is an adequate number of surveys for a 3,000 zone statewide model. Additional surveys can be conducted for additional cost.

Goods Movement information will be collected from businesses concerning the travel patterns of their employees and the manner in which goods are delivered to and from the business. Here too, 2,000 employees will be asked to complete a travel activity diary. While this may appear to be an inconvenience for businesses, experience in other states and metropolitan areas have shown a fairly willing audience of businesses that recognize the benefits to completing more accurate planning, and that these surveys play an important role in planning.

In addition, it is likely that new surveys will need to be completed to supplement existing data sources that may be incomplete for the needs of the model. Various sources of existing data will be examined, and information and observations from these will be drawn as required.

It is both practical and important to utilize data sources that have already been developed in the State's metropolitan areas for household travel and goods movement. Several side benefits can be realized from use of the data that's already been developed by others, such as using the parameters developed by the Oregon Department of Transportation (ODOT) for its *Small City Model* and calibrating that information with a simple survey of travel within four to six cities in Washington State that can be used as a surrogate for other cities of that size.

Moreover, information collected for the model development can be supplemented by information from NPTS, HPMS, permanent traffic recorder counts, and other currently available data sources.

With regard to economic characteristics, the IMPLAN data set should continue to be employed and updated as necessary. These data are highly specific to Washington State jurisdictions and are the data set used by other State agencies, thereby, providing a consistent set of data that can be utilized by others. The household and commercial establishment surveys, however, will provide an even greater level of detail about economic and travel characteristics that are essential to the comprehensiveness of the model and model function.

Management of the data collection effort is an essential component of the model development program. Moreover, the effort to review the quality and usefulness of the data that has been collected is necessary to the proper functioning of the model (e.g., the MEPLAN software will not accept certain parameters that appear to be anomalies), and is a time-consuming task. It's very possible that in this process a determination may be made that new data needs to be collected.

D. Existing Data. As described in task IF, much data was assembled for CCC model development that will need to be further refined and analyzed for an expanded statewide model. In addition, other data sources (e.g., tax assessor records, economic/demographic and transportation patterns, et al information) from Idaho

and Oregon, etc.) that will be needed for model development are available free of charge and frequently via the internet. These data will be used to establish transportation networks, analysis zones, link volumes, trip tables, economic centers, land markets and land availability, origin-destination patterns, and elasticities that will be used to construct the model and later during the calibration and testing phases of the model.

In addition, the surveys completed in section IIC (New Data Collection) may require additional data to fill information gaps that may occur; some of which may be available in existing data sources.

Refinement of these data is a time consuming process and needs to be well organized and coordinated with the model development needs as expressed in tasks IB and IC above.

These existing data sources are presented in Table II.1.

E. Integrating Land Use and Transportation. A comprehensive land use/transportation model is an ambitious effort that has been developed for some state-of-the-art statewide forecast models, but not all. The purpose of this *Land Availability Model* is to gain an understanding of the ability for the economy to expand within its own geographic constraints. This model could indicate, for example, whether new industries could expand or relocate based on an understanding of available floor space; i.e., where land use may be constrained. A detailed GIS would need to be built to accomplish this task and would require a complex data collection effort at the local level (e.g., using information collected by county and city tax assessors, zoning staff, economic development and real estate experts, and authorities governing public resource and recreational lands).

As with the Small City Model, information developed by the State of Oregon on land use availability can be used as a surrogate value for this function, but it would be highly inaccurate information and would place the credibility of the model in doubt when surrogate information was revealed to be a variable in the development of (for example) a localized analysis. In addition, relevant data from the Washington State "Buildable Lands" dataset and other appropriate state information should be reviewed in development of this model.

F. Develop Modal Networks. Modal networks will be developed for the following systems within the corridor. Attributes of a base year and no-build future year networks (in 3-year increments) will be defined. The following modal networks may cover the state with some external linkages.

- Road network (Highways of Statewide Significance)
- Rail network (Amtrak passenger and BNSF Freight)
- Intercity Passenger Bus network (Greyhound and Northwest Trailways)
- Air network (Sea-Tac, Spokane, and possibly Wenatchee, Moses Lake)

Table II.1
Existing Data Sources to be Further Utilized

For Person-Trips
- U.S. Census
- IMPLAN Washington State
- Office of Financial Management
- Office of Employment Forecasting
- Tax Assessor Records
- WSDOT Travel Delay Methodology
- Synthesized O-D table Developed by HDR
- PSRC Model et al
- Spokane Regional Transportation Council Model et al
- Thurston County Model et al
- Regional Transportation Council Model et al
- Washington State Airport Activity Statistics
- Commercial Airline timetables, services, capacity, etc.
- WSDOT Rail Office Passenger Rail service, etc.
- Amtrak Station on/off passenger data
- WSDOT Rail Office
- Intercity Bus Operators' timetables, services, etc.
- Washington State Ferries timetables, services, et al

