Using Geographic Information Systems for Regional Transportation Planning in a Growth Management Context

Final Report
October 1992

WA-RD 285.1

Washington State Department of Transportation
Washington State Transportation Commission

Transit, Research, and Intermodal Planning (TRIP) Division
and in cooperation with
U.S. Department of Transportation
Federal Highway Administration

TECHNICAL REPORT STANDARD T

1. REPORT NO. WA-RD 285.1	2. GOVERNMENT ACCESSION NO.	
4. TITLE AND SUBTITLE USING GEOGRAPHIC INFORMATION SYSTEMS FOR REGIONAL TRANSPORTATION PLANNING IN A GROWTH MANAGEMENT CONTEXT		5. REPORT DATE October 1992 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Timothy L. Nyerges and James D. Orrell III		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Washington State Transportation Center (TRAC) University of Washington, JE-10 The Corbet Building, Suite 204; 4507 University Way N.E. Seattle, Washington 98105		10. WORK UNIT NO. 11. CONTRACT OR GRANT NO. T9233, Task 9
12. SPONSORING AGENCY NAME AND ADDRESS Washington State Department of Transportation Transportation Building, KF-01 Olympia, Washington 98504		13. TYPE OF REPORT AND PERIOD COVERED Final report 14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

This study was conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration.

16. ABSTRACT

Growth management in Washington State provides a new context for regional transportation planning. A major part of this planning involves investigation of the latest information processing techniques and interjurisdictional coordination specifically with regard to transportation and land use linkages. Geographic information system (GIS) applications for transportation can assist transportation planners with data analysis concerned with these linkages. This project has identified information needs in the context of a regional transportation planning process, particularly the needs of Regional Transportation Planning Organizations (RTPOs). Urban and rural contexts are considered. Information processing tasks are elucidated and the software functions that address these tasks are presented. Data sources are identified for urban and rural traffic forecast modeling. Institutional and technical barriers inhibiting access to data for the regional transportation planning process are discussed.

17. KEY WORDS Regional transportation planning, growth management, GIS, information needs, geographic information systems, TIGER/Line, Census Transporation Planning Package	18. DISTRIBUTION STATEMENT No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22616

19. SECURITY CLASSIF. (of this report)	20. SECURITY CLASSIF. (of this page)	21. NO. OF PAGES	22. PRICE
None	None	50	

Final Report

Research Project T9233, Task 9
GIS for Transportation Planning

USING GEOGRAPHIC INFORMATION SYSTEMS FOR REGIONAL TRANSPORTATION PLANNING IN A GROWTH MANAGEMENT CONTEXT

by

Timothy L. Nyerges and James D. Orrell III
Department of Geography, DP-10
University of Washington
Seattle, WA 98195

Washington State Transportation Center (TRAC)
University of Washington, JE-10
The Corbet Building, Suite 204
4507 University Way N.E.
Seattle, Washington 98105

Washington State Department of Transportation
Technical Monitor
Judith Lorenzo
Assistant Program Manager
Scenic Highways Program

Prepared for

Washington State Transportation Commission
Department of Transportation
and in cooperation with
U.S. Department of Transportation
Federal Highway Administration

October 1992

DISCLAIMER

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

LIST OF TABLES

SUMMARY

This report documents tasks 1 and 2 of a three-part research project investigating the use of geographic information processing technology to support regional transportation planning. The Washington State Department of Transportation (WSDOT) recognizes that the emergence of a new mandate for regional transportation planning under the Washington State Growth Management Program provides a new context for the planning process. They also recognize that the use of geographic information processing technology can facilitate regional transportation plan development.

The findings documented in this report, in large part, result from two highly interactive workshops designed and implemented by the research team. Workshop participants included transportation planning professionals from the organizations responsible for plan development, as well as from other organizations representing important roles in support of transportation planning, including those offering information sources, e.g., the Census Bureau.. The workshops were designed, in part, to encourage intergovernmental coordination and cooperation as mandated in the growth management program.

The purpose of the first workshop was to identify, and begin the synthesis of, the broad range of information needs for regional transportation plan development. The methodology developed for the workshop and documented in this report may be of concern to other information gathering sources interested in geographic information system (GIS) implementation. The second workshop involved a more detailed examination of the information needs, data sources, and software functions necessary for regional transportation plan development.

This report further synthesizes the results from the workshops with other issues of concern in the implementation of geographic information processing technology in regional transportation planning. Specifically, the regional transportation planning process is discussed in terms of administrative and geographic dimensions as they interconnect with different scales of

transportation analysis throughout the state of Washington. Important products in this report include the following:

- A new synthesis of the technical aspects of the regional transportation planning process;
- The development of a database model showing the important data elements and their interrelationships involved in regional transportation planning contexts;
- A list of information categories and data sources to support the planning process;
- Identification of problems associated with data sources that impede the planning process;
- A detailed list of geographic information processing software functions cross-referenced with the regional transportation planning components;
- Recognition of the value of coordination and communication among the planning community in sharing technical solutions to facilitate the transportation planning process throughout the state;
- Recognition of the need for continued technical support for the planning effort, particularly among the newly formed Regional Transportation Planning Organizations (RTPOs); and
- Recognition that regional transportation planning involves extensive data inventory, analysis, and storage on an iterative basis, and requires sufficient budget resources for staff and other program requirements (e.g., computers, software, and data for which a fee is charged).

CONCLUSIONS AND RECOMMENDATIONS

This report presents a broad framework, which captures the interplay between the regional transportation planning process and information processing technology. The breadth and depth of the material presented should provide valuable insights for those interested in both policy and technical aspects of the regional transportation planning process. This project is the first step in undertaking the information technology transfer problem for transportation analysis in growth management. We believe that further detailed issues regarding information processing can easily follow the basic structure set forth in this report.

This research has benefited from the contributions of many individuals in the regional transportation planning community. Their open interaction in the workshops has added greatly to the clarification of regional transportation planning problems. As the planning process moves forward, there is a need for this type of exchange to continue between RTPOs and individual planners.

The synthesis of the workshops' results presents several important conclusions. The first is that the regional transportation planning effort needs further policy-level guidance if it is going to meet the goals of the growth management program. This is, however, an institutional problem, and not the primary focus of this research.

The second issue that needs more deliberation concerns data access and better coordination of data sharing. This report documents data needs and has begun the data source identification process. It notes specific cases where data exist but are currently inaccessible to the planning community because of institutional barriers. A coordinated and cooperative effort to overcome unnecessary obstructions to data sharing should be further pursued.

Third, and last, it has become apparent from this research that many of the RTPOs need greater technical support to implement the technical solutions identified here. Further investment in helping RTPOs implement appropriate information processing technology would be beneficial to

the regional transportation planning process, and ultimately to the quality of transportation statewide.

INTRODUCTION

RESEARCH OBJECTIVES

The first objective of this part of the research project was to identify the informational needs of the regional transportation planning process. Information needs were developed from two 1-day workshops, a literature review, a telephone survey, and a synthesis of the requirements outlined in the Growth Management Legislation.

The second objective of this research was to analyze and evaluate how the forthcoming Census Transportation Planning Package (CTPP) and TIGER/line data could support the transportation planning needs identified in objective 1. The report actually takes this objective a step further, responding to the broad set of needs identified in the two workshop sessions. The report documents a wide range of the data and sources necessary for regional transportation planning and provides a first step of identifying specific problems associated with their acquisition and implementation.

THE PROBLEM

This report documents the regional transportation planning process as mandated by the Growth Management Program created by the Washington State Legislature in 1990. It begins with a description of the planning problem and the required components for plan development. This description includes different perspectives on the regional planning problem, but ultimately recognizes that the process and information needs are similar for all jurisdictions involved in planning. The issue of scales of analysis is seen as the unifying dimension for the different institutional perspectives on the planning process.

Following this description, more detailed discussions of information processing tasks, information categories, and data sources are outlined. This effort focuses on the presentation of a single database model, which captures the essence of data requirements and data relationships, to support the planning process regardless of the geographic scale of analysis.

In the implementation section of this report, some specific issues associated with the integration of geographic information processing in regional transportation planning are highlighted. Further cooperative research regarding these issues is necessary to meet the challenges and goals presented in the growth management mandate.

