The Oregon Modeling Improvement Program: An Overview

prepared by
Oregon Department of Transportation
Transportation Planning Analysis Unit
MW Consulting
PB Consult, Inc.

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List of Abbreviations and Symbols

ATF	Alternative Transportation Futures study by WVLF
CAAA	Clean Air Act as Amended
CTPP	Census Transportation Planning Package
DLCD	Oregon Department of Land Conservation & Development
DEQ	Oregon Department of Environmental Quality
GIS	Geographic Information System
FHWA	Federal Highway Administration
IMPLAN	System of software and data sets for policy analysis
I-O Model	Input-Output Model
ISTEA	Intermodal Surface Transportation Efficiency Act
LANL	Los Alamos National Laboratory
LCOG	Lane Council of Governments
MWVCOG	Mid-Willamette Valley Council of Governments
MPO	Metropolitan Planning Organization
ODOT	Oregon Department of Transportation
OEA	Oregon Office of Economic Analysis
OECD	Oregon Department of Economic & Community Development
OHCS	Oregon Department of Housing & Community Services
OMIP	Oregon Modeling Improvement Program
OMSC	Oregon Modeling Steering Committee
OTP	Oregon Transportation Plan
SIP	Strategic Implementation Plan
PUMS	Public Use Microdata Sample
RTC	Southwest Washington Regional Transportation Council
RVCOG	Rogue Valley Council of Governments
TCSP	Transportation and Community System Preservation USDOT grant program
TDM	Transportation Demand Management
TLUMIP	Transportation and Land Use Model Integration Program
TOD	Transit-oriented development
TPR	Oregon Transportation Planning Rule
TRANSIMS	TRANSportation SIMulationS - a new model framework by USDOT
TRANUS	Modeling package for land use and transportation policies
TSP	Transportation System Plan
UrbanSim	Urban land use-transportation model
USDOT	U.S. Department of Transportation
WVLF	Willamette Valley Livability Forum

OREGON MODELING IMPROVEMENT PROGRAM
STRATEGIC ELEMENTS

- **RESOURCES**
  - Funding
  - Qualified Staff
  - Equipment
- **OUTREACH**
  - Oregon Modeling Steering Committee
  - Peer Review Panel
  - Statewide Modeling User Group
  - Training & Education
  - Information Sharing
  - Communication
  - Formal Education
- **DEVELOPMENT**
  - Research
  - Joint Model Development
  - Rural Joint Model Estimation
  - Urban Joint Model Estimation
  - Model Enhancements
  - Documentaion Enhancement
  - Transportation & Land Use Model Integration Program
- **IMPLEMENTATION**
  - Standards
  - Protocols
  - Case Studies
- **DATA**
  - Household Activity & Travel Survey
  - Recreation/Tourism Activity Survey
  - Oregon Travel Behavior Survey
  - Longitudinal Panel Survey
  - Commodity Flow Data Collection
  - Freight Shipper & Carrier Survey
  - Truck Generation & Distribution Survey
  - Truck Intercept Survey
  - Geographical Information System

EXECUTIVE SUMMARY

BACKGROUND

State highway departments historically responded to the broad public view that roads are key to a mobile, accessible and prosperous America. Beginning in the 1970s, several mandates dealing with how projects are selected and designed resulted from public concerns about the environmental and social impacts of road construction. Generally, they require an open public process, agency coordination, and alternative solutions. The mandates prescribe the process of considering how transportation infrastructure investments are decided and designed, and specified measures to ensure compliance and coordination.

To address these mandates, changing how to think about providing transportation services is important. Recognizing that land use, economic and transportation decisions and investments are related and interdependent is a big step towards addressing the intent of the mandates. The historic mathematical models used by engineers and planners are inadequate to analyze and predict the multi-dimensional environment that is now being considered. New methods that analyze travel behavior, location preferences, market forces, infrastructure, and policies are needed since past decisions were made without sophisticated modeling tools.

The Oregon Department of Transportation (ODOT) embarked upon a comprehensive Oregon Modeling Improvement Program (OMIP) in 1994. OMIP was developed to consider how to meet the new rules and regulations. It includes three primary areas of focus. First, it is important to bring together all stakeholders and to provide forums for information exchange and development of new ideas. Second, new and expanded modeling tools are required to provide information for efficient and effective-decision making. These tools need to address the number and type of interactions involved to allow analysis of complex relationships of land use, transportation and economics. And last, education and training on the need for and application of these tools is an ongoing program.

The Oregon program developed with a five-track approach that is intended to make the modeling program useful and accessible to decision-makers, stakeholders, and practitioners. The five OMIP tracks include:

- Resources
- Outreach
- Development
- Implementation
- Data

RESOURCES

Establishing and maintaining adequate funding is critical to the overall success of the program. This track is intended to ensure the availability of adequate staffing and resources to implement OMIP and to provide the necessary modeling activities to customers at the federal, state, metropolitan planning organization (MPO), and local levels. A large part of the OMIP program is to maximize resources across agency lines. This is accomplished in several ways, including sharing staff, joint contracting and partnership agreements. OMIP is also working to create career ladders within the agencies for modelers and to bring about comparable pay between agencies. Creating an attractive environment for recruiting and retaining employees is one of the most important functions of the OMIP program.

OUTREACH

The key to the success of the Oregon program comes from the collaboration and cooperation among everyone involved in program development and application. Several cooperative forums meet regularly to provide direction and discussion on OMIP.

The Oregon Modeling Steering Committee (OMSC) is a consortium of federal, state, and local agencies that provides oversight to the Oregon program. The OMSC regularly provides peer review for a variety of models and model applications. A statewide Modeling Users Group meets regularly to exchange information, solve problems, and provide training. This group includes technical staff from local jurisdictions and state agencies, consultants, and others involved in the day-to-day application of the tools. An internationally prominent Peer Review Panel meets regularly to review progress on the Transportation and Land Use Model Integration Program (TLUMIP) and to recommend improvements or modifications.

To provide overall coordination for the OMIP, the five-year *Strategic Implementation Plan (SIP)* incorporates work programs of all OMSC members. This plan is a living document and is updated annually. The SIP provides program direction for annual coordination of the Oregon MPOs and ODOT to coordinate modeling efforts for their respective Unified Planning Work Programs. In fiscal year 2003, ODOT and Metro will undertake a pilot joint partnership work program to enhance working relationships, to facilitate providing modeling services to customers, and for resource leveling between agencies.

Training and outreach are important OMSC activities to develop and implement the OMIP. Training stresses the multi-dimensional nature and connections between land use, transportation, economics and the environment when developing community solutions to transportation issues. Thinking in an integrated manner using integrated tools requires a new level of technical and policy competency. Outreach is important to share program information and to engage decision-makers and staff to define needs and opportunities. Future coordination with academia is needed to provide the necessary skills to fully implement the OMIP initiatives and to assist the evolution of simulation and modeling into public policy analysis.

DEVELOPMENT

Developing interactive and integrated technical tools includes research, model development and documentation.

The OMSC annually identifies research projects that benefit the OMIP and OMSC member agencies and jurisdictions. Projects to develop policy performance measures and for freight surveys were funded through joint programs. ODOT is currently funding research at the University of Texas to develop a framework to incorporate travel demand, location choice, and transport supply decisions into the models in a way that is both accurate and comprehensive.

The two primary modeling levels in Oregon are at the local and statewide levels. At the local level, ODOT or the MPOs provide modeling for their area while ODOT provides modeling for non-MPO areas. OMIP addresses the need for improved and integrated models at all levels throughout Oregon and several model improvements have been developed.

The Joint Urban Model Estimation is an estimated travel demand model using combined data for all Oregon MPOs, which has been calibrated and is available for use in the MPO areas. Similarly, a Joint Rural Model Estimation for the non-MPO areas in Oregon uses data from eight rural counties to do estimation and calibration. Local social and demographic data is used in the joint estimate model structures for both urban and rural areas to create local validated models. This method has proven to be very cost effective while providing more robust models for all areas, including Metro.

An OMSC subcommittee evaluated over 100 urban design variables for use in Oregon models to define statistically significant variable(s) to model urban design influences on transportation choices. This work is continuing as a research project into 2003. An OMSC subcommittee is also developing a standard documentation process for air quality conformity analysis.

TLUMIP is a significant component of the OMIP. In 1996, TLUMIP began developing and refining interactive statewide and urban transportation and land use models for use in planning and policy analyses at varying scales of geography. The first generation urban model, UrbanSim, was designed to operate in tandem with the urban travel models already in use in Oregon. Since developing the urban and statewide geography levels of models overstressed resources, the UrbanSim program was set aside so the team could concentrate on the statewide effort. The second generation model is incorporating information from UrbanSim while other refinements, outside of TLUMIP, continue through the University of Washington.

The first generation statewide model is complete and is being used to examine a variety of transportation and land use policy actions, investments and their interactions through time. The integrated model structure ensures that effects are consistently reflected in both the activity and destination choice models. The statewide model program implements using an established integrated land use-transportation modeling framework, and runs programs in a linked fashion to simulate changes in activities and travel distribution over time. It uses the TRANUS modeling package with some functions being carried out in Excel spreadsheets and R.

The statewide model has two primary elements, a location model and a transportation model. The location model allocates growth among zones and simultaneously determines the amount of trade occurring between zones by economic sector. The transportation model converts the trade flows into trips, apportions them among modes, and assigns them to the road and transit networks.

TRANSIMS is a model framework being developed by the USDOT to support a new transportation-modeling paradigm in response to policy issues in ISTEA. It is a multi-year program intended to depict travel demand response to transportation infrastructure changes and travel demand management actions (such as road pricing or fuel price changes) to accurately evaluate air quality impacts of proposed actions. The Portland metropolitan area was selected for demonstration of trip-planning capabilities of TRANSIMS. Metro is working with the Los Alamos National Laboratory to provide data for creating and testing the new modular tools, to evaluate software, and to apply TRANSIMS to two region projects for comparative evaluation.

IMPLEMENTATION

The Oregon modeling efforts have succeeded because of the cooperative and collaborative efforts of policy-makers and technical staff in Oregon and with developers from around the world. The OMSC provides a unique forum for intergovernmental discussion and debate on federal, state and local issues. Training and education programs cross agency and jurisdictional boundaries and further integrate staff understanding and awareness of land use, economic and transportation interactions. As the modeling program progresses, the OMSC is well positioned as the technical clearinghouse for modeling issues and applications.

Modeling practices at the MPO and local levels continue to be upgraded and standardized throughout the state. Several documents guide model development and application in Oregon, including:

- Travel Demand Model Development and Applications Guidelines
- Strategic Plan for Development of new Modeling Tools
- Modeling Protocol
- Model Documentation Guidelines

The UrbanSim prototype model was applied to a case study in Eugene-Springfield, Oregon. The case study was designed to test the model for performance (longitudinal calibration) and to assess how it works over time. The plan was to conduct a simulation from 1980 through 1994. The results of the case study provide useful insights into the behavior of the model over the historical period of the calibration. The simulated 1994 values of key variables of population and employment achieved fairly high correlation and goodness-of-fit measures. On the other hand, the results showed considerably lower ability of the model to reproduce the observed changes from 1980 to 1994. The corresponding correlation and goodness-of-fit measures were quite low. Considerable sensitivity testing of the model was carried out to learn more about the behavior of the model. Simulated annealing techniques (smoothing results to compensate for variability in raw data) were used to search for coefficient and parameter values capable of matching the calibration targets.

The first generation of the statewide model was applied in several case studies. The Willamette Valley Livability Forum (WVLF) facilitated and coordinated a long-range look at the future of land use and transportation in Oregon's Willamette Valley. Eight scenarios were modeled for the economic, land use and transportation effects of alternative land use and transportation policies. It is clear that different policy choices will have different impacts for the future and that combinations of policies will provide the most significant change. The statewide model was also used to evaluate the effectiveness of three alternative alignments to meet study objectives of a 1999 Oregon Legislature request to look at designating a north-south freeway in Central or Eastern Oregon, from the Washington to California borders. Overall, the project did not meet the objectives of transferring growth from the Willamette Valley to Central or Eastern Oregon.

DATA

Improved data collection and analysis methods are needed to provide coordinated, complete and reliable date for the improved models. A household activity and travel survey was conducted in 1994 by ODOT and the five Oregon/SW Washington MPOs. This resulted in a rich database of activity and travel information for almost 12,000 households. In 1997, ODOT sponsored a recreational/tourism activity survey to address information gaps in recreational/tourism travel and to provide a better picture of recreational travel behavior within the state. Additional data was collected in 2000 for an eight-county area in Oregon to support small-scale regional transportation models being built outside the MPOs.

New data collection methods for behavioral and demographic information are being considered, specifically a longitudinal panel survey. A panel of survey and modeling experts convened in May 2002 to help determine the best method of updating data for the Oregon models. This panel will help set direction for Oregon in establishing new methods of collecting time series data for continued improvements to model development.

Several research and data collection projects are actively trying to better assess ways to support freight movement within and through the Oregon economy. These include commodity flow data collection, freight shipper and carrier survey, truck intercept survey, and a truck generation and distribution survey

THE FUTURE OF OMIP

An aggressive outreach and communications program, combined with a broad education and training effort, will bring the tools and processes of the OMIP to decision-makers and practitioners throughout Oregon.

During the summer of 2002, a third symposium will be held in Portland, Oregon to further disseminate the most current advances in integrated modeling. In the fall of 2002, Oregon will host a workshop to evaluate the status of integrated modeling at the different levels of geography to set the direction for the next OMIP efforts.

OMIP is also exploring opportunities for European and North American collaborative efforts. In addition, OMIP is seeking to develop ties to universities with the intent to develop a multi-disciplined advanced degree program in transportation planning or simulation and modeling.

The OMIP has been very successful since its inception. The key to the entire program has been that everything is done in a non-mandatory and cooperative environment. Because of the level of coordination and cooperation that has been developed, Oregon has made remarkable strides in all areas of modeling in a very short time period. The cooperative nature of the OMSC is the foundation that will continue to support future growth of OMIP.

INTRODUCTION

This report provides an overview of the Oregon Modeling Improvement Program (OMIP). It incorporates sections of the document *Transportation and Land Use Model Integration Program: Overview of the First Generation Models* prepared for the Federal Highway Administration in August 2002.

Originally travel demand modeling was performed within the Highway Division of the Oregon Department of Transportation (ODOT). The principal effort was geared toward forecasting demand and testing highway project impacts relative to average daily travel patterns of automobiles. This standard practice is referred to as the Quick Response methodology, or "Black Box" approach. Travel modeling continued this way through the Surface Transportation Act era and the building of the national highway infrastructure.

In the early 1990s, the federal government was interested in integrating land use, transportation, economics and environmental issues. The Federal Intermodal Surface Transportation Efficiency Act (ISTEA) and the 1990 Clean Air Act Amendments (CAAA) were enacted to encourage local and state agencies to do a better job of integrating land use and transportation decisions. The level of analysis and type of information requested from modeling changed nationally in response to these acts. Oregon responded to ISTEA and the CAAA with the adoption of policy documents and regulations, including the Oregon Transportation Plan, Transportation Planning Rule and the Oregon Clean Air Conformity Rule. The demand on modeling results no longer focused on building roadways, but rather on analysis and discussion of the total system, linking land use and transportation.