For Freight-Trips
- Reebie Associates O-D traffic flows
- IMPLAN Washington State
- 1997 Commodity Flow Surveys – Washington State
- 1995 EWITS Truck Trip O-D
- Office of Financial Management
- Office of Employment Forecasting
- Washington State Freight Rail Plan
- Freight Railroad Track Charts and Train Volumes
- LPMS Data on Barge Movements et al
- Pipeline locations and volumes
- Washington State Airport Activities Statistics Cargoes
- Port Districts Data on Movements et al
- Business Associations

For Network Purposes
- WSDOT Travel Delay Methodology
- 1995 NPTS-Washington State trips/trip lengths
- 1995 ATS-Washington State trips and trip lengths
- PSRC Model et al
- Spokane Regional Transportation Council Model et al
- Thurston County Model et al
- Regional Transportation Council Model et al
- Intercity Bus Operators' timetables, services, etc.
- WSDOT Rail Office Passenger Rail service, etc.
- Commercial Airline timetables, services, capacity, et al
- Washington State Ferries timetables, services, et al
- Pipeline locations and volumes

For Future Years
- Office of Financial Management
- Office of Employment Forecasting
- PSRC Model et al
- Spokane Regional Transportation Council Model et al
- Thurston County Model et al
- Regional Transportation Council Model et al

For each of these networks, various attributes will be collected and defined, such as distances, speeds, travel times, capacities, service frequencies, and location of intermodal terminals. Cost functions will be generated to reflect travel costs or transport rates for each mode. The network data will be collected and processed for model use. Data sources and processing/cost function assumptions will be documented.

G. Develop Zone System. The State of Washington and relevant external areas will be broken down into 3,000 zones. Outside of Washington's metropolitan areas, most zones will consist of small township level zones, and at even finer levels to account for geographic areas where relatively significant economic activity occurs and where significant transportation systems and routes meet, as appropriate. These zones will be designed to facilitate transfer with other models within the corridor.

In Washington's metropolitan areas (Puget Sound, Spokane and Clark County), the zonal system will be constructed to allow for optimal interaction with those areas' metropolitan area forecast models. Part of the needs analysis and model design process will guide the team in determining the model's zonal system requirements, however, in our experience, a model containing about 3,000 zones is about right for the entire state.

Some external zones will represent trip originations or destinations from other US regions, as well as Canada and Pacific Rim countries. Zone attributes will be collected for each zone, including population by income group and employment by sector, and processed for model use. Data sources and processing assumptions will be documented.

H. Build and Estimate Model Components. WSDOT's MEPLAN software will be used to model economic-motivated travel under the Spatial Input/Output approach. This model will allow transferability to other corridors and expansion to statewide model coverage. For the modal networks to extend into other corridors, complete network flows will be developed for the statewide network.

The following key model components will need to be developed:

- Assignment and Route Choice Functions
- Mode Split Functions
- Land Market Model
- Trade Trip Conversion Model (converts economic flows to transport flows)
- Exogenous Travel Demand ("through" trips)

A significant amount of data will be collected for use directly by the model and/or to assist in selection of various model parameters. The primary data is the

Input/Output table and associated Make and Use Tables for the State of Washington. Import/export and through trip data (exogenous demands) will also be necessary to complete the economic picture. As discussed earlier, because of the scope of this effort, some model equations and coefficients may be borrowed from relevant existing models used in other states/regions, such as mode-specific utility functions, parameters, coefficient sensitivities, and nesting structure.

Other data will assist in selecting the appropriate model parameters to match base year economic and transport outputs. Economic data to be collected includes zonal population/employment, import/exports, and other work/vehicle data (e.g., vehicle occupancies, load factors, weight limits, daily labor attrition). Transportation data includes passenger and freight demands (e.g., O-D), mode split, and observed network use (e.g., volumes, ridership, tonnage, average trip lengths) by mode and route segment. Similar data will be collected for "through" trips with modeling assumptions made about the economic and transport behavior of these trips. Documentation will be made of all key data sources and assumptions used in developing these model components.

I. **Develop and Assess Full Model Interactions (Calibration and Testing).** This task will combine the various model components developed in the previous Task IIF. Assessing the validity of the model outputs will require fine-tuning of the parameters chosen for the individual model components developed initially.

This effort includes development and assessment of the following:

- Establish consistent interaction for Base Year
- Develop incremental models (3-year steps)

The combined model output will be assessed against existing economic and transport forecasts for both base year and incremental future years. This data includes zonal population/employment, state-level import/exports, and state/US economic growth indicators (e.g., GNP). National information will be particularly helpful in estimating "through" trips.

J. **Documentation.** As defined in the Work Program (Task ID).

K. **Training.** As defined in the Work Program (Task ID).

III. Estimated Budget

The budget required to complete the model development program is obviously dependent on the actual work program that is advanced in Task ID, however, an estimated budget is provided here based on the consultant team's experience in other states. This estimate is provided for information only and should be distributed and used with caution before the team completing the model development effort completes a negotiated budget.

As shown in Table III.1, the model development process including distribution, collection and analysis of 2,000 household travel surveys, commercial establishment surveys, model development, calibration, training and documentation, is estimated to cost just under $4.4 million over a three-year period.