The Washington State Department of Transportation (WSDOT) recognizes that growth management in Washington State provides a new context for transportation planning. A major part of planning in this new context involves investigation of the latest information processing techniques and inter-jurisdictional coordination specifically regarding transportation and land-use linkages. Geographic information system (GIS) applications for transportation can assist transportation planners with data analysis for growth management in various geographic areas of the state and, at the same time, foster inter-jurisdictional coordination among planners.

A GIS is defined as a system of hardware, software, data, people, organizations, and institutional arrangements for collecting, storing, analyzing, and disseminating information about areas of the earth. (1) The main focus of a GIS in transportation is on areas of the earth that involve a transportation network. (2, 3) A GIS can be used to integrate transportation information from disparate sources on the basis of geographic location, for example, an estimate of travel demand inferred from land use and transportation networks, or a state-wide distribution of travel studies performed by regional planning agencies.

In recent years, interest in GIS has reached such high levels vendors are now providing solutions for several transportation planning problems. How a GIS can support transportation modeling efforts is a growing interest among transportation management professionals. At WSDOT within the Planning, Research and Public Transportation Division, the Transportation Planning Office (TPO) is responsible for providing technical assistance to the Metropolitan Planning Organizations (MPOs) and the newly formed Regional Transportation Planning Organizations (RTPOs). This project was designed to assist in documenting the regional transportation planning process, specifically regarding the use of geographic information processing technology.

REVIEW OF CURRENT PRACTICE

LITERATURE REVIEW

Over the past several years, transportation modeling has been a large part of the planning effort of MPOs in Washington State. The Growth Management Program requires that RTPOs develop regional transportation plans and that these plans be consistent with the transportation elements of local comprehensive plans. This requirement will increase the level of effort expended on land use based travel demand modeling, which is part of the data analysis used in preparing regional transportation plans. In addition, the plan consistency required by the Growth Management Program necessitates an enhanced level of inter-jurisdictional coordination among MPOs, RTPOs, District Planning Offices, and local agencies.

During the 1980s part of the transportation planning efforts by MPOs across the U. S. was supported by the Urban Transportation Planning Package (UTPP), published by the Census Bureau. The UTPP was a special product of the 1980 Census organized for transportation planning applications. It contained population, employment, and supportive journey-to-work data. In an effort to continue support for such planning applications, the Census Bureau, in cooperation with the Federal Highway Administration (FHWA), will soon be releasing another Census Transportation Planning Package (CTPP). This refined set of journey-to-work transportation data is a special product of the 1990 Census. The CTPP will be compatible with the previously released TIGER/line street network files since the TIGER/line files provide the geographic reference elements for the CTPP. CTPP includes the following types of data: place of work, commuter trip (including both ends of trip), and place of residence. There is a statewide component consisting of place, county, and state level data, and an urban component consisting of transportation analysis zone, and census tract data.

In recent years, much of the transportation planning effort in the state of Washington has been undertaken by MPOs using transportation modeling software. Most experts now recognize that land use based transportation modeling is superior to traditional travel demand modeling based

on population estimates alone. (4) Several software packages now allow some form of land use based data input for modeling. (5) In addition, several of the software vendors of transportation modeling packages now recognize that data management can play a key role in analytical routines and graphics display. Much of that influence has come from a GIS approach to data processing. Consequently, many modeling vendors are trying to develop linkages to a GIS or develop such functions into their software, or both. Using the CTPP data requires a method of storage, manipulation, and analysis that can be provided by modeling and/or GIS software packages.

Integration of transportation modeling and GIS software takes many forms. (6, 7) One extreme approach is off-line, separate databases (data structures), where data is transferred between a modeling package and a GIS. The other extreme approach is total integration of modeling and GIS databases (data structures). Another system could have separate data structures, but an on-line transfer of data. This latter approach is the most common one in reaching effective solutions with minimum effort. Transportation modeling and GIS software together provide a depth of analysis that only sophisticated transportation modeling software can provide and the breadth of data management, manipulation, and display that GIS can provide.

A GIS can be used for several transportation planning applications that involve integrating data sets from several sources. Manipulation of these data to geographical distribution information has not been available before because of a lack of both analytical synthesis in software packages and of cartographical displays that effectively depict spatial distributions. (2) The context of growth management transportation planning, in which the goal is to develop an explicit linkage between land use and transportation systems, begs for the capabilities of a GIS approach.

However, before a tool can be effectively used, the problem itself must be well understood. The inter-jurisdictional emphasis on growth management's regional transportation planning focus involves a broadened perspective for transportation planning in Washington State. Hence, a significant part of this research has centered on the synthesis of regional transportation planning legislation from the Growth Management Act. The primary document used in this synthesis (described in detail in the Procedure section of this report) is the WSDOT Land Use and

Transportation Linkages Workbook. (8) Important connections are made between the general processes outlined in the workbook and the application of geographic information processing technology.

TELEPHONE SURVEY

A second part of the review of current practice involved a selective phone survey of regional transportation planning organizations around the country. The organizations contacted included the following: Metro-Washington D.C. Council of Governments; Chicago Area Transportation Study (CATS); Chicago Regional Transportation Authority (RTA); Metropolitan Service District (MSD)—Portland, Oregon; Fresno County Council of Governments—Fresno/Clovis, California; Metropolitan Transportation Authority (MTA)—New York City, New York; New Jersey DOT; the Columbia Area Transportation Study—Columbia, Missouri; and the Cleveland Area Metropolitan Planning Organization (MPO)—Cleveland, Ohio.

The agencies voiced several common themes regarding the implementation of geographic information technology:

- Connections between GIS and transportation modeling are just beginning. Many of the organizations were in the initial stages of implementing a GIS with TIGER file street networks.
- Improvement of locational accuracy and enhancement of link attributes, or TIGER file enhancement, was a major focus of development activity.
- Specific development efforts to address transportation-related air quality monitoring and congestion management were noted by Metro WDC and Fresno MTA.

This telephone survey primarily provided insight into the status of technology adoption—a measure of the current state of GIS in transportation planning around the country. It confirmed that at the current stage of GIS implementation, many of the conceptual and practical linkages with transportation planning remain to be implemented. Although other states have similar struggles, the goals and requirements of growth management in Washington State provide an added motivation for overcoming the problems of technology adoption.

PROCEDURES

This section reviews the approaches and results from two 1-day workshops designed and implemented by the project team. The workshop participants represented a broad cross-section of organizations responsible for the development of regional transportation plans. Representatives from federal, state, and regional government agencies that are linked to the planning process via their supporting roles as data providers also participated in the workshop.

WORKSHOP 1 INFORMATION NEEDS

The purpose of the first workshop was to begin the process of identifying the issues associated with implementing transportation planning under growth management. A graphic outline of the workshop process displays an overview of the process (see Figure 1). The work sessions identified in the figure are described in this section.

Individual Listing of Issues

The workshop began with each of the participants reviewing a list of issues compiled from returned questionnaires. The participants were then asked to consider this list and any other additional issues, and to identify the three issues of greatest significance to them. These three issues were then listed on separate 5" x 8" index cards along with the initials of the participant.

Clustering Issues to Form Working Group Themes

Related issues were clustered together to form subjects for discussion. Each participant forwarded the card stating their most significant issue first. This grouping activity was repeated two more times, thus addressing each of the three issues chosen by each participant. When participants had more than three highly-significant issues, their additional cards were considered one at a time for association with any of the existing working group themes.

A check was then made to insure that each working group represented at least two different issues, and that no one issue was represented in more than one working group in a given round. This was done because it spurred conversation for sharing information.