Methods to analyze the complex ways in which travel behavior, location preferences, market forces, infrastructure and policies interact have become important to inform policy-makers and to maximize private and public investments. Through regulation, public policies affect land prices and the distribution of uses. Infrastructure investments likewise drive private investment and business location decisions. The ability to simulate land use and travel behavior and to correlate the economic impacts are important for better growth management and more efficient, cost-effective investment in the transportation system.

Like other states, Oregon faces two issues for public policy decision-making for transportation investments. First is the issue of how to evolve the thought process of decision-makers and practitioners into a holistic, multi-dimensional manner integrating transportation investments, community values, economic opportunities and livability. Second, modeling practitioners recognize that the standard practices and modeling tools of the past decades are no longer adequate to support an interactive problem solving approach.

Average daily automobile models based on national averages are no longer adequate tools to address these policy issues. Peak hour mode choice models, based on local trip behavior integrated with land use, is the new standard. Consistency in model development is needed and it was clear that no one agency can develop a comprehensive program on its own. The key to

Oregon's success is development of a program that involved and maximized resources across public agency, jurisdictional and private business lines.

OREGON MODELING IMPROVEMENT PROGRAM

ODOT embarked upon a comprehensive Oregon Modeling Improvement Program (OMIP) in 1994. OMIP was developed to consider how to meet the new rules and regulations. It includes three primary areas of focus. First, it is important to bring together all stakeholders and to provide forums for information exchange and development of new ideas. Second, new and expanded modeling tools are required to provide information for efficient and effective decision making. These tools need to address the number and type of interactions involved to allow analysis of complex relationships of land use, transportation and economics. And last, education and training on the need for and application of these tools is an ongoing program.

OMIP developed with a five-track approach that is intended to make the modeling program useful and accessible to decision-makers, stakeholders, and practitioners. The five OMIP tracks include:

- Resources
- Outreach
- Development
- Implementation
- Data

This report documents the work completed to date in the OMIP under each of the five tracks. Each track is equally important to the overall success of the Oregon program.

RESOURCES

Each metropolitan planning organization (MPO) and ODOT provides transportation modeling services to local jurisdictions and other clients to meet federal requirements and for planning and project development. ODOT has the responsibility to provide technical assistance to jurisdictions not included in an MPO. It is also charged with coordinating statewide transportation programs to ensure consistency and compatibility of model development and application. Each MPO has the responsibility for providing this technical capability to its constituent jurisdictions. Agreements are frequent between ODOT and individual MPOs and among the MPOs (especially Metro) to supplement staff or to provide specialized assistance as necessary. All of these programs are coordinated independently with the Federal Highway Administration (FHWA). The relationships among ODOT, the MPOs, and FHWA, especially through the OMSC umbrella, is excellent and many joint and cooperative programs are undertaken as a result of these relationships. Discussions are beginning on how other state agencies can make better use of the statewide modeling tools, again through the OMSC umbrella

Closer coordination among jurisdictions, MPOs, ODOT and other state agencies is also dictated by the expansion of areas of interest. Traditional modeling boundaries are no longer appropriate. Areas of influence have broadened outside of MPO boundaries and many projects cover a broader area than the MPO boundary, including commuter and high speed rail and urban growth boundary analyses. Statewide and Metro modeling efforts are starting to merge and overlap requiring greater coordination at the boundary interface.

Opportunities for improving the state of modeling in Oregon and maximizing resources are becoming evident. These include:

- Better data collection mechanisms to limit duplication of efforts.
- Compatible and coordinated model development throughout the state.
- Streamlining the current and probable future trend of MPOs contracting to ODOT for modeling assistance.
- More comprehensive and complete answers that cover broader jurisdictional areas.
- Better consistency of data collection and maintenance and model development and application.
- Integrated effort to help gain grants or other funding.
- Broader technical and talent base available to all jurisdictions and agencies.
- Larger, more diverse staff attracts more qualified people.
- Senior and specialized experience is spread among modeling groups and encourages staff synergy.
- Better integration of land use and transportation issues statewide.
- More efficient and broader based problem solving.

Greater cooperation and resource efficiencies will result in cost-effectiveness and more integrated programs throughout Oregon. As closer cooperation and coordination occurs through the OMSC and among modeling partners, several items have also been identified that must be addressed:

- Local control of modeling is important and must be maintained, both in actuality and perception.
- Different agency and jurisdiction missions and priorities can conflict.
- With management and technical turnover in agencies and local jurisdictions, the potential exists for instability in management understanding and support for a complex, multi-year program.

Despite the cooperation among agencies and jurisdictions, resources continue to be a major concern for implementation of OMIP. ODOT and Metro closely coordinate their activities and, through different management structures, work to apply staff and funding resources as efficiently and effectively as they can to address their separate work programs and to support other MPOs as needed. ODOT provides additional support to other MPOs through annual agreements. However, work loads and staffing in the MPOs and ODOT are often subject to changing local priorities. For example, the focus by ODOT on maintenance and preservation of the existing highway system is greatly reducing the monies available for corridor and other system planning. This directly affects the amount of money available to the ODOT modeling program and MPOs and makes it difficult to manage a long-term program and maintain qualified staff. Budgets are routinely affected by non-modeling issues, such as funding shifts, unforeseen special projects, projects delayed to address environmental issues. With fewer large planning projects (environmental impact statements, corridor planning) base loads for several MPOs are changing, affecting the core modeling group.

Resources will continue to be a major focus of OMIP to ensure that adequate technical resources are available for implementation.

OUTREACH

The key to the success of the Oregon program comes from the collaboration and cooperation among everyone involved in program development and application. Several cooperative forums meet regularly to provide direction and discussion on OMIP.

THE OREGON MODELING STEERING COMMITTEE

The success of the Oregon modeling program is attributable to an uncommon level of collaboration and cooperation. The OMSC directs travel modeling in Oregon. This consortium is comprised of representatives of local, state, and federal agencies and all MPOs. Membership includes the key state agencies responsible for land use, transportation, economic and environmental policy development and implementation. Two new MPOs are being formed in the Corvallis and Bend areas and will be included as members on the OMSC. The Vancouver, Washington MPO is a member of the OMSC because of the mutual issues between Vancouver and Portland for community development.

Membership in the OMSC includes:

- Federal Highway Administration (FHWA)
- Governor's Office of Community Development (CDO)
- Oregon Department of Transportation (ODOT)
- Oregon Department of Land Conservation and Development (DL CD)
- Oregon Department of Housing and Community Services (OHCS
- Oregon Department of Economic and Community Development (OECDC)
- Oregon Department of Environmental Quality (DEQ)
- Oregon Department of Administrative Services-Office of Economic Analysis (OEA)
- Portland Metro (Metro)
- Mid-Willamette Valley Council of Governments (MWVCOG)
- Lane Council of Governments (LCOG)
- Rogue Valley Council of Governments (RVCOG)
- Southwest Washington Regional Transportation Council (RTC)

The MPOs have been key partners in the program since its inception. In addition to their participation in the OMSC, some have played an active role in the TLUMIP work. LCOG in Eugene hosted the application and testing of the first generation urban area model. Metro, the MPO for the Portland region, contributed substantial experience and results from its pioneering work in activity-based travel modeling. Metro and ODOT also work closely with the Port of Portland on freight planning issues, and they coordinate their efforts with parallel work in the Metro and Statewide freight models. Further collaboration will be evident as the 2000 Census becomes available, with the goal of creating traffic analysis zone systems in the statewide model that are compatible with those in the urban areas.

Among OMSC state agency members, opportunities to develop joint projects and integrate agency programs are identified regularly. OEA and the OMSC are discussing opportunities to use the statewide model for countywide population and employment projections. The statewide model is designed to do statewide forecasting, including forecasting for transportation investment. ODOT and OEA are continuing discussion on how the statewide model can be used for comprehensive planning and to define how local and state agencies can work together to use it effectively. The OHCD and DLCD have cooperatively developed a housing model for use in evaluating housing opportunities and needs in Oregon communities. Joint data collection efforts are being discussed among all OMSC members.

PEER REVIEW PANEL

An internationally prominent Peer Review Panel maintains a key role in the TLUMIP program. This panel meets regularly to review progress on the models and to recommend improvements and modifications. Their invaluable contributions shape the TLUMIP work program and heavily influenced the design of the second-generation models. Members of the peer review panel include:

- Julie Dunbar, Dunbar Transportation Consulting, Bloomington, IL
- Kim Fisher, Transportation Research Board, Washington, DC
- Robert Gorman, Federal Highway Administration, Washington, DC
- Frank Koppelman, Northwestern University, Evanston, IL
- Keith Lawton, Metro, Portland, OR
- Gordon Shunk, Texas Transportation Institute, Arlington, TX
- David Simmonds, David Simmonds, Cambridge, England
- Michael Wegener, University of Dortmund, Dortmund, Germany

STATEWIDE MODELING USER GROUP

A statewide users group includes technical staff from local and state agencies and jurisdictions, consultants, and others involved in the day-to-day application of these modeling tools. Participation on the users group is open to everyone in private business or public agencies to encourage understanding, cooperation, and technical excellence. This group of practitioners from throughout Oregon meets regularly to exchange knowledge and information, solve problems, and provide training.

TRAINING AND EDUCATION

Training and education are important activities of the OMSC in the development and implementation of the OMIP. Training stresses a different way of thinking about and solving community and transportation issues, considering the multi-dimensional nature and interconnectedness of land use, transportation, economics, and the environment.

It was recognized in 1994 that Oregon MPOs, counties, and individual cities would require technical assistance and guidance in developing and applying travel demand models to the wide spectrum of their planning and design study needs. Several training programs were developed to impart the necessary modeling skills. Early training focused on the theoretical underpinnings of integrated land use-transportation modeling, while more recent sessions focus on software implementation and data requirements. Education and training on the OMIP program helps staff from diverse agencies and jurisdictions better understand the integrated nature of their programs, and the importance of considering the broader range of impacts in analysis and decision-making. On-going training on modeling and modeling applications is provided as credit curriculum and to agencies as cooperative efforts with state universities.

The *OMIP Training Program* was prepared in 2001-02 to more completely define training and education necessary to fully implement the Oregon modeling program. It includes recommendations for training in model development, model application, model data, and modeling education and recommends a schedule for implementation. This document will be used as a strategic guideline for training activities by the OMSC.

Training and education efforts are planned for policy and decision-makers on the new approach to community and infrastructure development. Presentations and discussions are planned with the agency Directors represented on the OMSC as well as local government education through project application.

INFORMATION SHARING

ODOT's website (http://www.odot.state.or.us/tddtpau/modeling.html) provides outreach and information on OMSC meetings, key contacts throughout the state, research methodologies and findings, and related studies and reports. Technical reports on model development and research are also regularly posted on this website.

ODOT sponsored two Symposiums on Integrated Land Use-Transportation Modeling in 1998 and 2000 that emphasized OMIP and the TLUMIP work and related international research and development. Both Portland conferences drew worldwide attendance, and a third symposium is planned for Portland in July 2002. It will focus on implementation and model application as well as research and development. The 2005 Transportation Research Board Planning Methods Conference is planned for Portland and will be coordinated and sponsored by the OMSC.

COMMUNICATION

A multi-year *Outreach and Communications Strategy* will share results of the modeling program and increase awareness of modeling tools and their capabilities. This strategy addresses two user groups: those within Oregon who will use the models for planning and project development, and those outside Oregon who can benefit from the Oregon program's research and documentation. This program is especially important now that significant development of models is complete. To make OMIP more than a technical exercise, new ways of thinking and problem solving must become the way business is conducted in Oregon. This will be a major effort of the OMIP program over the next several years.

FORMAL EDUCATION

The TLUMIP work is expanding beyond the theoretical and practical limitations of current transportation planning practices. The innovative program attempts to create consistent and connected models of land use, transportation, the economy, and the environment. The second generation TLUMIP models are based upon stochastic simulations of travel and land use in Oregon. The transportation components of the second-generation model are based upon cutting edge research into activity-based travel modeling, as well as unique extensions to freight modeling. The software implementation for such models has been built from scratch, and employs a cluster of microcomputers to address the problem.

The TLUMIP work has drawn from numerous disciplines not normally encountered in travel demand forecasting. The unique skills are required for almost any scientific or engineering pursuit. Recent advances and techniques from other large scale simulations in meteorology, operations research, natural resources modeling, and logistics are integral parts of the current work. The project team has expanded its skill set and exposure to parallel works in related disciplines, in effect creating a new niche within the larger realm of simulation and modeling.

Much of this same theoretical and practical knowledge is needed to maintain and use the TLUMIP models. Their successful implementation requires an expanded academic foundation. Users of the TLUMIP models will clearly require a diverse skill set and capabilities not presently developed in the transportation planning profession. As a logical next step, the Oregon modeling program will investigate creative academic programs for opportunities to provide the necessary skills to engineers and planners to fully implement the OMIP initiatives and continue the simulation and modeling in public policy analysis evolution.

DEVELOPMENT

The integrated statewide transportation modeling concept was introduced in 1995. It is intended to have all Oregon cities, counties, MPOs and state agencies working together, using state-of-the art transportation modeling tools. This ranges from sophisticated statewide and local models to representative rural community models. Through the OMSC partnership, the analytical integrity and data consistency of model development and analysis is maintained at all levels

RESEARCH

Continuing research is important to expand the Oregon program. The OMSC annually identifies research projects that benefit the OMIP and OMSC member agencies and jurisdictions. Over the past three years, applications were submitted for funding under the Federal Transportation and Community and System Preservation (TCSP) program and the State Planning and Research (SPR) program. The cooperative OMSC efforts resulted in the following projects being funded:

- *Performance Measurements:* Difficulties have been identified with how different state policy documents use performance measures. For example, all MPOs have used alternatives to the Transportation Planning Rule (TPR) vehicle miles traveled requirements. Several state documents provide policy direction, such as maintaining the state's economic viability, but reliable and consistent performance measures dealing with policies are generally unavailable. Decision-makers need better performance measures to improve public policy and investments. This research incorporates and builds upon recent studies in land use and transportation system multi-modal accessibility measures, economic system sensitivity changes in accessibility, the interactions among land use, transport, and ecological systems, and environmental justice. The research will identify and test transportation plan performance measures that could potentially augment or replace the current TPR requirements. Specific plan performance measures to evaluate Oregon Transportation System Plans (TSPs) and other policy documents will be recommended.
- *Freight survey:* More detailed information on freight movement in Oregon is critical for development of the next phase of the statewide model to reflect actual use of the transportation system for this critical economic component. This effort intends to obtain information about the quantity and type of goods handled, where goods are going regionally, how they are being carried, and what are the key business factors considered in making shipment decisions. This research will build on the Metro/Port of Portland commodity flow study and expand that regional information base to cover the entire state, so data can be used in the statewide model and all local/MPO models.