Table III.1, Estimated Budget

	WSDOT	Consultants	Direct Costs	TOTAL
Project Management	$55,500	$262,800	$29,000	$347,300
Needs Analysis	$5,500	$121,000	$33,000	$159,500
Work Program	$650	$20,000	$1,000	$21,650
Policy Reviews	$7,300	$125,300	$42,500	$175,100
Tech. Reviews	$11,000	$188,000	$64,000	$263,000
New Data Collection	$1,750	$184,400	$1,510,000	$1,696,150
Existing Data	$2,700	$166,000	$108,500	$277,200
Model Networks	$15,250	$124,000	$6,000	$145,250
Zonal System	$350	$16,600	$800	$17,750
Set Up I/O Model	$1,650	$94,000	$4,700	$100,350
Model Calibration	$4,500	$826,000	$41,250	$871,750
Documentation	$3,250	$141,600	$7,000	$144,850
Training	$6,100	$127,300	$6,250	$139,650
TOTAL	**$115,500**	**$2,397,000**	**$1,847,000**	**$4,359,500**

Notes:

- WSDOT staff time includes an estimated 1,944 hours of a Sr. Engineer's time and 1,016 hours of a Jr. Engineer's time over a period of three years using rates provided by WSDOT.
- Consultant staff time includes an estimated 7,672 hours of a Sr. Consultant's time, 7,184 hours of a Jr. Consultant's time, and 592 hours for Other Consultant's time.
- Direct costs include fees paid to vendors for completion of household and commercial establishment surveys ($1,510,000), data purchase ($108,000), and travel, correspondence, computer, mapping, and other costs ($234,000).

Reductions in cost may be available from use of data produced by other states – including Oregon -- that are developing this type of forecasting model, and from materials produced by other Washington State agencies and organizations, and from private vendors such as Reebie Associates, Inc.

The State of Oregon has been developing a state-of-the art statewide model since 1994. While it's difficult to isolate the costs of the model development program from the other activities performed by the Transportation and Policy Analysis Unit, those other activities are very similar to the activities performed by staff within WSDOT's Transportation Planning Office. For example, in addition to their work on the Oregon Model Improvement Program, the current seven staff members:

- Complete the department's analysis, development and maintenance of the State's Congestion Management System and HERS (Highway Economic Requirements System);

- Conduct modeling for small Oregon jurisdictions;
- Participate in regional and large-scale transportation and land use studies and initiatives; and
- Complete air quality conformity and analysis for non-attainment areas.

In addition, the Unit supports the further development of the Portland Metro forecast model ($100K to $200K/year), and uses consultant and outside experts to complete research, model estimation and application, and as an on-call resource for technical, policy and public meetings.

In total, ODOT's Transportation Analysis Unit has been budgeted between $750,000 and $1.2 million annually since 1994. This budget has covered all surveys, staff salaries, direct expenses, administrative activities, grants to Portland Metro, and consultants.

The costs generated by the model development programs in Michigan and Ohio have been similar to Oregon's, and those states have also committed teams of five to ten staff dedicated to development, management and use of their statewide models.

IV. Recommended Schedule (assumes start date of 1/1/02)

As with the estimated budget, the schedule needed to complete the model development program is related to the work program that is advanced in Task ID, and the needs of WSDOT's Executive Management team. A recommended schedule (shown in Table IV.1) is provided below to provide an appreciation of the sequence of steps and the time necessary to complete this first generation model development effort. This schedule is limited to the first three years of model development, and thus, initiates the model calibration process, which will require a minimum of three years to review, refine and test model parameters, et al.

In general, the model design and needs analysis process typically takes about six months to complete, and this activity should always lead the development process. The next steps are to conduct the household surveys and goods movement surveys, which take about one year to develop and distribute the survey instruments, and to organize data that is retrieved from those surveys. These two surveys can be conducted simultaneously. (In addition, for optimal results, the surveys need to be conducted during restricted periods of the year – e.g., fall season.)

While the surveys are being performed, the model development team can be developing the transportation networks and the analysis zone boundaries in the model. Once the survey information is reduced and ready for input to the model, the model development process can start in earnest.

Finally, the calibration process requires approximately 12 to 18 months to complete properly.

This three-year model development process can be divided into two stages: 1) needs assessment and data collection, and 2) model development and calibration.

It should be noted that this schedule does not address the development of a *Land Availability Model*, which is considered part of the second-generation model development effort that should be completed only after this two-year program and the calibration process.

Table IV.1, Recommended Schedule

	Year 2002		Year 2003		Year 2004	
	1st and 2nd Quarter	3rd and 4th Quarter	1st and 2nd Quarter	3rd and 4th Quarter	1st and 2nd Quarter	3rd and 4th Quarter
Project Management						
Needs Analysis						
Work Program						
Policy Reviews						
Technical Reviews						
New Data Collection						
Existing Data						
Model Networks						
Zonal System						
Set Up I/O Model						
Calibration and Testing						
Documentation						
Training						