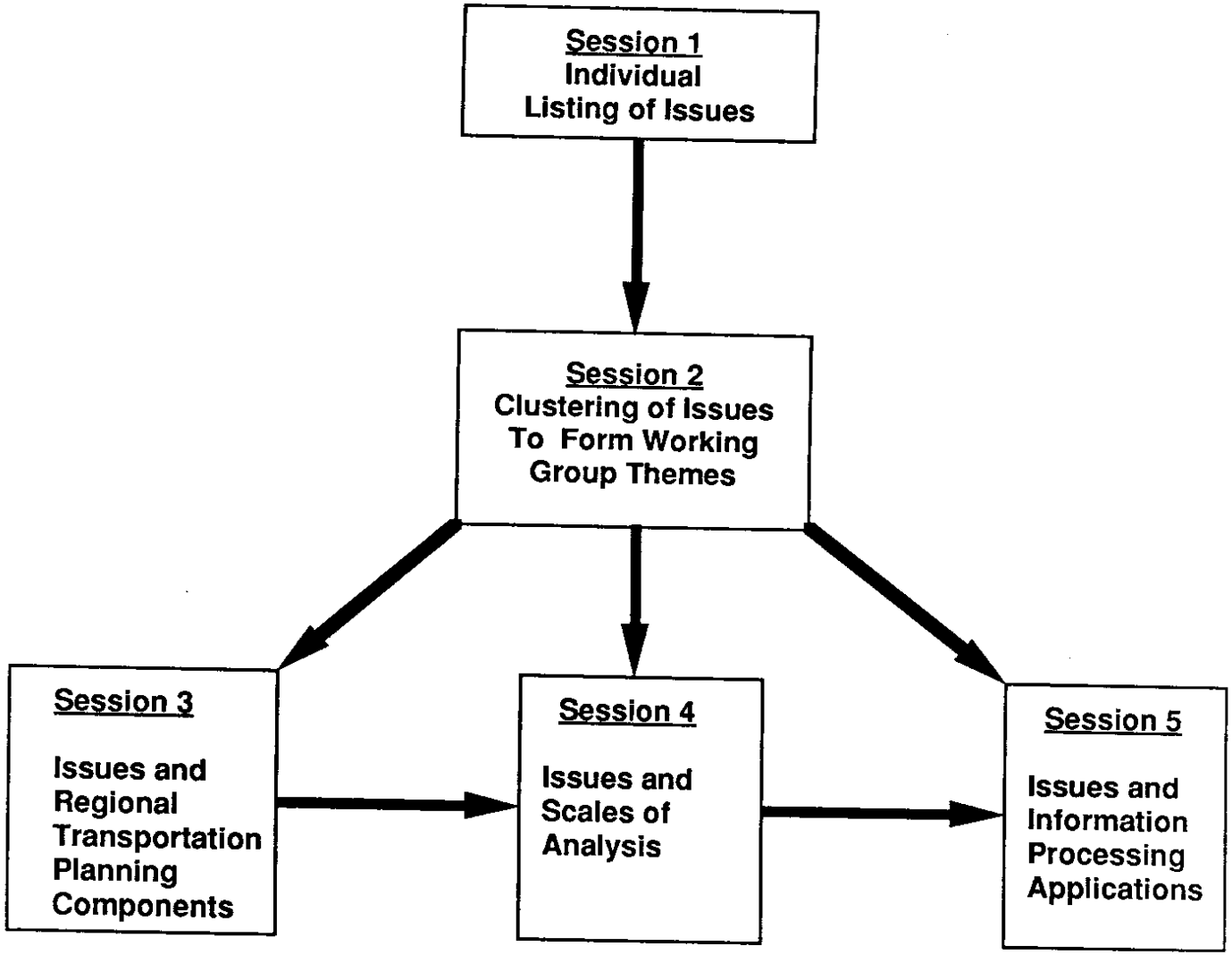

Figure 1. Workshop 1 Process Overview

Issues and Regional Transportation Planning Components

The third session of the workshop used the issues identified in session two to examine the relationships between these issues and the components of the regional transportation planning process as described in the Growth Management Act. This was accomplished using a matrix worksheet with issues listed on the left side of the matrix and the components for regional transportation planning listed across the top. (See Appendix A for a sample matrix.)

Participants formed small discussion groups based on their working group affiliations and used individual matrix worksheets to record the associations of the issues and the transportation planning components. Each individual considered the issues independently first and then recorded their observations on separate worksheets. After this independent work period, they discussed their results in small groups and arrived at a consensus of the relationships between the concerns and planning components.

At this point, they also reached a consensus regarding the total number of instances where each concern related to a component of the planning process (i.e., they counted the number of entries in each component column). They entered this total number in the bottom row of the worksheet. The total number of occurrences determined the ranking of each transportation planning component's overall importance in relation to the combined concerns represented by the clustering of issues. (See Appendix B for a sample tally.)

The consensus of issues were copied onto a separate worksheet and given to the facilitator as documentation for the activity. The participants also generated a generic description (title) for the cluster of issues at the bottom of the worksheet. Then, this description was transferred to a title card and placed on a large wall presentation matrix used to present the issues. The summary row totals from the bottom of the consensus worksheet were also recorded on the wall presentation matrix.

The total number of times an issue appeared reflected subjective observations. Totals were dependent upon both the number of concerns considered within a cluster of issues and the participants' interpretations of how each concern was related to the planning components. These

totals were only useful for describing the relative importance of each transportation planning component within an issue cluster and were not used to compare concerns between different cluster groups.

Issues and Scales of Analysis

The purpose of this evaluation was to consider at what scale(s) it is important or necessary to consider each issue in developing a regional transportation plan. This information is important in considering suitable information processing applications and application functions for each issue.

In this working session, the process that was used to consider the associations between issues and transportation planning components was duplicated for consideration of the geographic scale constraints. Each grouping of issues (labeled for ease of reference) was evaluated for association with several different geographic scales of analysis. The scales considered were intersection, link, corridor, sub-area, urban-wide, region-wide, and state-wide.

Issues and Information Processing Applications

The purpose of this activity was to induce the participants to consider the types of applications needed to support the planning process for the identified problems. During the final working session, the researchers asked the participants to consider the issue clusters from the previous two sessions in terms of appropriate information processing applications.

As a starting point for this activity, the participants were given a list of applications identified from returned questionnaires. They were then asked to complete a worksheet describing the particular aspects of data, software, and hardware pertinent to the application solution. This activity was done to link the two workshops, as information synthesized from the first workshop was used in the second workshop.

WORKSHOP 2—THE REGIONAL TRANSPORTATION PLANNING PROCESS

Workshop 2 presented a framework for understanding the regional transportation planning process, synthesized from materials documented in Workshop 1 and many hours of discussion with the individuals responsible for conducting this planning process. Much of the effort focused

on recharacterizing the process of regional transportation planning, particularly the modeling process, compatible with the material presented in the WSDOT Workbook on Land Use and Transportation Linkages. The process is characterized here using three interrelated dimensions to explain regional transportation plan development: an administrative focus, a geographic focus, and a focus on scales of transportation analysis.

Administrative Focus

One perspective of the regional transportation planning process is administrative. This perspective centers on the nature of an RTPO's inception. A number of RTPOs have evolved primarily out of existing MPO institutions. This type of RTPO has benefited from the MPO institutional history and its traditional role in transportation planning. In effect, much technical and policy-level expertise, important in large-scale transportation planning efforts, was incorporated into the new MPO/RTPO institution, as they are really the same organization, but address federal and state mandates, respectively.

On the other hand, a number of RTPOs have formed without the benefit of the MPO institutional history and its associated resource base. These RTPOs have faced significant challenges by just bringing organizations in a region together to talk about planning. Many of these newly formed RTPOs are just beginning to build a technical base to meet the transportation planning requirements of growth management.

Geographic Focus

A second perspective of the regional transportation planning process is geographic. Three types of geographic foci that are important in the regional transportation planning context are urban, urban-rural transition, and rural. Much of the concern in growth management centers on the urban-rural transition zone, particularly as it relates to the establishment of urban growth boundaries. There are varying opinions as to how the formation of such boundaries affect urbanization and, consequently, transportation. It is beyond the scope of this research to address this issue. The researchers recognize that the regional extent of RTPOs makes each of the three geographic foci a concern for all RTPOs. RTPOs that are primarily rural have areas of

urbanization and associated congestion problems. RTPOs that are primarily urban have significant rural transportation concerns as well.

Scales of Transportation Analysis

The intersection of geographic and administrative perspectives based on scales of analysis provides a key to understanding the commonality in the planning process for all RTPOs. The scales of analysis typically employed in transportation planning include region-wide, urban-wide, sub-area, corridor, link, and intersection. These scales of analysis are represented in Figure 2.

Most of the scales of analyses are listed for each column and row. The important difference is the emphasis given to each type as shown by differences in text size. The MPO and RTPOs are generally concerned with planning issues related to urban and urban-rural transition geographic foci. Thus, the scales of analyses of greatest importance are region-wide, urban-wide, sub-area, and corridor. On the other hand, much of the effort in newly formed RTPOs is concerned with corridor, link, and intersection scales of analysis resulting from more localized transportation problems, such as the seasonal impact of tourism, agriculture, and other commercial-industrial transportation.