ODOT is funding research at the University of Texas at Austin titled *Towards Behaviorally Consistent Integrated Transport/Land Use Models In Support of Infrastructure Systems Decisions.* The goal of this research is significant behavioral and statistical improvements in integrated transportation/land use modeling methods. The proposed framework will incorporate travel demand, location choice, and transport supply decisions in a way that is both accurate and comprehensive. This model will serve as a tool for transportation engineers and planners who depend on transportation models to coordinate the efficient use of scarce resources, and will be a resource for students to understand advanced modeling in the context of actual human behavior.

JOINT MODEL DEVELOPMENT

Most communities in Oregon are required to adopt a TSP to ensure that transportation facility plans adequately support planned land uses. Local and regional TSPs must coordinate and be consistent with state transportation plans. Most of Oregon is outside an MPO and many local jurisdictions cannot afford to build models to analyze their infrastructure needs and opportunities.

Modeling in Oregon occurs primarily at two levels - at the local and statewide levels. Locally, most MPOs provide modeling for their member jurisdictions and ODOT provides modeling for non-MPO areas and MPO areas that require assistance. OMIP addresses the overall, statewide need for improved and integrated models.

Using the combined data from the MPO *1994/1995 Travel Activity Survey*, ODOT and the MPOs jointly estimated a travel demand model for all areas within Oregon. This joint estimation brings best modeling practices to all areas of the state. It saves development cost and effort by eliminating duplication of efforts. Because the model structures are all consistent, peer review efforts are simplified. The joint model estimation project was validated in 2001 and is now available for use.

RURAL JOINT MODEL ESTIMATION

The Rural Joint Model Estimation was done for non-MPO areas in Oregon. It uses local data from eight rural counties to do estimation and calibration. This process is broadly applied to replace individual city models in rural areas. It provides an effective and more efficient method of modeling with greater sensitivity for smaller jurisdictions. Several prototype rural models were estimated to cost-effectively provide modeling tools for areas outside MPOs.

URBAN JOINT MODEL ESTIMATION

The Urban Joint Model Estimation incorporates the unique characteristics of each MPO into data sets that others can use. Localized data reflects how Oregonians respond in Oregon situations – Eugene/Springfield for bicycle/pedestrian data, Salem for government data, Portland for high-density urban area data. This effort combines the best of all models into a model more robust than any single existing model.

This model includes destination-choice considerations, e.g., certain income levels are more likely to go to job A than job B. Bringing in mode choice allows pricing considerations. Various income levels value time differently, so this can be considered in road pricing analyses. The inclusive value of multi-modal accessibility is included in the model. Other models have depended on auto accessibility but this uses all modes, weighing them, and the value of these modes becomes part of destination choice.

In 2002, Oregon will recognize two new MPOs. Led by ODOT and supported by other OMSC agencies, the Bend and Corvallis area MPOs will have fully operational integrated models by the time their designation is confirmed.

MODEL ENHANCEMENTS

A subcommittee of the OMSC conducted a study to better understand how aspects of urban design influence transportation choices. From over 100 urban design variables considered, nine different quantifiable aspects of urban design were identified and analyzed. The design variables were evaluated for such things as explanatory power (e.g., auto ownership, mode choice), development difficulty, and ease of data collection. The following categories were identified and several variables were listed for each category: accessibility, balance, bicycle-oriented, connectivity, crime, diversity, neighborhood design, pedestrian, transit-oriented development.

Three co-linear accessibility-related variables were successfully integrated into a single statistically significant variable. The composite variable was tested in both auto ownership and mode choice models. Sensitivity tests were conducted to see how changes in the urban design variable would affect the predicted use of non-automobile travel modes.

Two important results of this study:

- It defined a way to design variables so that the relative significance of each component is preserved in the composite urban design variable.
- It demonstrated that it takes a very large density change to effect even a small change in auto use. Only extreme changes have any significant impact.

Work continues on defining variables to be included in the joint estimation model. A report on *Statistical Analysis of Urban Design Variables and Their Use in Travel Demand Models* is being prepared to document the process and findings.

DOCUMENTATION ENHANCEMENT

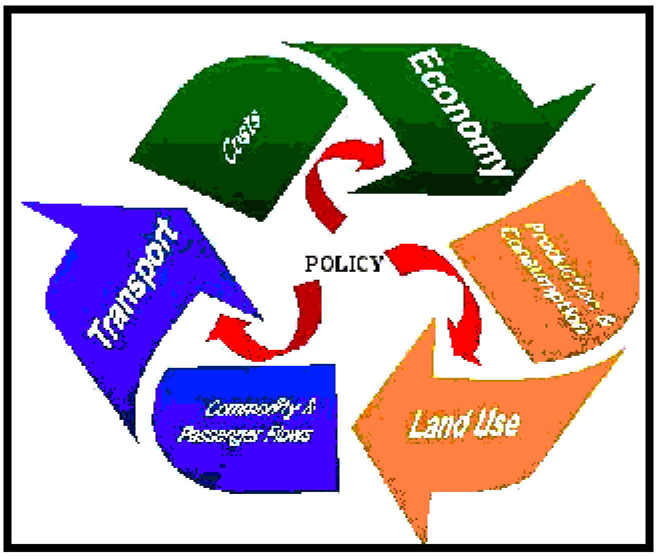
An OMSC subcommittee was formed to develop a standard documentation process for air quality conformity analysis. This effort, advocated by FHWA and the Oregon Department of Environmental Quality, provides a standard and consistent format for documentation and analysis throughout Oregon and a solid basis for analysis if needed for defense in legal actions. A draft documentation process is anticipated to be complete by 2003.

TRANSPORTATION AND LAND USE MODEL INTEGRATION PROJECT

In 1996, ODOT embarked upon the Transportation and Land Use Model Integration Project (TLUMIP) to develop analytical tools to help policy makers better understand these complex relationships. TLUMIP was intended to develop and refine an interactive statewide transportation and land use model for use in transportation planning and policy analyses at varying scales of geography. Goals and objectives identified to guide the initial TLUMIP program are included in Appendix A.

The model simulates land use and travel behavior mathematically and relies on various data, from business sector exports to transportation operator characteristics. This statewide model is a valuable complement to regionally focused MPO models. Figure 1 represents the complexity of the interactions and the interdependence of economics, land use and transportation.

Figure 1. Schematic Representation of the Statewide Model



In Figure 1, the model starts with an input-output economic model of commodities by standard industrial code in dollars. The amounts correspond to the production and consumption of goods and services. As the model distributes these goods and services regionally, it looks for available land or locations for the production (industry) and consumption (households) of goods and services. This is the land use or land allocation portion of the model. After the production and consumption of goods and services are located within the model area, it then generates the travel required for production and consumption of these goods and services. This generation of movement represents vehicle and freight trips on the system. These trips are assigned to travel the system via the shortest path possible. As the number of vehicles and roadway congestion rise so does the costs of using the roadways. These cost increases are then fed back into the economic model where the model reiterates until there is little change in these costs. At this point the model advances to the next time period and continues operating until it reaches a predetermined forecast year. Policies can be introduced at any point for testing.

The program has made considerable progress. The completed first generation model demonstrates the overall concept validity and it places useful tools into the hands of planners and policy-makers. The statewide model has been tested in various ways. The second generation models are continuing development, with an expected completion before 2003. Analyses will consider numerous policy issues, including how alternative land use and transportation policies affect state highway congestion and land use patterns. It will help identify the outcomes to provide understanding of the sensitivity of growth patterns and highway congestion to various land use and transportation policies.

TLUMIP is expanding capabilities of modeling throughout Oregon to more thoroughly simulate travel and land use behavior and to reflect the economic impacts of that behavior. The models use the strength of geographical information systems (GIS) to analyze land use and transportation data and to display information in easily understood maps and graphics. Models developed at the statewide and urban levels are being integrated to allow analysis of the entire state transportation system in a multi-modal, coordinated, and standardized process.

Design of First Generation TLUMIP Models

The design of the first generation models began with an assessment of the policy and investment issues they should be able to address. The need to evaluate unique Oregon issues, such as urban growth boundaries, influenced the design of the model. Key Oregon policy makers were interviewed to define important issues that the model should address. The study team, with help from the Peer Review Panel and OMSC members, identified eleven key issues that the candidate models should assess. Table 1 on the following pages lists these key policy issues and the level of modeling analysis.

The initial model vision was to operate at three geographic levels: statewide, substate and urban area. The statewide model assesses broad policy options and intercity travel and provides the basis for the substate model. The regional substate model gives a finer level of analysis along the major transportation corridors. Finally, the urban model handles the high-resolution analysis of the local impacts of policy decisions and investments. All three model levels address the first five issues identified in Table 1. The next four issues are germane to the substate and urban levels, while the last two issues are considered only in the urban model context.

The program began by assessing the existing integrated land use and transportation models in the United States and abroad. Consensus that existing models were not suited to examine many of the identified key issues was quickly reached. Most existing models operated at the extremes of geographic detail – they were either too abstract or only suited to small area studies. The study team concluded that a series of nested models of activity, location, and travel choice offered the most promise, since it held the best possibility to operate at the various specified geographic levels, as well as reflecting current literature. Unfortunately, no existing model possessed the desired characteristics, so the team decided to pursue parallel model development efforts.

The first of these efforts, UrbanSim, is a dynamic, non-balanced framework of individual choice at the urban level. Literature discussed these models, but had no implementation successes, so development began from scratch. The study team and Peer Review Panel felt that this approach held promise for the urban areas, but it posed significant risks for the statewide model development. After considerable discussion and research, it was decided to build the statewide and substate models using the TRANUS package, an existing modeling framework task.

Table 1. Capabilities to Address Policy Issues

Analysis Issue	Applicable Scale			Required Data	Modeled Response(s)[1]
	Statewide	Substate	Local		
Effect of land supply on land use and location decisions	■	■	■	Zonal area, employment and housing by type, network travel times by mode, exogenous constraints on growth (non-movable businesses, urban growth boundaries).	Changes in residential and commercial land prices, changes in land consumption by category of use, migration of employment.[2]
Effect of congestion on land use and location decisions	⊠	■	■		Changes in zonal accessibility and its indirect effect on residential and business location choice.
Cumulative effects of retail location choice		⊠	■		Current and lagged changes in land prices and land use in the target and adjacent zones, increased infrastructure cost as a function of increased travel demand, changes in zonal accessibility and destination choice.
Effect of large commercial development on periphery of the growth boundaries	⊠	■	■		
Effect of land supply on travel behavior	■	■	■	Employment and household supply by zone, network travel times and cost by mode, estimates of the elasticity of trip generation by trip purpose	Changes in trip generation as a function of zonal accessibility and congestion[3], changes in destination choice as a function of changes in residential and business location choice.
Effect of highway capacity increases on travel behavior[4]	■	■	■		Changes in trip generation and destination choice by trip purpose, changes in corridor and systemic network measures[5], changes in travel disutility by trip purpose and area (county, zone group, etc.).
Effect of network connectivity on travel behavior		⊠	■		Changes in trip generation and destination choice as a function of zonal accessibility, changes in network measures for the study area.

[1]Some measures of effectiveness will be applicable for all analyses, such as changes in consumer surplus (for persons) or aggregate changes in transport cost (for freight).
[2]Zonal accessibility is a derived output of the travel model which is fed back into the land use model until user-defined equilibrium occurs; it is primarily a function of zonal density and the level of congestion on the network serving it.
[3]These changes can be measured both in terms of changes for a single zone or group of zones, or systemwide using measures such as changes in vehicle miles and house of travel by area, corridor, trip purpose, mode of transport, etc.
[4]These effects are still not well understood; see TRB Special Report 245.
[5]Includes but not limited to changes in vehicle miles and houses of travel by mode and trip purpose (under congested conditions and total) for the corridor under study, a buffer zone around it, and for the state or substate area as a whole.

Table 1. Capabilities to Address Policy Issues (continued)

Analysis Issue	Applicable Scale			Required Data	Modeled Response(s)[6]
	Statewide	Substate	Local		
Effect of parking supply on travel behavior		☒	■	Total travel time and cost by mode, employment and household supply by zone, exogenous forecast of parking cost and supply by zone.	Changes In mode choice as a function of parking cost at the destination, lagged residential and business location choices as a function of decreased accessibility and changes in land prices.
Effect of urban form on mode choice		☒	■	Zonal area and density, parking cost and supply by zone, travel cost and time by mode.	Changes in mode choice as a function of destination parking costs and differential travel times and costs, lagged changes in residential and business location choice and attendant changes in trip generation and destination choice.
Effect of rail investment on highway use	■	☒		Rail service and network attributes, rail passenger and freight origin-destination data by mode of access and trip purpose (persons) or commodity family (freight), zonal accessibility.	Truck-rail diversion by commodity group as a function of current and lagged cost and travel time differentials, changes in unit transport cost by mode, passenger mode choice as a function of travel time and cost differential and changes in consumer surplus.[7]
Effect of changes in the demographic composition of Oregon	■	■	☒	Changes in household composition by time period, estimates of trip generation elasticity by household type.	Changes in trip generation by area and household type[8], changes in the demand for employment by businesses, inducement

[6]Some measures of effectiveness will be applicable for all analyses, such as changes in consumer surplus (for persons) or aggregate changes in transport cost (for freight).
[7]Estimation of passenger patronage will not be possible using the Phase II model. Exogenous estimates of modal shifts can be accommodated but not explicitly modeled in the statewide model.
[8]Three household classifications based on income (low, medium and high) have been specified for the statewide model, based upon data availability.

UrbanSim

The urban land use-transportation model, UrbanSim, was designed to operate in tandem with the urban travel models already in use within Oregon. This represented an entirely new approach to land use modeling, building on current thinking about how urban systems develop and mature. It is a disequilibrium model, which represents a radical departure from the deterministic models employed previously. The deterministic model forces the system to balance production and attraction within itself, while the disequilibrium model allows variation in production and attractions. In the market place, it is important that disequilibrium allows for the forces of supply and demand. Some of the key features of this model include:

- The model simulates key decisions and choices impacting urban development. The mobility and location choices of households and businesses and the development choices of developers are explicitly modeled.
- The model explicitly accounts for land, structures (houses and commercial buildings), and occupants (households and businesses).
- The model simulates urban development as a dynamic process over time and space, as opposed to a cross-sectional or equilibrium approach.[9]
- The model simulates the land market as the interaction of demand (location preferences of businesses and households) and supply (existing vacant space, new construction, and redevelopment), using price for reconciliation.
- The model incorporates governmental policy assumptions explicitly, and evaluates policy impacts by modeling market responses to them.
- The model is based on random utility theory and uses logit models for implementing key demand components.[10]
- The model is designed for high levels of spatial and activity disaggregation, with a zonal system identical to travel model zones.
- The model presently addresses new and redevelopment, using parcel-level detail.

The UrbanSim model recognizes that urban development evolves over time, and space is the composite of the interactions of individual actions taken by households, businesses, developers, and governments. The structure of the model includes components reflecting the behavior of these agents, all interacting through the land market. This behavioral approach provides a trackable theoretical structure, unlike "Black-Box" or abstract urban models that do not clearly identify agents and actions being modeled. It is more straightforward to explicitly incorporate policies and evaluate their effects.

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[9] A cross-sectional model is one based upon observed behavior from a single year or point in time. Using such a forecasting model implies the assumption that the same behavior or process will occur unchanged in the future. This is a common practice in urban travel forecasting models.

[10] The logit model is one member of a family of discrete choice models, which are used to choose between several alternatives. An example would be a logit model of dwelling type choice. This model's most common urban use is for mode choice. The choice set typically includes non-motorized travel, private auto, and various transit alternatives. When the dependent variable (transportation mode choice in this case) is categorical rather than continuous this model is preferred. The probability of selecting an alternative is related to its utility to the user, which is calculated using a utility expression. Because the actual user utility cannot be known with certainty, and such utility varies even between similar individuals, random utility theory provides a method that permits variance in the logit model.

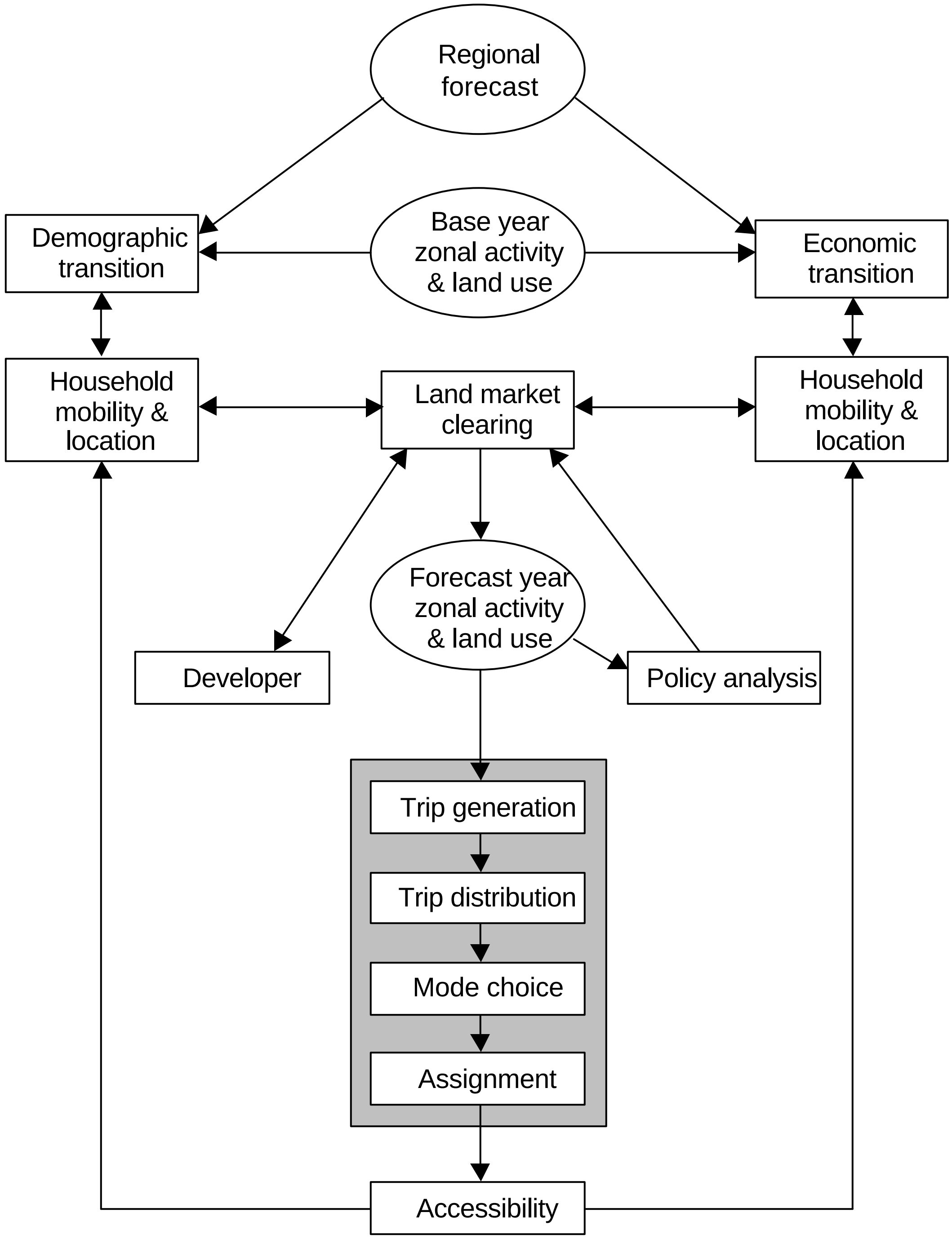
Table 2 lists key decision-makers and their decisions or actions pertaining to urban development in general and land use and transportation in particular. The household, worker, business, and developer decisions are modeled, while the government and institutions (such as lenders) decisions are model inputs. Those actions listed in bold italics are included in UrbanSim.

Table 2. Decision-Makers and Choices Affecting Urban Development
(Actions in ***bold italics*** are included in the model)

	Decision-makers	Choices/actions	
Market Decisions (Endogenous)	Household	***Mobility (move or stay)*** ***Location (where to move)*** ***Housing type (single/multi)***	Tenure (rent/own) Housing price Auto ownership
	Worker	Labor force participation Job change Full-time/part-time Multiple jobs	Workplace choice Wage to accept Mode of transportation to work Trip linking
	Business	***Number of employees*** Wages to offer ***Type of space (office, retail, etc.)*** Tenure (rent/own)	Lease/purchase cost (willingness to pay) ***Mobility (move or stay)*** ***Location (where to move)***
	Developer	Land purchase Infrastructure investment ***New development***	***Redevelopment*** ***Land use*** ***Density***
Public Policy Decisions (Exogenous)	Municipality	Tax rate Tax abatement/incentives Zoning ***Land use plans*** Urban design	***Development fees*** Amenities (parks) Services (fire, police) ***Infrastructure (***water, sewer***,*** ***transportation)***
	Transit agency	***Transit infrastructure*** ***Levels of service***	Transit fares
	Lender	Mortgage loans Development loans	Interest rates
	School district	Tax rates	School quality
	Other agencies	***Fees, laws, regulations governing land use, transportation, environment***	***Highway***, rail, ports, airports

The Figure 2 flowchart presents a graphical view of the model system key components. As noted, the behavior of households, businesses, developers, and governments occur through the land market. The model draws on random utility theory for its theoretical foundation, and builds on techniques of disaggregate choice modeling widely used in mode choice models. In extending discrete choice modeling methods to households and businesses, the model employs a technically sound framework so that the operator can follow its behaviors and the calculations.

Figure 2. UrbanSim Model Structure



Exogenous inputs (developed external to the model) include base year land use, population and employment, regional economic forecasts, transportation system and land use plans, land development policies (such as density and environmental constraints), and development impact fees. Scenarios of differing assumptions and external inputs are created using a graphical user interface. The model is run using the given scenario, and the results of one or more scenarios are compared in the viewer component of the graphical user interface.

The model endogenously (internally) predicts business and household locations, the location, type, and quantity of new construction and redevelopment by developers, and the prices of land and buildings. Two modules, demographic transition and economic transition, predict changes in household and business distribution by type (e.g., age, income, business by industry) at the regional level, consistent with aggregate control totals.

The household mobility and location module simulates household decisions about whether to move or remain in their current residence and, if they choose to move, their selection of housing type and zone. These choices are modeled in much the same way as the travel mode choices of commuters, using multinomial or nested logit estimation techniques.[11] In the Business Mobility and Location module, businesses make similar choices regarding mobility, building type, and location choice. Household and business characteristics influence choices, as do location attributes such as accessibility and prices.

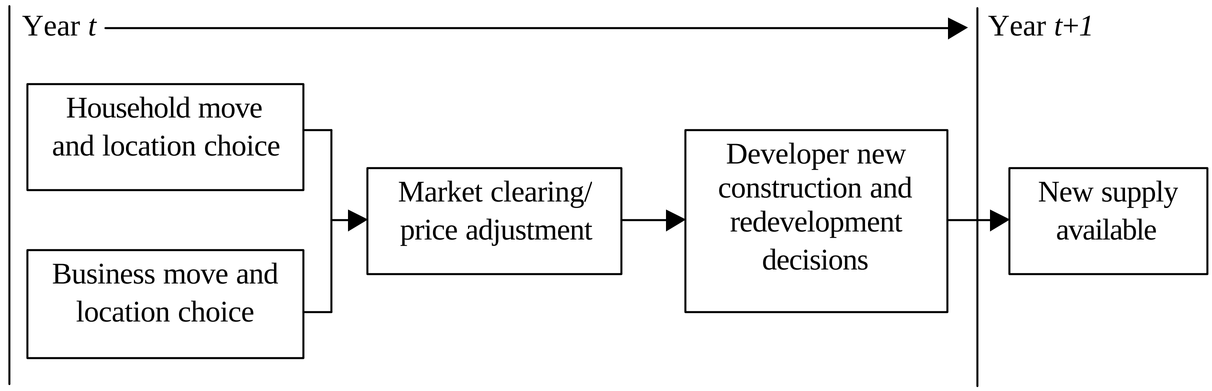
In the development component, the model simulates developer choices to convert vacant or developed land to urban uses, including the type of improvements and density, based on profitability expectations. These are constrained by government policies such as zoning regulations and infrastructure availability. These profitability expectations are influenced by prior prices and identified (revealed) demand in the location and building type preferences of businesses and households.

By reconciling prices, the model simulates land market clearing for the competing demands of household and business locations and structures against free space in each zone. The demand-to-supply ratio for each zone for each type of space (housing and commercial structures by type) induces proportional price adjustments for these structures. The adjusted prices produce new market signals to the subsequent year demands, thereby influencing preferences for zones and building types. These household, business, developer, and government interactions produce outcomes representing the distribution of population and employment, as well as the prices, uses, and density of land development. A data file is written for any desired year of a travel model run. The data is fed into the traditional urban travel forecasting models, producing new travel times, costs, and patterns by mode. These new travel times compute new accessibility indices in subsequent years, which are used until the travel models are run for the next target year.

[11] Multinomial and nested logit models are discrete choice models that model the user or consumer choice between competing alternatives based upon one or more functions that estimate the utility or usefulness of each alternative to the user. These models are estimated using observed or stated preference data using statistical techniques.

The model steps through one-year intervals, which has several advantages. First, many of the actions modeled occur in about one year intervals or less, including household and business location changes. Major transportation system changes and other longer timeframe actions are introduced in a particular year, so the model shows the influence in subsequent years. Figure 3 illustrates these dynamics.

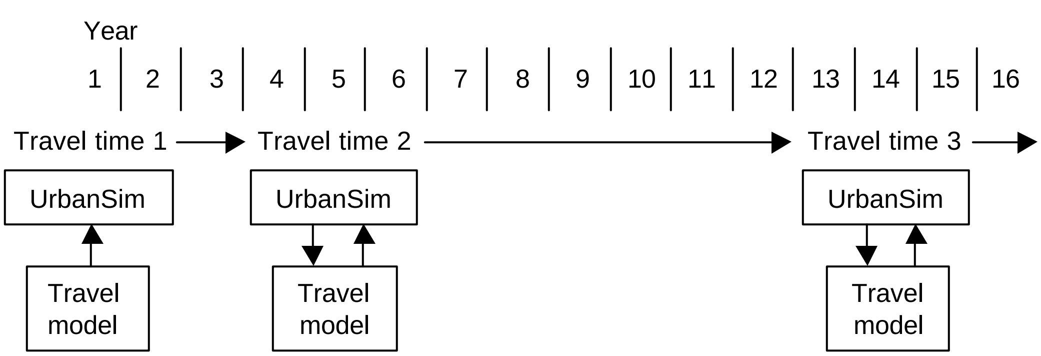
Figure 3. Modeling Changes Over Time



Households, businesses and developers are assumed to be price takers. This assumption implies that the model adjusts prices annually, after computing the total demand for each location and building type within the location choice components. The developers then estimate the profitability of alternative construction projects. They undertake new construction and redevelopment based on current market information, including demand, and prices adjusted to reflect the current supply and demand. Each year begins a new construction cycle for new and moving households and businesses. Land development decisions currently assume occurrence once a year, although multi-year construction timetables for large construction projects are more realistic and will be implemented in later model enhancements.

The urban simulation model integrates travel forecasting models through a longer-term time movement to account for transportation system changes. These are reflected through accessibility indices in the model. Figure 4 illustrates this sequencing.

Figure 4. Land Use-Transportation Sequence



Although the travel times remain constant until the subsequent model run, the accessibility indices adjust according to the varying activity distribution. Two factors apply since travel times are only updated in the years that the models are run. First, the urban model uses accessibility indices to measure the relative accessibility to various activities from each potential location. These are computed as entropy measures of location activity, discounted by the travel time between the source and each potential destination for the activity (such as shopping). Second, major transportation improvements are fairly set in time, such as opening a new freeway section. Users must determine the appropriate model years with respect to the significant transportation system changes in intermediate years.

In operation, when UrbanSim reaches a travel model year, it writes those results into external data files and suspends operation until the travel model sequence is executed using current land use data. Once the travel model run creates new travel time matrices, the user resumes the simulation that runs until the next travel model year, when this process is repeated.

The model was developed using the Java programming language under Microsoft Windows 95/NT. Object-oriented programming techniques gave maximize flexibility and reduced development costs. A graphical user interface was developed for the creation and evaluation of scenarios and the visualization of model results.

The UrbanSim software implementation includes three core model components: GIS Viewer, a database and user interface. The viewer provides basic visualization of model inputs and outputs. The user interface is the focus for model interaction and is designed to conform to Microsoft Windows 95/NT platform interface standards.

Data requirements for UrbanSim include the following. These data are stored by scenario in database format, and can be easily entered or edited using the user interface.

- Regional Forecast. This external input allocates employment and total households. Required data items are employment and total households.
- Existing Land Use. Existing land use is a basic requirement. The aggregation level of most model components, except the land development component, is the cross-classification of zone and land use category. For these “building objects” the model needs the following items in the base year: land use category, acres, land value, improvement value, housing units (for residential land categories), and square footage of improvements (for nonresidential land categories). The model’s land development component can consider new construction on vacant land and redevelopment of existing land uses. For new construction, vacant parcels are overlaid with the land use plan using GIS and serve as the basic development units. The user needs the full parcel file to have information on the improvement and land value, housing units, square footage and land use of existing parcels that might be redeveloped. Substantial detailed data is needed for useful analysis, since redevelopment is complex.
- Land Use Plans. At a minimum, the model needs comprehensive land use plans for a GIS overlay onto vacant land parcels. Preferably this is assigned to each existing parcel so that redevelopment can conform to land use plans. The user inputs the allowable conversion of land use plan designations to actual (existing) land uses.