These perspectives on regional transportation planning provide an important setting for the remaining discussion in this report. It provides the justification for examining the more specific technical needs of the planning process from a single vantage point. Information needs can be identified for most of these concerns within one framework. Within this framework, each specific planning situation can be discussed with its own particular emphasis without artificially isolating it as a unique concern.

Perspectives on Regional Transportation Plan Making

Geographic Focus	Administrative Focus: Urban Emphasis, MPO Tradition (some rural concerns)	Administrative Focus: Rural Emphasis, New RTPOs (some urban concerns)
Urban	Region-Wide Urban-wide Sub-Area Corridor	Region-Wide
Urban-Rural Transition	Sub-Area Corridor	Sub-Area Corridor
Rural	Corridor Link Intersection	Corridor Link Intersection

Figure 2. Association of Transportation Planning Scales of Analysis with Administrative and Geographic Perspectives for Regional Transportation Plan Development. Print sizes in the matrix represent the relative importance of the analytical scales.

Regional Transportation Plan Components

The Washington State Growth Management Act identifies the specific components required for the development of regional transportation plans. These components are listed here as a background for subsequent discussion. The definitions have been adopted from the WSDOT's workbook on Land Use and Transportation Linkages. (8)

1. **Public Involvement**

   RTPOs must provide for public involvement in the planning process.

2. **Transportation Policy Board**

   RTPOs must create a Transportation Policy Board, consisting of city and county representatives from each RTPO jurisdiction, to advise the RTPO members.

3. **Regional Goals and Policies**

   Goals and policies must be developed by the RTPO in conjunction with the policy board. Intergovernmental coordination and level of service standards are required here, but other issues, such as environmental equality, are also included.

4. **Regional Transportation System Needed**

   To identify regional transportation system needs, researchers must assess present and future transportation demand in the context of economic and environmental constraints. This component is, thus, the result of a detailed system analysis.

5. **Regional Land-Use Strategy**

   RTPOs must define the regional land-use strategy on which their transportation planning is based. This strategy includes local comprehensive plans and provides regional input to the local planning effort.

6. **Regional Transportation System Analysis**

   This component represents the multiple stages of system inventory and analysis at the heart of the planning process, which is particularly important in this research effort. A detailed consideration of the planning sub-components associated with this

step is given in the task analysis discussion appearing in the section titled Synthesis of Workshop 2 Results.

7. **System Improvement and Strategy Plan**

   This component of the plan identifies specific improvements to the system and priorities of implementation, and includes the Transportation Improvement Program (TIP).

8. **Financial Plan**

   Funding availability for identified improvements are addressed in the financial plan. This component provides the link back to the policy board, where the final decisions are made regarding physical implementation.

9. **Performance Monitoring Program**

   Each RTPO is required to specify and implement a performance monitoring system as part of the planning process. (This issue is not further addressed in this report.)

These components are presented in Figure 3 in the form of a process outline and integrated with additional steps from a traditional transportation planning viewpoint.

Regional Transportation Plan Making Process

The regional transportation plan components linked in Figure 3 provide a process overview for plan development. This overview identifies three general phases of the process: a policy phase, an analysis phase, and a plan phase. Since the success of each of these phases depends on intergovernmental coordination, the subtitle "intergovernmental coordination" is included with each title on the graphic.

Figure 4 shows a second level of detail for the transportation system analysis phase. This outline integrates the specific requirements of the regional transportation planning components and the technical steps normally undertaken in a transportation modeling activity.

The processes diagrammed in Figures 3 and 4 differ from the traditional view of transportation modeling in three important ways:

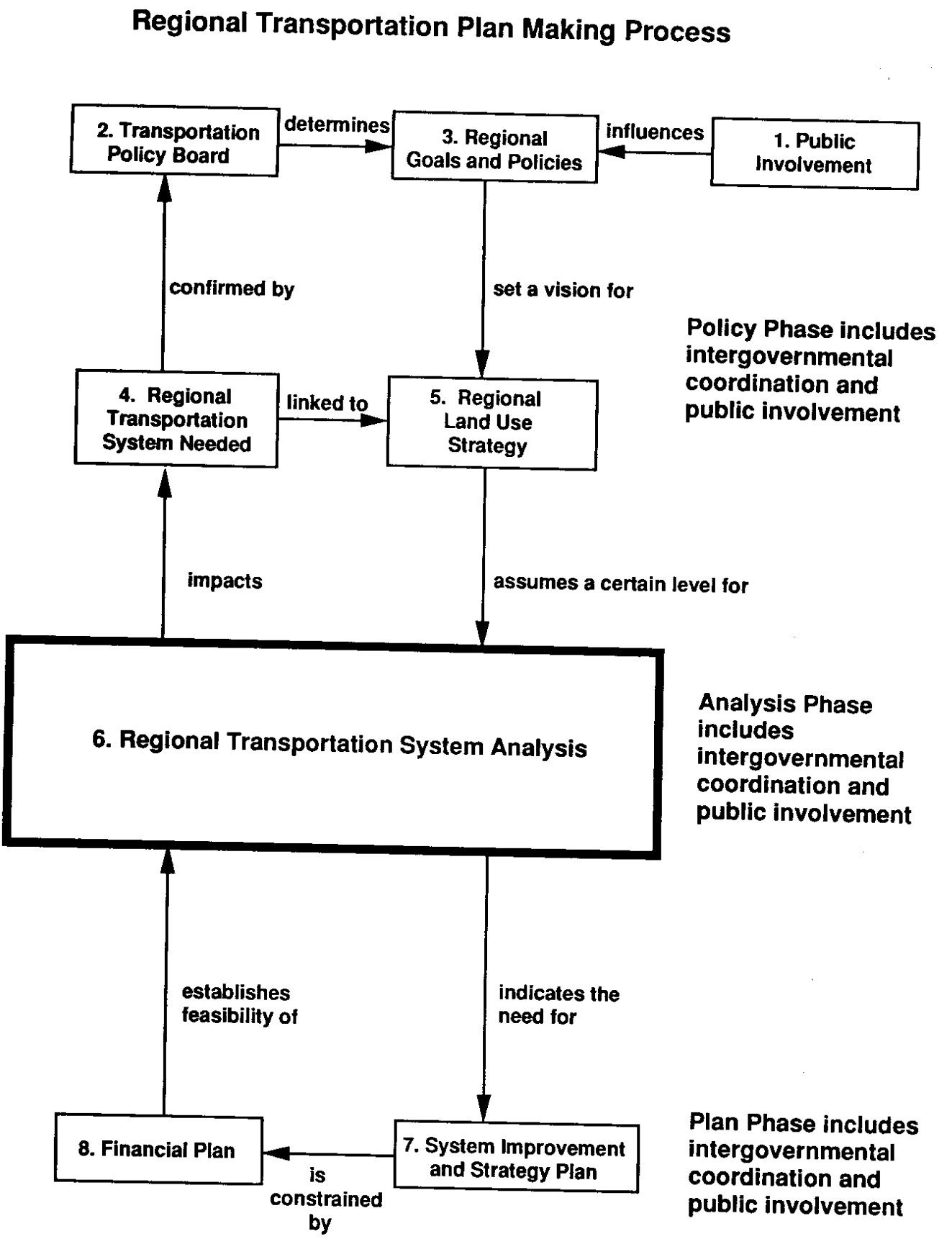

Figure 3. Regional Transportation Plan Making Process

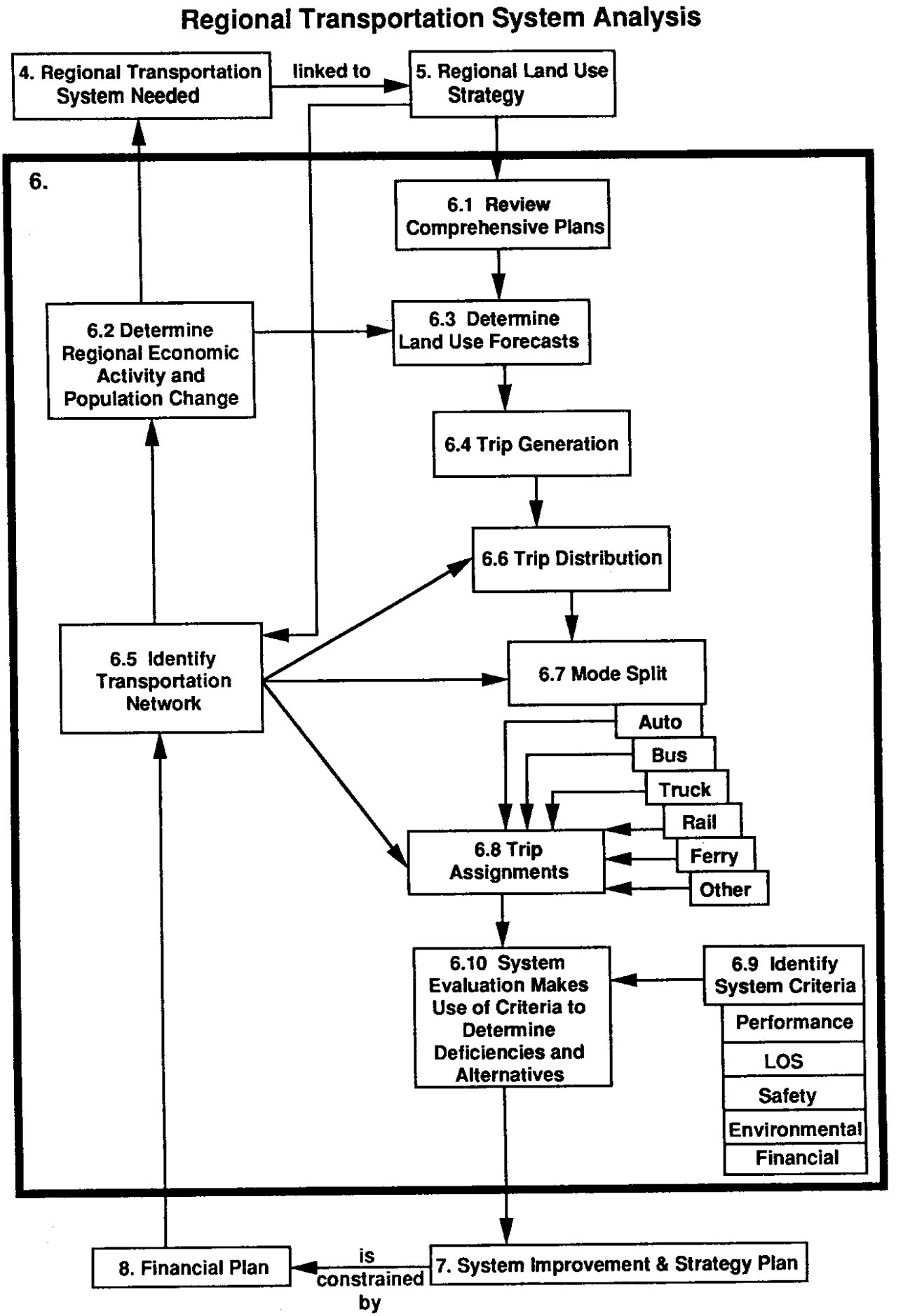

Figure 4. Regional Transportation System Analysis

1) Explicit links to land-use characterization, in terms of both population change and economic activity, are included. The latter issue includes a concern for regional transportation demands from truck and tourism traffic in addition to typical employment or journey-to-work concerns.

2) System criteria are included that recognize environmental, financial, and safety factors as important concerns, as well as the common system performance and level-of-service criteria usually used in planning.

3) The analysis phase is explicitly linked with system improvement planning, financial planning and, at a policy level, with regional needs. This linkage implies that the planning process is iterative rather than linear. It also suggests that it may be appropriate for geographic information processing technology to have a more integral role in supporting interactive problem solving and decision-making.

What are the current concerns in this process? And how do they differ for the two administrative foci (urban emphasis and rural emphasis) discussed previously? In most cases MPO/RTPOs have moved beyond the initial consideration of policy-level components and are currently concerned with the system analysis level components. The dominating concern in this process is the issue of data acquisition to support analysis. Newly formed RTPOs are generally still concerned with various aspects of the policy phase and only now are beginning to deal with the analysis phase issues.

In the following sections the workshops' results are presented. These results emphasize the technical aspects associated with the transportation system analysis phase. The important point to note here is that the administrative and geographic foci intersect on the issue of scales of analysis. Despite the different institutional concerns in the process, the continuum of information needs is shared by all RTPOs.

DISCUSSION

SYNTHESIS OF WORKSHOP 1 RESULTS

The issues identified in the first workshop were divided into two categories: institutional and technical concerns. As the first step in our synthesis, we combined the issues identified in the first workshop into a single database and resorted them based on their primary concerns' emphasis—institutional or technical.

Institutional Issues

Several institutional concerns were identified:

- Guidelines (roles, data, analysis),
- Identification of roles, responsibilities, cooperation (of key players and agencies),
- Criteria (data, planning, analysis),
- Standardization of LOS/Technical criteria,
- Consistency of regional transportation plans,
- Unifying multiple agency priorities,
- Staffing,
- Elected official involvement,
- Information dissemination, and
- Sources of, access to, and timeliness of data.

The above list indicates that a significant number of the issues identified in the first workshop were associated with institutional concerns. Clearly, two things were requested by workshop participants: 1) further policy-level clarification of the growth management program's transportation provisions, and 2) development of appropriate institutional guidelines. It is not in the scope of this project to develop such guidelines, but it is of interest to the WSDOT Transportation Planning Office in their ongoing efforts to provide transportation planning, a growth management program, and technical assistance to WSDOT districts, locales, and the RTPOs.

One of the institutional concerns identified in the workshop is the **issue of information sources, access, and dissemination.** This is a key consideration of this research project. The development of a prototype information processing application to partially support this activity (a GIS application for monitoring transportation planning studies) within WSDOT was undertaken

as Task 3 of the project. (9) This prototype will provide WSDOT with information concerning how a GIS application might help with institutional concerns, by organizing the data describing regional transportation system studies and research.

Technical Issues

Several technical concerns were identified:

- Data collection & analysis,
- Data inputs for modeling,
- Standardization of models/formats/data,
- Data requirements & transfer, and
- Environmental issues.

These five summary-level technical issues, synthesized from Workshop 1 on information needs, provided a starting point for the development of a more comprehensive list of regional transportation planning issues and, subsequently, specific tasks related to those issues. Table 1 represents the elaborated synthesis of issues resulting from the information needs workshop. This list of issues was used as a starting point for the development of a comprehensive list of tasks (discussed in the next section) that are directly linked to the process diagrams outlined in Figures 3 and 4.

SYNTHESIS OF WORKSHOP 2 RESULTS

This section outlines a detailed list of information processing tasks associated with regional transportation plan development, which was used as the starting point for the second workshop. The refinement of this list of tasks started with the list of issues in Table I and the process diagrams in Figures 3 and 4. This list should serve as a starting point for developing more detailed work plans in specific planning settings. Its primary purpose, here, is as a foundation for developing a database model for regional transportation planning, which, in turn, is used to develop a comprehensive list of information categories and data sources. The list of tasks provided in Table 2 is subdivided into three major sections (Policy Phase Tasks, Analysis Phase Tasks, and System Phase Tasks) corresponding with the major groups in Figures 3 and 4.

Table 1. Synthesis of Issues from Information Needs Workshop

Land Use Issues
- Current Land Use Data
  - Zoning Data, Employment Data, Building Permits, L&I Employee File Data, Employment Security Data
  - UTPP/CTPP
- Forecast Land Use Data
  - Office of Financial Management (OFM) Forecasts

Transportation Issues
- Network Enhancement
- Travel Behavior
- DOL Plate Match Data
- LOS Data: Highway capacity manual software, Urban Mass Transit Authority (UMTA) Annual Statistics
- WA State Energy Office TDM monitoring Data?
- Household Survey Data

Environmental Issues
- Air Quality Data: CO, NOx, PM1O, SO2
- Fleet attributes (mpg, emissions, AVO)
- Atmospheric & Topographic
- Water Quality Data (State Shoreline Act)

Information Processing System Management Issues
- Requirements
- Format/Database Structure/Standardization
- Data Collection/Data Sources
- Transfer Protocols/Media
  - Backup Utilities, Conversion Utilities, Compression Utilities
  - Coordinate System Conversion Routines
  - Data Reformatting Routine For Address Matching

- Inventory of Data Analysis Applications
- Standardization/Guidelines
- GIS Software
- Transportation Modeling Software
- Environmental Modeling
- Graphics Software (Drawing Capabilities)
- CAD
- Spreadsheets
- Database Programs

Table 2. Tasks by Plan Component (See Figures 3 and 4)

Policy Phase Tasks

1. Public Involvement

- Synthesize plans for public meetings.
- Develop an overview of plans for public meetings.