- Households. To identify household characteristics for predicting location, mobility and travel behavior, several components are stratified, such as household size, age of household head, presence of children and income. A synthetic household generator creates the base year household data at the zone level used by the model.[12]
- Businesses. A business establishment file is used to create the employment/space/zone allocation, ideally address-matched to the parcel file. This file provides the joint employment distribution by industry, nonresidential space, and zone needed as land use model inputs. The employment data are classified into business types by industry and size category. The business is treated as the behavioral unit instead of individual employee, since it closely reflects the decision-making units. The business size is important in predicting mobility, location choice, trip attractions, and potentially, policy responsiveness to transportation demand management (TDM) measures. Major businesses (250 or more employees) are relatively scarce, have large physical capital investments in place, and a very low moving probability, so they are excluded from the business movement and location choice modeling. Tracking these major employers allows proper employment reporting by industry and zone.
- Environmental Constraints. The model uses environmental constraints to modify the development potential of environmentally sensitive land. These data are captured as GIS themes, and overlaid with vacant parcels to integrate these attributes to vacant parcels.
- Development Costs. The land development component requires development cost information to compute the profitability of alternative development projects at each site. These costs include hard development costs (replacement costs for the improvements), soft development costs (the combined development impact fees, building permits, and other costs assigned by a jurisdiction), and demolition costs, by type of land use. Hard construction and demolition costs are expressed in dollars per unit for residential, and in dollars per square foot for nonresidential uses.

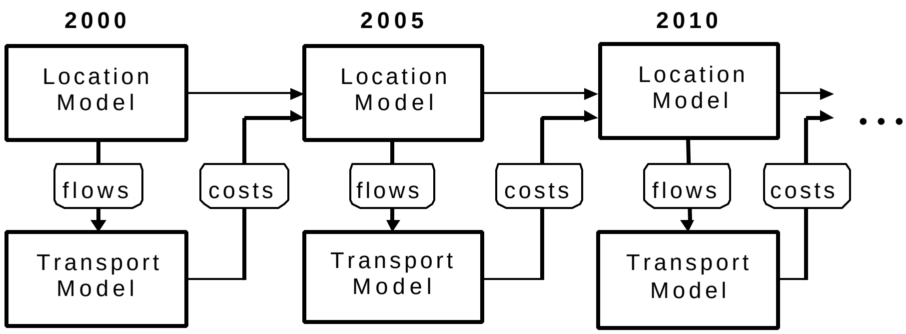
Statewide Model

The Statewide Model is implemented using an established integrated land use and transportation modeling framework. The programs run in a linked fashion to simulate changes of activity distribution and travel over time. It is implemented in the TRANUS modeling package with some functions using Excel spreadsheets. The TRANUS system is a flexible tool for the simulation and evaluation of land use and transportation policies. Unlike many models considered, TRANUS employs a totally consistent location and travel choice model. It explicitly models the land use, economic activity, and the transportation system relationship. While the framework of TRANUS is fully specified, definition of the study area and its attributes is flexible so that as little or as much detail as desired can be included in the definition of the system under study. De La Barra (1989) discusses the TRANUS framework in considerable detail.

[12] The household synthesis process described by *Beckman, et al.* (1996) is used. Briefly, this approach uses joint distributions of seven household characteristics from the Public Use Microdata Sample (PUMS) and several marginal distributions of household characteristics available at the Census block group level. An iterative proportional fitting method is used to generate households consistent with the PUMS and block group distributions. Individual households are then allocated to zones within block groups in proportion to the available housing of appropriate types.

The transportation model converts the trade flows into trips, apportions them among modes, and assigns them to the road and transit networks. Figure 5 shows how these programs are linked to simulate changes over time.

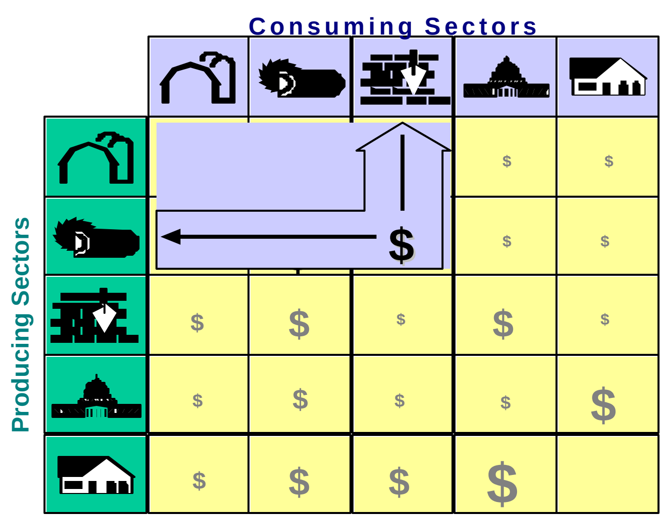
Figure 5. Sequence of Activity and Transportation Modeling



For each time period, the location model determines the activity sites and the transactions between them. Another program converts the transactions into transportation flows. The transportation model then takes the flows, calculates trip type generation, apportions the trips between modes, and assigns them to the road and transit networks, while simultaneously determining the travel costs between zones. The resulting travel costs are then input to the activity model for the next time period.

The location model incorporates a model of the study area economy. It is like an economic input-output (I-O) model that includes a spatial dimension. I-O models represent the trading relationships between sectors of the economy. Each sector of the economy produces goods and services that are consumed by other economic sectors. Products flow in one direction, dollars in the opposite direction, as illustrated in Figure 6.

Figure 6. Schematic Representation of an Input-Output Model



Intermediate production is those goods and services produced by one economic sector for purchase by other sectors for use in their production processes. Final production is goods and services not used to make other goods that are exported from the area or are sold to private individuals or government. Every increase in final goods production induces a chain of intermediate goods production. For example, a construction company building a house requires a sawmill to make lumber, which requires the production of saws and other machinery. I-O models track production and consumption relationships and allow induced demand to be calculated from final demand changes. The statewide model is based on an I-O model produced by IMPLAN. This is a system of software and data sets originally developed by the U.S. Forest Service for policy analysis and now maintained by the Minnesota IMPLAN Group, Inc.

The Statewide Model adds a spatial dimension to the I-O model to determine where induced production will likely happen as well as calculating total induced production for the area. The computation chain considers the cost of producing and consuming goods and services in different zones. Production/consumption costs are affected by land prices and transportation costs. The chain starts with final production growth forecasts for all goods and services by economic sector for the five-year analysis period. These are based on the OEA population and employment forecasts. The forecasted increments of final demand are then allocated to zones based on the share of the total sector production and the price of production in each zone. The model component that does this is calibrated from 1990 and 1995 economic data. After the final demand growth is allocated by zone, the statewide model computes induced production and allocates it based on the production costs in each zone. The zonal production costs depend on the cost of consuming intermediate production from other zones, which depends on transportation costs. It also depends on the cost of consuming land in the zone that depends, in turn, on the zone's land supply and its aggregate demand for use. The model reiterates the induced production calculations by economic sector, allocating the production among zones, determining if land constraints exist, and adjusting prices, until the price change between cycles is very small.

The location model results are the annual production allocation in dollars, by economic sector, to each zone. Annual production in dollars is converted to employees based on current labor productivity rates by sector ($/employee) and households ($/household). The location model also produces a set of annual dollar flows of goods and services by zone and by economic sector, which are converted by another program into transportation flows (for example, tons of freight movement).

The transportation model uses several steps to assign the transportation flow paths and compute transportation costs. First, possible paths between zone pairs are determined for each trip type and travel mode. The model identifies six distinct pathways for each combination of zones, trip type and mode. As pathways are determined, the cost of traveling each path is computed, including the amount and value of travel time, distance-related costs (e.g. tolls and distance fares), and transfer costs. Next, the model calculates the number of each trip type to convey each flow. This model component considers trip generation as a function of travel costs (elastic trip generation). For example, a family remotely located makes fewer shopping trips than a family located in a more accessible area to purchase the same goods. In this way, the model considers how increased costs from congestion can inhibit trip making and how new facilities that reduce travel costs can induce trip making.

Following trip generation, trips are split among modes and assigned to previously determined paths. In the statewide model, the modal structure is simplified. Passenger trips are split between public and private modes. Since only truck freight is modeled, no mode split freight trips are required. Once mode splits are determined, trips are assigned based on the relative travel costs of each path. The resulting trip assignments are evaluated to determine congestion levels and how congestion affects travel costs. This results in a recalculation of travel costs for each path. The program returns to the trip generation step, refigures the trip generation rates based on the recalculated costs, then to mode split again, then trip assignment, and finally back to recalculation of costs. This cycle is reiterated until minute changes occur in trip assignments between cycles. The transportation analysis results are tables of trips and costs between zones by mode and type. Another program converts these tables into inter-zonal costs that the activity model uses for the next period of analysis

The statewide model divides Oregon and Clark County, Washington into 122 zones. An additional 25 external zones represent areas outside the modeling area where products flow to or from. At this level, the model can study inter-city flows or large changes in land use (such as relaxing urban growth boundaries). The statewide model is also viewed as the background for a finer level of zonal and network detail that can be organized to conduct major corridor studies. Many of the corridors identified for evaluation by the model are only partially within the traditional urban travel modeling areas, and some corridors connect two metropolitan areas. A prototype substate model is designed for use in these studies. The Willamette Valley, the eleven counties in Northwest Oregon that contain the majority of the state's population and employment, is the focus of the substate modeling efforts. This area extends from Vancouver, Washington in the north to Eugene, Oregon in the south, and includes several of the popular tourist destinations in the state.

Using the candidate corridors and the zone systems of the existing urban models as a guide, the substate area is broken into approximately 350 zones, using census tracts to define the zone boundaries. All MPOs but one use tracts to define the traffic analysis zones in their travel forecasting models, allowing their zone system to nest beneath the substate model zone system.

A typical TRANUS application encompasses between 25 and 50 zones. The statewide model (122 zones) already pushes the limit on the number of zones it can handle. Concerns about data availability and model performance generated a decision to pursue the hybrid modeling approach, as illustrated in Figure 7. The statewide model simulates the interaction between sectors. Once the statewide model iterates to convergence, the trip matrices by purpose are exported to an external program that synthetically assigns the origins and destinations (at the statewide zone system) to the substate modeling zones. If no better data is available, the flows are evenly distributed to the substate zones nested beneath each statewide zone. Most of the Willamette Valley uses land use data at the substate zone level to apportion the flows. The expanded trip matrices are then assigned to a roadway network finer than the statewide level, which allows modeling of a broader range of alternatives at an appropriate scale.

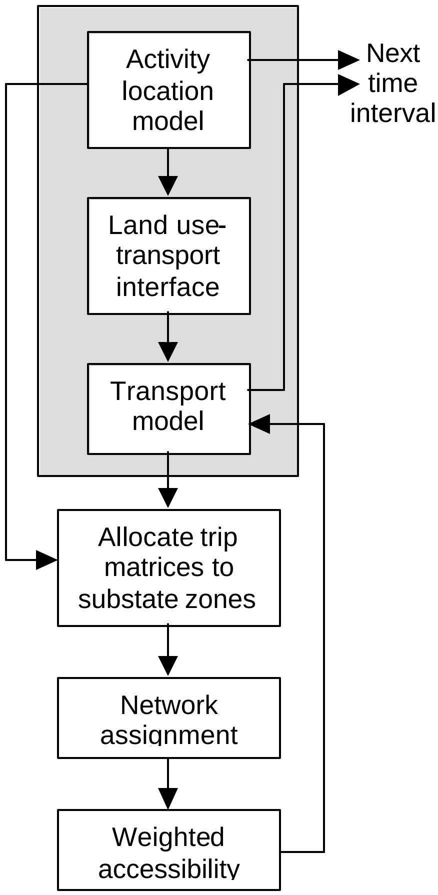


Figure 7. Substate Modeling Framework

The TRANUS transportation model is used for the substate network assignment, maintaining a consistent methodology and user interface. Finally, the substate model zone-to-zone impedance and accessibility indices are passed back to the statewide model. Based on each substate zone's share of the statewide zone nested beneath it, a weighted average is used to integrate values back into the statewide zone system. If the resulting statewide zonal accessibility indices change significantly, the statewide model can be run again with the new values. This feedback loop continues until a user-specified degree of convergence is achieved between the substate and statewide transportation model results.

Model Simplifications

It is difficult to model economic, land use and transportation elements interactively in a quantitative way that reasonably replicates what is actually happening. The interacting systems are complex and the resources required to measure and analyze the systems are large. Considerations include:

- Oregon is large geographically and has great variation in the distribution of population and employment.
- The Oregon economy is quite diverse and complex.
- The transportation network is expansive, complex and varies considerably across the state.
- There are numerous types of land uses.
- Government policies are numerous and complex.
- Data is limited and requires a coordinated and substantial effort to ensure adequacy, consistency and timeliness.
- Funding for staff and computing time is often limited.

To address these considerations and to minimize the risks inherent in developing an advanced model, numerous simplifications were made for economic sectors, geographic activity zones, the transportation network, trip schedules and purposes, land use, and certain other factors.

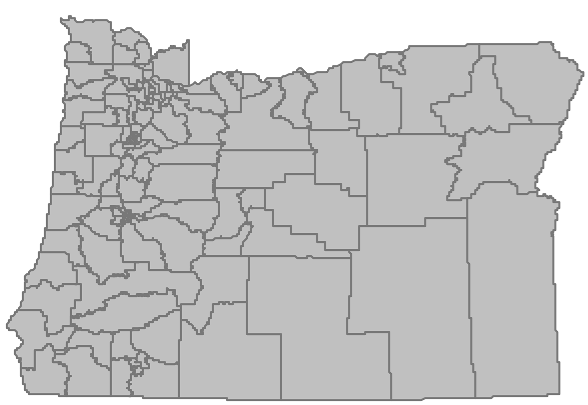
Economic Sectors. The model of the economy and its trading relationships is expressed through 15 sectors, including the 12 business and 3 household sectors listed in Table 3. Although this economic sector description is very generalized, it includes all economic activities tracked by economists.

Table 3. Model Economic Sectors

Symbol	Description
AGFF	Farms, Forests, Fisheries
CONS	Construction, Mining
OMFG	Food Processing, Non-metallic Minerals, Metals, Other
WOOD	Lumber and Wood Products, Pulp and Paper
PRNT	Printing and Publishing
TECH	Machinery and Equipment, High Tech, Transport Equipment
TCPU	Transport, Communications and Utilities
WLSE	Wholesale
RETL	Retail
FIRE	Finance, Insurance, Real Estate
SERV	Lodging, Personal/Business/Health Services, Amusements, Organizations
GOVT	Education, Other Government
HHLo	Low Income Households
HHMi	Medium Income Households
HHHi	High Income Households

Geographic Activity Zones. The modeled geographic area (Oregon and Clark County, Washington) grouped all activities into a 122-zone set (Figure 8). Over half (67) are located wholly or largely in the Willamette River Basin. Almost half of these (35) are within or encompass significant portions of metropolitan areas. Twenty-five (25) zones represent areas external to Oregon and Clark County.

Figure 8. Geographic Activity Zones



The modeled transportation network is simplified in several respects:

- Auto, bus, passenger rail and truck freight are represented. Air travel and rail freight are excluded because they are likely to have little effect on the Willamette Valley study results because average travel distances for both extend considerably beyond the Willamette Valley.
- Modeling of bus transportation is simplified by ignoring route constraints within metropolitan areas (except for bus rapid transit in the Eugene/Springfield metropolitan area). Buses are assumed to travel on the entire modeled road network in metropolitan areas subject only to prevailing roadway speed conditions and minimum wait times.
- The road network includes only state highways and urban arterials. This incorporates the large majority of travel.

Daily trips were grouped as follows to simplify the endless possibilities for trip schedules and purposes:

- Trips made from home to work and back by low, medium and high income households (3 categories).
- Work-related trips other than commuting or transporting goods (e.g., trips between businesses).
- Recreation trips made from the home.
- Other trips made from the home (e.g., to and from the home and stores, schools, churches).
- Other trips made from locations other than home (e.g., to shopping from a recreation destination, restaurant from work).
- Truck freight (e.g., all goods movement by truck).

Only residential and commercial/industrial land use categories are modeled. All residential land use is considered urban residential land. Rural residential land is represented as an equivalent low-density urban use. There is no explicit multi-family residential land modeling apart from other urban residential land.

The model does not explicitly account for a variety of factors effecting the desirability of various locations, like the quality of public services, views and other aesthetic considerations. The factors are calculated during model calibration as a set of equivalent zonal costs called "shadow prices". Since these factors are not explicitly modeled, it is impossible to estimate how changing these attributes would affect land use and transportation.

<u>Model Calibration</u>. Research of current practices surprisingly found no existing clearly defined model calibration or validation criteria for integrated land use-transportation modeling. The study team and Peer Review Panel together developed several criteria for assessing model performance:

1. Match production by sector and zone.
2. Match number of trips and average trip distances by trip purpose.
3. Minimize zone-specific constants by sector.
4. Network flows to match counts by mode of transportation, with emphasis on interurban routes.
5. Match increments of land to changes in land price.
6. Match CTPP distribution for commuting flows.

Each criterion has a specific numeric target. The network flows, for example, must fall within specified ranges based on total observed volume. Some targets are more liberal than for traditional urban travel models, owing to the complexity of the integrated models and their coarser geographic detail.

Several subjective performance tests were also developed. Each required the model to produce sensible and reasonable results. Additional criteria for which specific numeric targets could not be defined include:

7. Destination and route choice response behavior.
8. Trip generation sensitivities.
9. Path and transportation cost testing.

The statewide model is judged to perform well by meeting the calibration targets. The criteria appear realistic regardless of the geographic scale applied. However, the criteria are oriented primarily towards the normal (transportation) system validation criteria used in traditional urban travel forecasting models. Additional thinking is needed to develop model criteria for the activity and location parts of the model. Even in their present form, though, the standards can be useful performance measures for any integrated land use-transportation model.

Model calibration is the process of using data to establish the various mathematical equations that replicate observed behavior. Model validation is the process of comparing model outputs against data to determine how well the model replicates aggregate measurements of behavior. The statewide model is calibrated and validated using data from 1990 and 1995, including data from the following sources:

- IMPLAN Model
- Oregon truck survey
- Oregon household travel surveys
- State employment records
- Highway and local road inventories
- County assessment records
- Land sales records
- Metro (Regional Land Inventory System) data
- Statewide zoning
- Census

The model calibration is a highly iterative process because of the interrelated model components. Three major calibration and test series involved numerous iterations during the initial model development. These included:

- Initial base year (1990) calibration.
- Initial 1990-1995 calibration and validation.
- Long-range application including recalibration and validation during the study to include the passenger rail transportation and update the road network.

The initial base year calibration focused on finding the correct factors for replicating the activity distribution, passenger trip generation, and truck freight trip generation. The activity distribution calibration was targeted to match measured production by zone at reasonably close prices and small shadow prices with no observable biases. Transportation calibration targets match total trips and average trip length for each transportation demand category within about 20 percent of measured values, match passenger trip targets by substate area within nearly 20 percent, and match average weekday counts along major intercity corridors within about 20 percent.

After base year calibration, the focus turned to the model application for the 1990-1995 time increment and the parameter adjustments to replicate observed changes. Global increments of final production were input, the activity and transportation models run, and the results compared to target values. The primary evaluation criteria for the model were:

- Closely match the actual increments of change in households and employment by sector for each zone.
- Match target passenger trips by sub-state area within about 20 percent.
- Match the expected change in passenger trips by sub-state area within about 20 percent.
- Match 1995 truck and auto average weekday counts along major intercity corridors within about 20 percent.

Finally, during the applications of the model, the long-range results of the alternatives were evaluated to assure that reasonable results were being obtained, e.g., land prices respond to supply constraints and travel patterns respond to congestion.

A common obstacle to the use of land use-transportation models has been the amount of data required beyond for the needs of traditional travel forecasting models. The widespread deployment of GIS has collected large data sets and the tools needed to manipulate and render them. The data required to develop and apply integrated land use-transportation models is not difficult to acquire, but it is unfamiliar to most transportation planners.

The data required to develop the statewide and substate models are shown in Table 4. The transportation supply and demand data are comparable to those required to develop traditional travel demand forecasting models. The same is true for the land use-transportation interface data, except that factors must be developed to translate flows in dollars to equivalent person and freight movements.

Robust land price and supply data proved the hardest to obtain. Residential land sale transaction data is readily available, but non-residential sales are not plentiful even over a five-year period. Eventually, a Delphi panel of commercial realtors convened to help derive current and historical trends in non-residential land prices for the three metropolitan areas in the Willamette Valley (Salem, Eugene, and the Portland/Vancouver area). The use of Delphi panels to collect certain types of land data is likely to play a larger role in future model development.

The first phase goal of TLUMIP was to develop a set of prototypical integrated land use-transportation models at the statewide, substate, and metropolitan levels. The statewide model was implemented and calibrated in TRANUS, while a new innovative urban land use model, UrbanSim, was developed. ODOT staff and the OMSC implemented and used these prototypical models for planning and policy analysis. The experience gained with the first generation models was very positive and encouraging. Clearly, the integrated land use-transportation models are plausible and can provide policy-makers and planners with timely information about the interaction between the economy, land use, transportation and the environment.

Table 4. Statewide Model Data Requirements

Land use and socioeconomic data	**Land use-transportation interface data**
Base year socioeconomic data (input-output accounts, induced production, etc.) Exports by sector Imports by sector Restrictions on internal production by zone and sector Location utility function parameters Demand function parameters Demand substitutions Attractors of exogenous demand Attractors for induced production Global increments of exogenous production and consumption Increments of exogenous demand, production, and external zone exports and imports Increments of endogenous location attractors, production restrictions, and value added to production	Time and volume conversion factors, directionality of flows Intrazonal costs Exogenously defined trips **Transport supply and demand data** Network (link endpoints, length, capacity, etc.) Transit lines Trip purpose characteristics (available modes, value of travel and waiting time, etc.) Trip purpose characteristics (available modes, value of travel and waiting time, etc.) Trip generation and mode split parameters (elasticity, dispersion, and scaling factors) Energy and operating costs Vehicle operating characteristics User charges (fares and tariffs) Speed-flow curve parameters (for network assignment)

Second Generation Statewide Model

Capitalizing on the promising aspects of both first generation models, a second generation modeling system is being developed. Modeling requirements were thoroughly reviewed and a new model specification developed. This underwent extensive revision through the peer review process. The resulting design brought the parallel tracks in the first generation model into a single unified development effort. The goals and objectives established for this second-generation model are included in Appendix B.

The second generation model includes several important characteristics:

- Operate at a single geographic scale, using traffic analysis zones within the urban areas and larger zones outside.
- Have full integration of the economic, land use, and transportation model elements.
- Be fully dynamic.
- Be a hybrid equilibrium (for economic and transportation markets) and disequilibrium (for activity and location markets) formulation.

- Activity-based travel models.
- The data required for the model must be affordable, both in terms of time and money.

A modular, component-based modeling system is under development to meet these objectives. The second generation models will be developed in an open source environment, enabling others to use and contribute to the development of the software. More detailed information about the second generation models can be found in *Parsons Brinckerhoff, et al*. (2000).

TRANSIMS

The Transportation Model Improvement Program is a national program initiated for the purpose of developing a new transportation-modeling paradigm in response to policy issues in ISTEA. It is a multi-year program that is intended to depict travel demand response to transportation infrastructure changes and travel demand management actions (e.g., road pricing, parking supply actions, fuel price changes and employer travel-reduction programs) to accurately evaluate air-quality impacts of proposed actions. As part of this USDOT program, the Los Alamos National Laboratory (LANL) is developing a new model framework known as TRANSIMS (TRANsportation SIMulationS). The first demonstration of interim operating capability was in Dallas, Texas, where the dynamic ("real time") assignment algorithms were showcased.

The second demonstration for trip-planning capabilities is in the Portland, Oregon metropolitan area. Metro is providing the information to create a simulation network that includes every road and street in the region. Data includes capacity and speed estimates, the location of traffic control devices and signal timing plans, turning lane locations and length, parking locations, and transit system specifications. Population and employment data is at a small level of geography. Databases were built to efficiently organize and analyze traffic count data.

LANL is using the data to create and test the new modular tools. An algorithm was developed to synthesize the population of the entire region. The algorithm preserves all the relationships and cross-classifications found in the census. A trip planner module estimates the number, types, and the schedule of trips for each person in the region for the entire day. An assignment algorithm encompasses micro-simulation techniques. Cars, transit vehicles, and trucks can be viewed in very small time increments as they move through the network. Metro is refining several algorithms within the model to improve the calibration to survey data and count information.

Metro is also working with the commercialization vendor for the software as interface tools are being developed. Metro staff provides comments on functionality, ease of use, accuracy, and so on. The USDOT intends to deploy the final software tools to major U.S. cities within the next two or three years.

In 2003, the algorithms within the technology will be fully validated and the user interfaces will be complete. Metro will then use TRANSIMS to run two comparative forecasts, one for the Regional Transportation Plan and one for a major corridor project, preferably including road pricing. Metro will document the differences between TRANSIMS and the traditional model-based results, with a focus on evaluating data unobtainable with the traditional approach.

IMPLEMENTATION

The Oregon modeling efforts have succeeded because of the cooperative and collaborative efforts of policy-makers and technical staff in Oregon and with developers from around the world. The OMSC provides a unique forum for intergovernmental discussion and debate on federal, state and local issues. Training and education programs cross agency and jurisdictional boundaries and further integrate staff understanding and awareness of land use, economic and transportation interactions. As the modeling program progresses, the OMSC is well positioned as the technical clearinghouse for modeling issues and applications.

STANDARDS

The *Travel Demand Model Development and Applications Guidelines,* developed in June 1995, is currently under contract to be updated. These guidelines recognize the proper level of complexity of mathematical formulation and level of detail required for a range of sizes -- from Portland, a region diverse in transportation infrastructure, to the three other Oregon MPOs (with populations exceeding 50,000), and entire regions with population less than 50,000. These are stratified into those in air quality non-attainment and those who are in attainment. Similarly, the level of complexity considers the full range of model complexity from typical or common practice (generally found in most MPOs) through acceptable practice, "best" practice, advanced practice, and finally "state-of-the-art", which often borders on academic research. The travel demand modeling capabilities within the Portland region generally represent advanced practice, with some of its initiatives considered "state-of-the-art". The statewide guidelines are intended to support best practice as the yardstick of acceptable practice, while simultaneously supporting extending the methodology to advanced or state-of-the-art practices. The specification of model development and application guidelines is formulated in the context of a two-dimensional framework -- region size and model capability.

Modeling practices at the MPO and local levels continue to be upgraded and standardized throughout the state. Specifically, the following documents guide model development and application in Oregon:

- Strategic Plan for Development of New Modeling Tools. The purpose of this plan is to lay the groundwork for the coordinated development of new modeling tools over the next five years at the statewide, MPO and local levels. It promotes cost-effective expenditure of modeling resources by matching the development of new modeling tools with prioritized needs.
- Modeling Protocol. The protocol sets requirements for the development and use of the statewide, MPO and local urban area models to ensure that these activities are performed at acceptable professional levels and that modeling products conform to federal and state requirements.
- Model Development and Application Guidelines. This document provides guidance on development and application of transportation models to ensure consistency and comparability in modeling process and results throughout Oregon.

- Model Documentation Guidelines. These guidelines respond to the need for clear, thorough documentation to be prepared in a standardized format as a part of all model development projects. The intent is for models to be reviewed for compliance with specific modeling requirements, such as those for air quality conformity analysis.

CASE STUDIES

Case studies provide an opportunity to test methodologies and technical capabilities of the models. They also provide a public forum to begin discussions on policy issues and how these tools can help decision-makers in the future. It is important that modeling tools be developed that provide accurate and reliable information. It is just as important that decision-makers understand the potential of these tools and use them to explore public policy issues in a multi-dimensional and holistic manner.

Throughout the development of the first generation models, difficult technical issues were solved and complex models were successfully employed. Further collaborative research and development will enable these models to more accurately respond to user requirements and facilitate the analysis of a wider range of policy and investment options. This in turn will provide policy and decision-makers with useful tools to help guide the future growth of Oregon.

UrbanSim – Eugene/Springfield

The UrbanSim prototype model was applied to a case study in Eugene-Springfield, Oregon. The case study was designed to test the model for performance (longitudinal calibration) and to assess how it worked over time. A simulation was conducted from 1980 through 1994. Considerable work went into the development of the dataset and associated calibration targets. Developing the 1980 dataset almost two decades later proved to be a formidable challenge. While LCOG could provide some GIS coverage from that period, a large amount of manual data processing was required. Most parcel data did not contain the year the buildings were built or their commercial square footage. There was some mismatch between parcel boundaries between 1980 and 1994. Most of these data problems were overcome using manually generated data.

The case study results provided useful insights into the model behavior over the historical period of the calibration. The simulated 1994 values of key variables of population and employment achieved fairly high correlation and goodness-of-fit measures. On the other hand, the model results showed considerably lower ability to reproduce the observed changes from 1980 to 1994. The corresponding correlation and goodness-of-fit measures were quite low. Extensive sensitivity testing of the model was performed to evaluate the behavior of the model. Simulated annealing techniques (smoothing results to compensate for variability in raw data) were used to search for coefficient and parameter values capable of matching the calibration targets. A detailed review of the longitudinal calibration results can be found in *Waddell, et al.* (2000).

First Generation Statewide Model – Willamette Valley Livability Forum

The Willamette Valley Livability Forum (WVLF) facilitated and coordinated a long-range look at the future of land use and transportation in Oregon's Willamette Valley. The WVLF is a voluntary organization of local governments, MPOs, business and citizen groups, and state agencies, formed to promote dialog and recommend actions on regional land use and transportation issues. In 1999, the Forum initiated a long-range, comprehensive, regional look at the future of land use and transportation in the Willamette Valley. This effort brought together the following three innovative analytical modeling efforts and the leaders of these studies were partners in the WVLF project:

- Environmental effects of alternative land use futures by the Pacific Northwest Ecosystem Research Consortium, a consortium of the U.S. Environmental Protection Agency, Oregon State University, University of Oregon, and University of Washington.
- Economic effects of alternative land use futures on the farming and forestry industries and public infrastructure by the Willamette Valley Alternative Futures (WVAF) project, a collaborative research study coordinated by the 1000 Friends of Oregon.
- Economic, land use and transportation effects of alternative land use and transportation policies by ODOT and the OMSC for the Alternative Transportation Futures (ATF) project.