2. Transportation Policy Board

- Organize Transportation Policy Board.

3. Regional Goals & Policies

- Develop an overview of alternative scenarios for different goals and policies coordinated through the Policy Board and with input from public involvement.
- Define Level of Service (LOS) standards and intergovernmental coordination policies.

4. Regional Transportation System

- Develop an overview of LOS standards and their influence on alternative scenarios—the nature of mobility.

5. Regional Land-Use Strategy

- Develop an overview of regional land-use assumptions and impact on mobility needs.
- Develop an overview of needs and requirements for land use strategy to meet those needs.

Intergovernmental Coordination (in all three phases: Policy, Analysis, and Plan)

- Foster an exchange of data and information among jurisdictions.
- Foster consistency among comprehensive plans for jurisdictions in the RTPO.
- Foster group cooperative work in understanding different plans.

Table 2. Tasks by Plan Component (See Figures 3 and 4) (Continued)

Analysis Phase Tasks

6.1 Comprehensive Plans

- Review land-use assumptions from local comprehensive plans within the RTPO as available. Inform local planners of regional transportation perspectives to facilitate regional integration of goals and policies.
- Comprehensive plans are an important source for existing land use within an RTPO including: population, housing, employment, and land supply (developable/undevelopable).

6.2 Regional Economic Activity Population Change

- Identify current population and employment mix and locations.
- Identify forecast population and employment mix and locations.
- Identify other current economic and population activities impacting the transportation system (e.g., tourism, regional shopping travel, commercial and industrial trucking).
- Identify other forecast economic and population activities impacting the transportation system (e.g., tourism, regional shopping travel, commercial and industrial trucking).

6.3 Land Use Forecasts

- Identify forecast land uses.
- Acquire aggregate existing land use and transportation levels from adjacent regions (if appropriate).
- Acquire aggregate forecast land use and transportation levels from adjacent regions (if appropriate).
- Integrate land-use forecasts with other economic and population activities (identified above) to support calculation of trip generation scenarios below.

Table 2. Tasks by Plan Component (See Figures 3 and 4) (Continued)

6.4 Identify Transportation Network

- Identify Transportation Network:
  - interstate,
  - state routes/primary arterials,
  - secondary arterials,
  - secondary collector/county routes,
  - important intersections/interchanges,
  - ferry route,
  - HOV routes,
  - rail,
  - bike, and
  - other.
- Identify functional classification for networks.
- Identify transit services on network.
- Identify safety concerns on network (accident locations).

6.5 Trip Generation

- Identify geographic scale of analysis.
- Identify population enumeration units.
- Create traffic analysis zones through aggregation.
- Compare origin and destination productions.

6.6 Trip Distributions

- Link origins and destinations.
- Develop trip table summary.

6.7 Mode Split

- Introduce behavioral characteristics, if available.
- Determine percentages of mode use for truck (RV, commercial, industrial), bus-van, auto, rail, ferry, bicycle, walking.
- Establish balanced assignments.

6.8 Trip Assignment

- Assign trips to routes on network.

Table 2. Tasks by Plan Component (See Figures 3 and 4) (Continued)

6.9 Identify Transportation System Criteria

- Identify system performance/LOS criteria for all modes on the network.
- Identify safety criteria for all modes on the network.
- Identify environmental criteria:
  - critical areas,
  - air quality,
  - water quality,
  - noise criteria,
  - open space, and
  - scenic views.
- Identify initial financial criteria.

6.10 System Evaluation

- Identify existing facility deficiencies for all modes based on criteria.
- Identify forecast facility deficiencies for all modes based on criteria.
- Identify proposed transportation solution alternatives.

Plan Phase Tasks

7. System Improvement & Strategy Plan

- Outline system improvement needs and TIP priorities.

8. Financial Plan

- Ascertain costs and a financial plan for TIP.

Although all of the plan components have been examined, emphasis here is on the analysis phase, as the components of this phase are the most intimately affected by information processing technology. The analysis phase is the phase in which databases are developed to help provide an analytical understanding of the transportation problem. The analysis phase helps decision makers to understand the correlation of what is expected from the system and what is financially feasible to implement.

A DATABASE MODEL FOR REGIONAL TRANSPORTATION PLANNING

The information processing tasks identified above provide a base from which a generic database model was derived. This database model represents the set of data and the relationships between those data necessary to support the regional transportation planning process (Figures 5a and 5b). Since this diagram serves as a general description, only the most significant elements and relationships appear. Elements and relationships can be added or deleted to suit the needs of a particular scale of analysis in specific organizational contexts.

The database model also provides insight regarding the types of analytical operations that must be performed on the data elements as the process progresses. The three common relationships, as noted in each diagram's key, are association, aggregation, and generalization.

Interpreting the Database Model

Several data elements represent critical connections when considering this model's applicability to all planning contexts. The first is the land-use element (shown in the upper left-hand corner of Figure 5a). Land use, as represented here, incorporates the perspective of an urban geographic focus, from which employment and residential populations are derived. This is the common interpretation of the land use and transportation linkage. The database model also shows land use as the origins of truck traffic generation (e.g., commercial, industrial, agricultural, and recreational), which is a primary concern in the rural geographic focus, and an additional concern in the urban geographic focus.