The ODOT/OMSC modeling project involved the application of the recently developed statewide transportation and land use model. The ATF project was funded by a TCSP grant from the U.S. Department of Transportation. An ATF Steering Committee provided direction for development of scenarios to be modeled. Eight transportation and land use scenarios were modeled. The scenarios with their respective policy variables are summarized in Table 5.

Table 5. Study Scenarios with Policy Variables

Scenario	**Policy Variables**			
	Road Network	**Transit Network**	**Mileage Tax (TDM)**	**Land Use**
No Action (reference scenario)	No major improvements	No major improvements	No major programs	***Historical Trend***
Highway Emphasis	***Major improvements***	No major improvements	No major programs	***Historical Trend***
Transit Emphasis	No major improvements	***Major improvements***	No major programs	***Historical Trend***
Mileage Tax Emphasis	No major improvements	No major improvements	***Major program***	***Historical Trend***
Compact Development Emphasis	No major improvements	No major improvements	No major programs	Plan Trend
Hybrid 1	***Only rural improvements***	***Major improvements***	***Graduated Mileage tax- 10¢ to 20¢***	***Plan Trend***
Hybrid 2	***Moderate improvements-urban & rural***	***Moderate improvements***	***Graduated mileage tax-5¢ to 10¢***	***Plan Trend***
Hybrid 3	***Moderate improvements - urban & rural***	***Moderate improvements***	No Major Programs	***Historical Trend***

The scenarios vary by land use, road networks, public transit networks and mileage tax (transportation demand management). Five scenarios were chosen to test the responsiveness of land use and transportation patterns to various public policies. The scenarios do not represent proposals but were chosen to represent a range of possible policy types. The objective was to identify scenarios with clear differences and variance from the reference scenario in only one respect to facilitate the evaluation. After evaluating the five scenarios, the ATF Steering Committee defined two additional scenarios that blended elements of the five policies to assess their aggregate effects. An eighth scenario was defined as part of a separate project and blended policies in a third hybrid combination.

To focus the statewide model outputs, the WVLF ATF Steering Committee identified the following evaluation measures:

- Distribution of growth in households within the Willamette Valley and surrounding regions.
- Distribution of growth in jobs within the Willamette Valley and surrounding regions.
- Changes in per capita passenger and vehicle miles traveled in the Willamette Valley.
- Changes in per capita passenger and vehicle hours traveled in the Willamette Valley.
- Changes in passenger and vehicle travel times in the Willamette Valley.
- Changes in auto and truck speeds on urban and rural freeways and arterials in the Valley.
- Changes in auto travel times between selected Willamette Valley cities.
- Emissions from vehicles in motion in the Willamette Valley.
- Changes in residential and industrial/commercial land prices in the Willamette Valley.

A summary of the more significant modeling results from this analysis follows:

- *Congestion will increase and vehicle miles traveled per person will decrease.*
  - The model assumed that the Willamette Valley population will double by 2050. With this projected population increase, even if major investments are made in highways and public transit, travel delay and traffic congestion will increase. Passenger vehicle miles traveled decreases for all scenarios as a result of this increased congestion. Even so, the transportation policies chosen today can make a difference in just how the transportation system works in the years ahead. For example, the increase in travel time is significantly less for the three hybrids.
  - Of the policy choices modeled, city-to-city traffic congestion increases the least when the highway and transit infrastructure expansion is coupled with taxes to reduce demand. Over the 50-year period, Hybrids 1 and 2 result in the smallest increases in average travel time. Hybrid 3, which excludes the mileage tax, results in a significantly greater increase in average travel time over the other Hybrid scenarios. The Highway scenario, with no public transit expansion, has the greatest increase in travel time of all scenarios tested.
  - The policy effects are different for trucks than for passengers. Truck travel times increase more under all scenarios. Moreover, truck travel time increases are mitigated more by highway improvements than are passenger travel time increases.
- *There is much inertia in the current system.*
  - Regional growth varies little among scenarios. It takes major policy shifts over a long time period to effect significant change because development patterns and travel behavior change very slowly. Modeling shows that, even after projects are constructed and in use, it takes years for them to manifest themselves into different land use patterns and travel

levels. Substantial policy shifts can alter overall growth of the Willamette Valley, but due to geographic circumstances and local policies, impacts are greater at the local level than at a regional level.
    - The hybrids show more pronounced differences because of the combined economic, land use and transportation elements. It should be noted that the future year population was fixed, constraining the distribution around the state responding to the various economic, land use and transportation variables. Realistically, some population migration out of the study area would occur, responding to the policy variables applied.
- *Where people and jobs locate is affected by several elements:*
    - *Transportation improvements and location.* Highway expansion decentralizes both jobs and housing, while transit expansion centralizes jobs and decentralizes housing. Highway expansion tends to keep growth within the Willamette Valley, while transit expansion and a mileage tax tend to move some growth to areas outside the Valley. Increased mobility by any mode increases the population of metropolitan fringe areas and neighboring cities.
    - *Supply of land, which affects land price.* Strong urban growth boundaries influence land use more than they do travel. The Compact scenario constrains the availability of land to develop, increasing land prices. As a result, land prices within metropolitan areas increase, directing more development to smaller cities and outside the Willamette Valley. This scenario also increases city-to-city and longer distance travel. Hybrid scenarios increase the compact scenario effects - the land price push combined with the city-to-city mobility pull increases the population shift to smaller cities.
    - *Transportation costs.* Mileage tax increases private vehicle costs in the Willamette Valley and decreases the overall amount of travel in the Valley. It shifts more development outside of the Valley where there is no tax, offsetting some travel reductions within the Willamette Valley.
    - Growth in areas outside the Willamette Valley is greatest for scenarios that restrict land supply and impose taxes in the Valley (Hybrids 1 and 2). Adding improved mobility further reinforces movement out of the Valley. The area south of the Willamette Valley in the I-5 corridor experiences the greatest growth as a result of Hybrid scenarios 1 or 2.
- *Transit ridership increases with increases in transit infrastructure, mileage taxes, and restrictions on highway expansion.* Transit service as a percentage of total trips increases most significantly relative to strong investment in public transportation and mileage taxes.

It is clear that different policy choices will have different impacts for the future and that combinations of policies will provide the most significant change. This project provided several scenarios with very different results. By modeling various combinations of land use, economic and transportation policy options, decision-makers can anticipate events and adopt policies to help shape the Willamette Valley for future generations.

First Generation Statewide Model - House Bill 3090

The 1999 Legislature asked ODOT to look at the results of designating a north-south freeway in Central or Eastern Oregon, from the Washington to California borders. The objectives of House Bill 3090 were to:

- Define a better north-south connection to I-82 in Eastern Oregon.
- Increase growth of Central/Eastern Oregon.
- Decrease growth in the Willamette Valley.
- Decrease travel and congestion on I-5 in the Willamette Valley.

Three alternative alignments were identified to connect with existing freeways in Washington and California. The same parameters were used for this study as for the WVLF ATF model runs. Results of this model run concluded that a new freeway from Washington to California through Central or Eastern Oregon would:

- Significantly reduce travel time from Washington to California.
- Improve market accessibility to both Central Oregon and the Willamette Valley.
- Result in minimal differences in growth in Central and Eastern Oregon.
- The US 97 improvement could slightly increase growth of the Willamette Valley.

Overall, the proposal did not meet the objectives of transferring growth from the Willamette Valley to Central or Eastern Oregon. The results of this model run were also used as one of the hybrid alternatives considered for the ATF project.

General Conclusions

Although there were counter-intuitive results from several of the model runs, general observations were as expected:

- Policies have a greater effect locally than regionally.
- Land use and transport policies in metropolitan areas affect growth of nearby smaller cities.
- Combinations of policies will provide the most significant changes.
- Complex issues require a holistic decision-making approach.

The WVLF ATF project defined several "pure" scenarios to allow the model to maximize results for each scenario. Combining elements of each "pure" scenario and selecting policy options for impact and political reality provided realistic scenarios for further consideration. Because of limited funding and time, additional scenarios and refinements were not considered, but this project provides a good basis for conversations about how future growth can occur. The House Bill 3090 project concluded that a new north-south freeway in Eastern or Central Oregon would not meet the objectives of transferring growth and potentially saved substantial money and effort from an investment that would not have accomplished the desired results.

To better use the statewide model capabilities, the manner of asking policy questions is changing. The question is not simply "what happens if we do this?" The statewide model can help us think about the following policy questions:

- What development patterns do we want?
- How do we want to disperse population & jobs?
- How will people respond to different policy actions?
- What must we do to make our desired future happen?

DATA

Data to support the Oregon modeling program can consume a significant amount of resources, both for collection and analysis. Historically, data has been collected independently by different jurisdictions and agencies, using different methodologies for data collection and recording. This has made it difficult to compare or transfer data from one jurisdiction or one model to another. The OMSC has undertaken several collaborative data collection efforts to ensure consistent collection methodologies and model applications.

HOUSEHOLD ACTIVITY AND TRAVEL SURVEY

In spring 1994, a household activity and travel survey was conducted in the Willamette Valley in Oregon and in Southwest Washington. This cooperative research project was sponsored by ODOT and the five MPOs in Oregon and SW Washington - Metro, MWVCOG, LCOG, RVCOG, and RTC. This cross-sectional survey provided Oregon data to support OMIP activity-based models. The result was a rich database of activity and travel information for almost 12,000 households.

Each of the MPOs was considered as a distinct universe for the purposes of sampling. The same design was customized to meet the needs of each MPO and they helped to define the geographic areas to be included in the sample universe. In four of the five MPOs, the sampling strategy was a stratified sample based on location categories of the immediate environment or situation, such as inner urban, satellite cities, suburban areas. In one of the MPOs, a random sampling design was used.

The survey was conducted in three phases: survey design and implementation, revealed preference survey implementation, and stated preference survey implementation. In addition to traditional travel data, the MWVCOG survey collected time-use activity data for a 48-hour period to capture day-to-day variation in personal travel behavior. The survey also included an enrichment sample of public transit users.

RECREATION/TOURISM ACTIVITY SURVEY

Recreation and tourism play a significant role in the Oregon economy. In-state and out-of-state visitors to Oregon recreation and tourist attractions contributed more than $4 billion to the state economy in 1995, a 52 percent increase over 1990.

In 1997, ODOT sponsored a recreational/tourism activity survey to address information gaps in recreational/tourism travel and to provide a better picture of recreational travel behavior within the state. Between April and June 1997, demographic data and 48-hour travel data were collected from two separate sources. One source was the guests of 95 lodgings in Multnomah, Lane, Hood River, Deschutes and Lincoln Counties who were provided with self-administering surveys that were returned to the lodging staff. The second was visitors to recreational attractions who were interviewed by survey teams at eight key Oregon attractions. The response rate for the lodging surveys yielded 355 completed surveys for the five counties. The intercept surveys at recreational attractions collected data from 1329 visitors.

OREGON TRAVEL BEHAVIOR SURVEY

Using the 1994 household activity and travel survey instrument as a base, ODOT collected data in eight rural Oregon counties in 2000 to examine travel behavior and trip generation by households. This analysis estimated trip-making characteristics to support small-scale regional transportation models being built outside the four MPO areas in Oregon. The data for this analysis came from approximately 3200 two-day household activity surveys.

Small rural areas account for about 31 percent of the population and 86 percent of the area of Oregon. Since most of this area is sparsely populated, the eight counties were selected to provide a good cross-section of Oregon's rural areas, and surveys were conducted in the more populous parts of those counties. The surveyed counties included: Clatsop, Coos, Deschutes, Josephine, Klamath, Lincoln, Malheur and Umatilla.

LONGITUDINAL PANEL SURVEY

The OMSC is preparing to update the 1994 household activity and travel survey information. It intends to modify the survey style and begin a longitudinal panel survey in fiscal year 2003, unless persuaded that other methods are more appropriate.

There is solid evidence that longitudinal panel survey data can significantly enhance the ability to understand and forecast travel behavior. A panel survey is one of the few methods available to the analyst to understand how traveler behavior is influenced by information acquisition, experimentation, and learning. It provides an opportunity to identify behavioral change over time. In effect, the panel survey provides information to understand cause and effect relationships and the process of change.

To help the OMSC decide whether a longitudinal panel will be developed, survey and modeling experts participated in a panel discussion at the end of May 2002. A background white paper for the expert panel addressed several objectives:

- Address different model forms for implementation, which rely on the survey data to quantify the estimation parameters, or provide operational information.
- Summarize the goals of the survey and define the subject areas where data is needed.
- Identify the challenges inherent in a panel survey.
- Summarize a literature review to provide information regarding the procedural issues in conducting a panel survey.
- Address needs for additional complementary surveys (e.g., housing location for movers, stated choice experiments where appropriate).

Results of the work session will be documented and will potentially form the basis for a Request for Proposals to design and initiate the survey.

FREIGHT DATA COLLECTION

With increasing demands on the transportation system and a reduction in financing for new major transportation facilities, movement of goods and services throughout the state of Oregon is becoming a bigger challenge. The Portland metropolitan area has succeeded in establishing a market as a regional distribution and transshipment center for international commerce. The combination of the four "R's" -- rivers, rail, roads and runways -- and the available transportation services help the region build on this historically competitive advantage. The economy of Portland and the rest of Oregon depends on the ability to move freight through this regional and multi-state hub.

Commodity Flow Data Collection

Metro, in cooperation with the Port of Portland and ODOT, conducted a commodity flow data collection and analysis project in 1997 to better understand how commodities move in and through the region. This effort obtained information about the amount and type of goods being handled, where they are headed within the region, how they are being carried, and what factors businesses consider in making shipment decisions. The study resulted in several work products: commodity scoping and 2040 projection refinement, truck/commodity origin-destination data collection, design and implementation of a stated preference survey to determine the elasticities of factors influencing shipping decisions, and development of a commodity carrier forecasting model. This information is currently being updated.

Freight Shipper and Carrier Survey

At the same time, ODOT conducted a freight shipper and carrier survey to obtain better freight movement information throughout the state. This survey focused on identifying concerns, bottlenecks and other problems with moving freight over the Oregon transportation system.

Truck Intercept Survey

In 1998, ODOT sponsored a statewide commodity flow survey to support statewide travel model development. Using an intercept survey of freight trucks, data was collected at Oregon ports of entry. Data collected included weight, vehicle and commodity classification, and origin-destination information. Over 16,000 truck drivers were interviewed, providing an extensive database on goods movement by freight trucks within Oregon. The survey focused on long-haul truck movements on the Interstate and U.S. highway system. The data was analyzed to determine the flow of goods by truck volumes, payload weight and cargo value between three general regions within Oregon. Diurnal distribution and fleet ownership attributes by commodity group were also defined. This study tried to understand the economic and transportation relationships between Oregon regions and the degree to which highways help facilitate these movements.