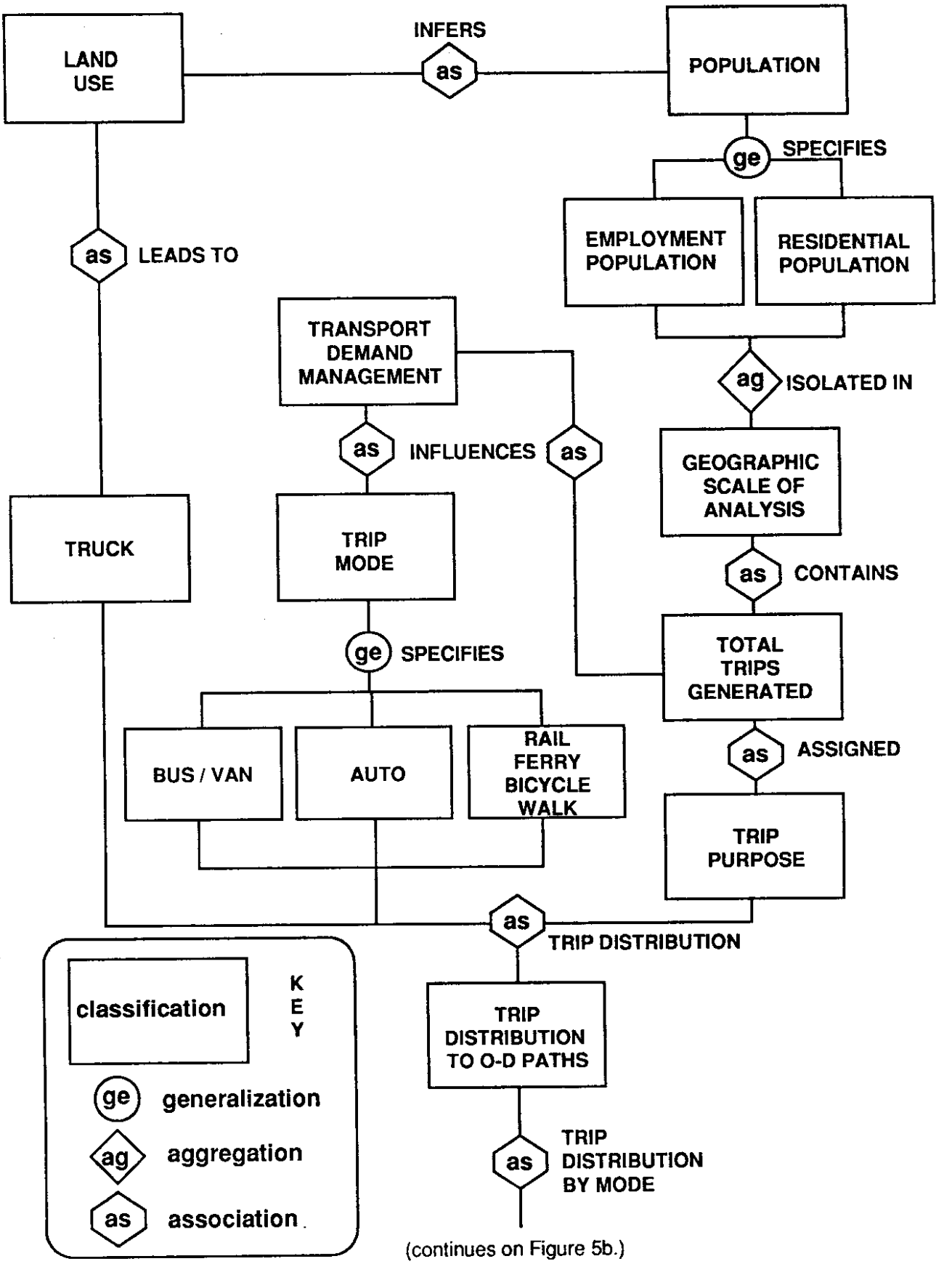

Figure 5a. Database Model for Travel Directed at Developing Trip Distributions

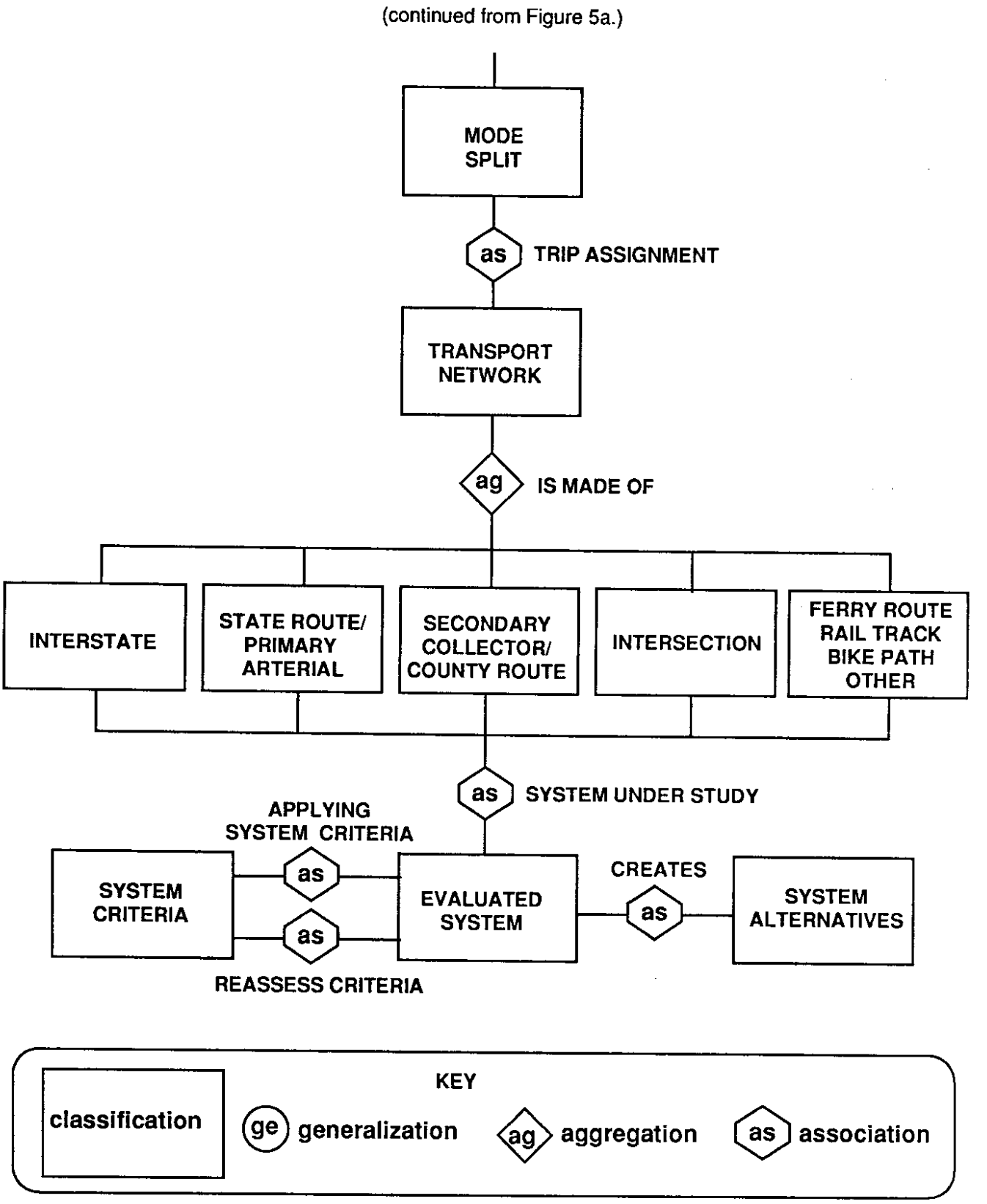

Figure 5b. Database Model for Travel Directed at Loading Trip Assignments onto Transport Network and Performing System Evaluation

The second data element of particular interest is the geographic scale of analysis (shown on the right side in Figure 5a). This element provides a means to incorporate different scales of aggregation as necessary for a given analysis type. Examples would include TAZs, census tracts, and other specialized sub-areas for urban, urban-rural transition, or rural areas.

The final data element of interest here is the transport network in Figure 5b. Again, depending on the type of analysis being done, different aspects of the transportation network could be considered in different combinations.

This database model provides clarification of the important linkages in the transportation planning process for the various organizations throughout the state.

Data Categories and Sources

The database model and the other background material presented in this report provide a means to organize a more specific list of data categories and data sources necessary to support the regional transportation planning process. This list provides a starting point to identify the specific information needs and sources for implementing transportation system analysis. Details of each of the data categories listed in Figures 5a and 5b are given in Table 3. In addition, a data source is suggested for each data category (the source appears in parentheses for each of the data categories).

RTPOs may choose the appropriate data categories for their specific circumstances. Some are perhaps more applicable than others, depending on whether state-wide, region-wide, urban-wide, corridor, link, or intersection analyses are being performed. However, it is important to note that RTPOs will need to consider most of these categories, as different scales of analyses require a slightly different approach to transportation planning problems.

Table 3. Data Categories and Data Sources

Land Use:
- existing:
  - building permits (city and county building departments)
  - property (county assessor)
  - land cover (aerial photo/satellite imagery, e.g., Earth Observation Satellite (EOSAT)/Spot Image)
- forecast:
  - comprehensive plans (city/county)

Employment Population:
- existing:
  - employee count (Labor and Industries)
  - employee count (Employment Security Department)
  - employee count (vehicle registration - Department of Licensing)
  - employee count (driver licensing - Department of Licensing)
- forecast:
  - economic growth rates (Dept of Economic Development)

Residential Population:
- existing:
  - census counts (U.S. Census)
  - average household size (U.S. Census)
  - group quarters (U.S. Census)
- forecast:
  - life expectancy tables (Health, Education, and Welfare)

Geographic Scale of Analysis:
- state-wide (WSDOT Geographic Services)
- region-wide (MPOs, RTPOs)
- urban-wide (MPOs, RTPOs)
- rural-wide (RTPOs)
- subarea: traffic analysis zone (TAZ)/tract/block (MPOs TIGER/line)
- corridor (in-house developed)
- link (enhanced TIGER/line)
- intersection

Total Trips Generated:
- (CTPP, household surveys, employee surveys, truck surveys, auto ownership-DOL, ferry surveys)
- trip attractions
- trip productions
- work patterns
- travel behavior assumptions (travel behavior studies)
- telecommute
- compressed work
- part-time
- multiple jobs

Table 3. Data Categories and Data Sources (Continued)

Trip Purpose/Trip Type (household surveys, employee surveys, truck surveys)
- shopping (work-based non-home)
- day care (work-based non-home)
- journey to work (home-based work, non-home based work (CTPP))
- commercial
- industrial
- tourist
- recreational
- linked trips (two or more of above at different locations)

Transportation Demand Management (Washington State Energy Office):
- parking cost
- parking supply
- parking inventory
- parking subsidy
- HOV policies

Vehicle Type:
- Passenger Vehicle Type:
  - bus (rider/non-rider on board survey, ridership monitoring)
  - van
  - automobile (household surveys)
  - rail
  - ferry
  - bike
  - walk
- Commercial Vehicle Type:
  - truck (including RV)
  - bus
  - van
  - automobile
  - rail
  - ferry
  - bike courier
  - walk courier

Trip Distribution Origin-Destination Pairs:
(CTPP, household surveys, employee surveys, truck survey, truck logs, license plate surveys)