Truck Generation and Distribution Survey

The OMSC is initiating a research project consisting of collecting data at trucking facilities (focusing on freight terminals, Port sites, and distribution centers) and/or from truck drivers. The survey may include origin/destination, departure and arrival times, duration of stay, and route choice questions. To link new and existing data, commodities carried and weight will also be recorded. The research project will analyze the survey data and related information to identify and statistically test truck generation, distribution and routing relationships, and to incorporate this information into the statewide transportation model.

The State of Oregon places a high priority on maintaining its competitive posture in the international and domestic marketplace. The ability to move commodities in and through the state is an important element within this framework. Through the statewide model, economic and commodity flow forecasts will be linked, building on the information obtained from these studies.

THE FUTURE OF OMIP

A major focus for the next several years is to identify opportunities to apply the various models to address policy and project development issues. An aggressive outreach and communications program, combined with a broad education and training program, will inform customers and other model users of the tools available and how to use them. The intent is to move decision-makers and practitioners to a new way of thinking about and evaluate public policy and infrastructure investment decisions. An increased level of understanding and comfort with OMIP tools and processes will maximize their value and ensure their use as the way we do business.

Standards and guidelines will continue to be updated and refined as model development and refinement occurs.

During the summer of 2002, a third international symposium will be held in Portland, Oregon to further disseminate the most current advances in integrated modeling. One of the featured advances is the second generation statewide model being developed in Oregon. The model is called the Disaggregate Estimator of Spatial Patterns of Activity Interaction (DESPAIR). The Beta version of DESPAIR is expected to be operational during the winter of 2002. In the fall of 2002, Oregon will host a workshop to evaluate the status of integrated modeling at the different levels of geography. OMIP has made substantial gains in large scale integrated models and urban level transport models but these efforts need to be brought together to provide advances in urban level integrated modeling. This workshop will set the direction for these efforts.

OMIP is also exploring opportunities for European and North American collaborative efforts. Bringing together resources from both Europe and North America will accelerate advances in the industry. In addition, OMIP is seeking to develop ties to universities with the intent to develop a multi-disciplined advanced degree program in transportation planning and/or simulation and modeling.

The OMIP has been very successful since its inception. The key to the entire program has been that everything is done in a non-mandatory environment. All participating agencies and jurisdictions agree that this type of working environment is preferred because it offers the most latitude to perform within the local political environment while maintaining the ability to influence the big picture of modeling in Oregon. Individual ownership to the program has created a healthy working relationship among agencies and jurisdictions that previously had little contact or communication. These agencies and jurisdictions are now communicating regularly and are building work plans together, assisting each other to raise the level of performance of modeling in Oregon. Because of this coordination and cooperation, Oregon has made remarkable strides in all areas of modeling in a very short time period. The cooperative nature of the OMSC is the foundation that will continue to support future growth of OMIP.

APPENDIXES

APPENDIX A

OREGON DEPARTMENT OF TRANSPORTATION TRANSPORTATION AND LAND USE MODEL INTEGRATION PROGRAM Original Goals and Objectives - May 1996

TLUMIP Goals

The Oregon Transportation and Land Use Model Integration Program (TLUMIP) has four important goals. These goals are designed to provide the basis for a truly statewide system of land use and transportation analysis that is comprehensive, consistent and coordinated and that address key elements of ODOT's mission in the areas of statewide transportation planning and statewide planning.

Goal #1: Develop long-term economic, demographic, passenger and commodity flow forecasts for statewide and substate regions, and maintain databases needed for periodic updates.

The State should provide long range forecasts (i.e., for a minimum of twenty years) of sufficient detail to support travel demand modeling, land use allocation models, and policy analysis as required under ISTEA, the Statewide Planning Program and the TPR. These data bases and forecasts should directly support statewide planning for intrastate commodity flow analysis and freight and goods movement, and should provide the level of detail necessary to provide control totals to metropolitan, city and county planning agencies for use in developing and applying land use allocation models and travel demand models. Forecasts and databases available at the substate level should include interregional commodity, freight and passenger flows.

Goal #2: Integrate statewide and metropolitan level land use data bases, land use modeling, and spatial analysis methods to support transportation and statewide planning in the state of Oregon.

In addition to providing the data bases and forecasts needed for planning and evaluation of transportation facilities and long term assessment of land use patterns, ODOT, in conjunction with metropolitan, city and county planning organizations, should provide a lead role in establishing the administrative procedures and planning processes necessary to develop, coordinate and review data bases, forecasts and models produced under this program. This effort will be designed to be integrated into the work programs of both ODOT and participating agencies, and will be designed to foster and provide a sustainable, long term commitment by all study participants.

Goal #3: Establish methods for evaluating key policies in the Oregon Transportation Plan, implementing the Statewide Transportation Planning Rules and assessing progress made toward achieving goals implicit in Oregon's Statewide Benchmarks.

A significant goal for ODOT, other state agencies, and the metropolitan and local planning organizations participating in this program, is preparing a comprehensive inventory of the policies and plan elements that must be addressed by the models and data bases developed under this work program. This goal will be addressed by preparing a formal inventory of statewide policies and developing evaluation methods that relate these policies to the data and models required to analyze them. Emphasis will be placed on the relationship between policy evaluation and the modeling processes, the relationship of policies to data and forecasts, and the ability of modeling process (es) developed through this program to aid in evaluating the effectiveness of pubic policy as they apply to the OTP and the TPR.

The Oregon Statewide Benchmark program has established a comprehensive catalogue of measures designed to show the progress being made in attaining the goals and objectives of the Statewide Planning Program and the relationship of planning goals to the overall quality of life throughout the state. Many of the benchmarks in this program affect and are affected by elements of the OTP and requirements in the TPR. Evaluation procedures, databases, and forecasts related to key benchmark data will be identified through this program. Recommendations will be developed and periodically reviewed to assess whether the goals stated in the Oregon benchmarks program are being attained as they relate to the OTP and the TPR.

Goal #4: Develop the tools, guidelines and institutional support necessary for ODOT and other planning agencies to sustain the models and data bases needed for integrated land use and transportation facility analysis.

The investment in developing the data and models needed to analyze the implications of statewide policies and track information necessary to evaluate the success of these policies needs to be supported and sustained as efficiently and cost-effectively as possible. To achieve these goals, written guidelines will be developed under the Transportation and Land Use Model Integration Program describing the best practices for applying the models developed under this program. Interagency cooperative agreements and protocols for sustaining the databases and models will also be developed through this program. And a long-term strategy for maintaining and updating the analytic processes, models, forecasts and databases developed through this program will be prepared.

These four broad goals form the basis that policymakers and senior staff of ODOT and participating state, metropolitan, city and county organizations will use to evaluate the effectiveness and continuing viability of the Transportation and Land Use Model Integration Program.

As the Transportation and Land Use Model Integration Program is implemented and applied to transportation and statewide planning policy analysis and decision making, ODOT and participating governmental agencies will be using the processes and data bases developed through the program to meet several of the primary objectives of their respective agencies. These objectives may be modified over time, but include:

TLUMIP Objectives

Objective #1: Provide a framework for improving land use forecasting methods and developing true integration and feedback between travel demand models and land use allocation models at the substate and metropolitan level.

Developing models that include meaningful feedback between traditional travel demand models and the advanced land use allocation models developed through this work program is one of the most important technical requirements of this work program. Such feedback should go well beyond the integration of composite impedance functions used in typical adaptations of existing land use models and include interrelationships that are reflective of statewide and local planning policy.

Feedback and the integration of land use and travel demand models should also fully reflect planning guidelines included in rules and regulations implemented under federal guidance in ISTEA and state guidelines in the TPR. The modeling effort should be designed to be conducted in an environment that leads to significantly improved methods for forecasting future land use, and supports a process of evaluating the consequences of implementing alternative transportation plans and evaluating the implications of current and proposed changes in policy on the pattern of future land use and development. These processes should also reflect recommendations for advanced state-of-the-art and state-of-the-practice as identified by, among others, the National Association of Regional Councils and the federally sponsored Travel Model Improvement Program.

Objective #2: Improve and enhance growth management, corridor planning and congestion management system studies that rely on long range economic forecasting, land use allocation models and data that can be generated by the Land Use Model Integration Program.

The work program will support TSP development and MPO/urban area modeling programs in Oregon by providing consistent statewide demographic and employment forecasts, improving external passenger and commodity flow forecasts at the metropolitan, city and county level and improving the data and analysis that supports the Oregon Congestion Management System (OCMS).

Objective #3: Improve and enhance the Oregon Highway Monitoring System's analytical processes (OHMS).

The OHMS is a key contributor of data and information to the OCMS, the Statewide Highway Plan, and Statewide Corridor Planning. Key elements of the OHMS include:

- Improving traffic forecasting methods;

- Providing the necessary sensitivity of travel demand models to land uses and land use related variables;
- Integration of statewide travel demand with urban area modeling;
- Improving land use and travel demand modeling in urban areas of the state; and
- Improving the ability to model, display and analyze travel demand, land use and policy sensitive information.

Objective #4: Provide technical support for the Highway Plan update, reengineering of Project Selection and Development, and special projects (such as the Willamette Valley Strategy) that advance comprehensive transportation planning in the State of Oregon.

Future updates of the Oregon Highway Plan will be based on policies in the OTP and on a comprehensive assessment of transportation facilities and system needs. Statewide modeling and databases, as developed for this program, will support analysis of alternative policies and strategies for meeting the objectives of the plan. The reengineering of the Project Selection and Development process will be supported by this program by enabling ODOT to identify transportation needs in a timely manner and evaluate prospective alternatives taking into account the effect of an individual project on land use and other transportation facilities in the same corridor or transportation "market". Finally, several corridor level studies and initiatives are either underway or contemplated by ODOT for the future. Among those already underway is the Willamette Valley Strategy. Development of statewide travel demand forecasts and integrated land use models are expected to improve the quality and level of analysis available to ODOT and participating agencies as they develop and refine corridor level studies in other parts of the State.

From Request for Proposals, May 9, 1996

APPENDIX B

OREGON DEPARTMENT OF TRANSPORTATION TRANSPORTATION AND LAND USE MODEL INTEGRATION PROGRAM Updated Goals & Objectives - June 1998

<u>TLUMIP Goals</u>

Goal #1: Develop a set of integrated land use and transportation models that will enable ODOT and the MPOs to do analysis needed to support land use and transportation decision making.

The goal is to produce models that:
1. Can be used to analyze the potential effects of transportation and land use policies, plans, programs and projects on travel behavior and location choices.
2. Are integrated at the statewide and substate levels and are connected with metropolitan transportation models.
3. Are connected by a consistent theoretical framework, automated linkages for passing data, and procedures for coordinating between ODOT, MPOs and local governments.
4. Are built on platforms that can be modified and extended as necessary to implement improved analysis methods.
5. Produce outputs that can be used in other analysis packages for assessing transportation system performance.

Goal #2: Develop and maintain databases needed to make periodic long-term economic, demographic, passenger and commodity flow forecasts for statewide and substate regions.

The State should work with the MPOs to develop and maintain the databases needed to produce twenty-year forecasts of sufficient detail to support travel demand modeling, land use allocation models, and policy analysis as required under ISTEA, the Statewide Planning Program and the TPR. These databases and forecasts should directly support statewide planning for intrastate freight and passenger movements and distribution of population and employment growth. The forecasts should provide the level of detail necessary to provide control totals to metropolitan, city and county planning agencies for use in developing and applying land use allocation models and travel demand models.

Goal #3: Develop the expertise, guidelines and institutional support necessary to sustain the models and data bases needed for integrated land use and transportation facility analysis.

The investment in developing the data and models needed to analyze the implications of statewide policies and track information necessary to evaluate the success of these policies needs to be supported and sustained as efficiently and cost-effectively as possible. To achieve these goals, written guidelines will be developed under the Transportation and Land Use Model Integration Program describing the best practices for applying the models developed under this program. Interagency cooperative agreements and protocols for sustaining the databases and models will also be developed through this program. And a long-term strategy for maintaining and updating the analytic processes, models, forecasts and databases developed through this program will be prepared.

These program goals form the basis that policymakers and senior staff of ODOT and participating state, metropolitan, city and county organizations will use to evaluate the effectiveness and continuing viability of TLUMIP.

TLUMIP Objectives

Objective #1: Provide training on the integrated transportation and land use models.

The models need to be presented to a wide technical audience. This will be done through a statewide conference and model documentation. Selected ODOT staff and MPO staff will be trained so they may acquire a working knowledge of the theory of the models, how the models work, the data used in the development and updating of the models, the procedures for calibration and validation of models, and methods for applying the models.

Objective #2: Connect the statewide and substate models with the metropolitan area models.

The first generation work began with a vision of a nested model framework for the metropolitan, substate and statewide components. The 1st generation statewide and substate models do nest, but the metropolitan model does not. Although it now appears that a fully nesting structure may not be possible, the models should be built on consistent frameworks, produce consistent results and efficiently pass information between one another.

Objective #3: Transfer the statewide and substate model to a platform that is extensible and can be modified by ODOT in the future.

The first generation model was developed using TRANUS. This off-the-shelf modeling application was chosen because it appeared to be able to accomplish the objectives of fully integrating transportation and land use modeling, being affordable and being open. The state and substate models are large implementations of integrated models using TRANUS and have revealed some limitations of the application. Furthermore, the application has not been as open as had been anticipated. It is ODOT’s desired to have the models implemented using applications that ODOT can extend and modify as necessary to make future model improvements.

Objective #4: Integrate rail transportation into the statewide and substate model.

The 1st generation models do not model rail transportation. The 2nd generation models should include this component so that ODOT may assess passenger and freight mode choices.

Objective #5: Develop a working metropolitan model that integrates transportation and land use components.

The metropolitan area prototype model does not fully integrate transportation and land use components. The model connects the simulation of residential and business locations with the existing metropolitan travel demand model implemented with the EMME/2 software. The transportation model feeds accessibility parameters to the land use model. The land use model in turn feeds the transportation model land use allocation information that then is used for trip generation and distribution. The objective is to develop the prototype into a working model and create logical and efficient connections between land use and transportation components.

Objective #6: Establish data linkages between the statewide, substate and metropolitan models and analytical software for assessing highway system performance.

ODOT periodically evaluates highway system performance for updates of the state Congestion Management System, Highway Plan, Oregon Transportation Plan, Corridor Plans and STIP. The primary analysis tools have been the Highway Performance Monitoring System-Analytical Package (HPMS-AP) and the Highway Economic Requirement System software (HERS). In the future, ODOT may be using the FHWA Surface Transportation Efficiency Analysis Model (STEAM) and other similar software. Presently ODOT does not have effective methods for combining the results of metropolitan transportation models with ODOT data to produce a combined dataset that can be used in these analysis packages. Therefore, one objective of the 2nd stage work is to develop efficient methods for combining the outputs of models at all geographic scales to produce the needed datasets.

Objective #7: Establish university research linkages.

ODOT believes that research links with universities are an important part of a continuing program to develop good and practical models. University research has always been important to the development of modeling practice. ODOT would like to support university research that uses Oregon data so that the results will have practical applications for the Department.

From Request for Proposals, June 22, 1998

APPENDIX C

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