Mode Split on Origin-Destination Pairs (derived):
network links characterized by mode

Table 3. Data Categories and Data Sources (Continued)

Transportation Network (enhanced TIGER/line, traffic counts):
- rail
- ferry route
- interstate
- state route / primary arterial
- county route / secondary collector
- intersection
- accident locations (State Patrol, County Road Information System (CRIS))
- travel speeds
- transportation improvement program

System Criteria:
- DOT performance standards (USDOT/WSDOT)
- level of service standards (WSDOT Bill Osterholt)
- air quality thresholds (Puget Sound Air Quality Authority (PSAQA))
- safety standards (WSDOT)

Evaluated System:
- threshold identification
- LOS for each link and node (derived)
- deficiencies by network links and nodes (derived)
- average link speeds (derived)
- vehicle miles traveled (derived)

System Alternatives (derived):
- results of network under certain policy plan
- environmental feasibility
- mobility feasibility
- financial feasibility

GIS Functions

Several functions in a GIS can be used to implement the information processing tasks discussed above (see Tables 4a-4e). Each of these tables include functions grouped according to the common categories of data entry, data output/display, data management, data manipulation, and data analysis, respectively. These functions have been identified by a literature search and through the authors' personal experience with GIS, particularly in a project dealing with manipulation of TIGER/line files. (10) The list of functions combines elements from a table produced by Rhind and Green (11), a list in a bid specification for a digital mapping system in the State of Alaska (12), and a list in a volume on GIS functions edited by Guptill (13).

This list of functions provides a quick reference of generic operations one expects to find in a GIS software package. After documenting the types of tasks of particular concern in a problem context, this list could be used to derive a list of desired GIS functions to accomplish these tasks.

GIS implementation is underway in a number of MPOs and RTPOs. Because each organization's institutional arrangement is different, the technology it uses is different. The degree to which the findings of individual MPOs or RTPOs apply differ in each instance. Each organization must determine its technical comfort level with the different GIS and transportation modeling software on the commercial market.

Table 4a. Data Entry Functions in a GIS for Transportation

Digitizing:	manual digitizing or automatic scanning input
Data validation:	integrity constraints for data quality checks such as detection of 'overshoot' digitizing errors
Import files:	ability to load in (import) bulk spatial and attribute digital data in various file formats such as census data
Attribute entry:	attributes keyed by location or by feature name
Interactive editing:	capability for a user to add/delete objects/data values one at a time with the use of retrieval criteria at the option of the user
Batch editing:	capability for a user to add/delete objects/data values in bulk processing
Map edge match:	matching the edges of maps by selecting a center line having a band width
Missing values:	check for missing attribute values or feature codes
Identifier numbering:	Node and Link sequential renumbering after edits have been made on a network

Table 4b. Data Output/Display in a GIS for Transportation

Export files:	ability to export files to user definable file formats for use in modeling programs. (An example of this is TIGER/line to UTPS, or TIGER/line to TMODEL2. This should include ability to output nodes, links, and area centroids in an order as defined by an analyst.)
Symbolization change:	any graphic symbolization could be created at the option of the user
Softcopy graphics:	viewing of maps, graphs on CRT monitor
Hardcopy graphics:	maps, graphs on laserwriter printer/plotter
Reports:	reports on content of database, report formatting to support analysis, formatted summary tables
Display window:	the area of the database currently being examined
Overview window:	a window used for quick spatial orientation that shows the entire geographic domain
Pan:	the ability to roam across a geographic domain bringing data to the CRT screen without having to change the display window
Zoom:	changing the area of the display window to examine more or fewer features, resulting in a change of scale of the display image. (A change in accuracy usually does not occur.)

Table 4c. Data Management Functions in a GIS for Transportation

SPATIAL	
Spatial data description:	construction of point features, link/node topology with shape records, chain encoding of polygon boundaries. (Surface coverages may be useful. Complex features may be useful.)
Network structure:	Node based network or link based network created as an option
Global topology:	global network topology for any geographic domain and any set of data categories to be defined by system administrator at the request of users
Locational reference:	use of absolute referencing such as latitude/longitude, state plane or UTM coordinate reference system or relative referencing such as route-milepoint, HPMS, route and log mile, street address or other specialized system depending on problem orientation
Locational cross-reference:	cross-reference of locational reference systems, such as route milepoint with HPMS, or address with route milepoint
Spatial sorting:	sort (reorder) the data on x or y or a combination of both
Spatial indexing:	after data is sorted then build an index
ATTRIBUTE	
Attribute data description:	construction of attribute fields to qualitatively and quantitatively describe data categories
Attribute sort:	sort data for any attribute
Attribute indexing:	create an index for quick retrieval by attribute value
BOTH SPATIAL AND ATTRIBUTE	
Map area storage/retrieval:	continuous geographic domain for any area or group of areas can be stored and retrieved as a single database
Object store/retrieval:	storage/retrieval of objects described as points, lines or areas and the attributes that describe them
Browse facility:	retrieval of any and all data categories
Access and Security:	multi-user or single user access with read/write protection
Roll-back facility:	supports restoration of database state in the event of system failure, minimal data redundancy
Subschema capability:	select parts of a corporate-wide database for special management
Database size:	No limitation on the number of points, lines or areas per map, maps per data base, or coordinates per line or area should exist for logical storage of elements within the capacity of physical storage.
Data definition:	software to manage descriptions and definitions of the data categories and the spatial and attribute data descriptors of these categories
Catalog:	create a catalog of all data by spatial or attribute data

Table 4d. Data Manipulation Functions in a GIS for Transportation

SPATIAL

Structure conversion:	conversion of vector to raster, raster to vector, quadtrees to vector, network to network in cooperation with locational referencing
Object conversion:	point, line, area, cell, or attribute conversion to point, line, area, cell, or attribute
Coordinate conversion:	map registration, 'rubber sheet' transformations, translation, rotation, scaling, map projection change, or image warping
Spatial selective retrieval:	retrieval of data based on spatial criteria, such as rectangular, circular or polygonal window, route-milepoint reference, point proximity, corridor, or feature name
Locational classification:	grouping of data values to summarize the location of an object such as calculations of area centroids, proximal features, Thiessen polygons
Locational simplification:	coordinate weeding (line thinning) of lines
Locational aggregation:	grouping of spatial objects into a superordinate object, such as polygons grouped into larger polygons removing interior boundaries
Locational disaggregation:	subdivide a district based on assumptions of continuous density across the district
Spatial clustering:	Interactive creation of zones (e.g., TAZs) based on clustering of areas with homogeneous characteristics; clustering algorithm interfaces.
Pseudo link:	automatically create pseudo links (or allow creation of such) to load population of districts (at a TAZ centroid) to the nearest node or link
Micro-macro network hierarchy:	different levels of the network should be supported for different aspects of a model(s) simultaneously allowing input from one level to another (as feeders into arterials)

ATTRIBUTE

Attribute selective retrieval:	retrieval of data based on thematic criteria, such as name of road, attribute of road, Boolean combination of attributes
Attribute classification:	grouping of attribute data values into classes
Class generalization:	grouping data categories into the same class based on characteristics of those categories
Attribute aggregation:	creation of a superordinate object based on attribute characteristics of two or more other objects
Arithmetic calculation:	calculate an arithmetic value based on any other values (add, subtract, multiply, divide)

Table 4d. Data Manipulation Functions in a GIS for Transportation (Continued)

SPATIAL AND ATTRIBUTE	
Node/Link attribution:	distances and delay (friction) functions associated with node/links used to compute link attribute values dynamically from attribute and/or spatial data, thus loading values onto node/link in real time. (This can be used to compute and load mode choices, number of trips, travel time, etc.)
Variable length segmentation:	segmentation of a route based on the homogeneity of attribute values along this route. (Could be done dynamically for best results to support display and network overlay.)

Table 4e. Data Analysis Functions in a GIS For Transportation

SPATIAL AND/OR ATTRIBUTE	
Spatial object measurement:	individual object and interobject calculations for line length, polygon area, and surface volume, distance and direction point to point, point to line, polygon perimeter, percent of total area, percentiles, range, mid-range
Spatial descriptive statistics:	centroid (weighted, geometric). Nonspatial descriptive statistics: frequency analysis, measures of dispersions (variance, standard deviation, confidence intervals, Wilcoxin intervals), measures of central tendency (mean, median, mode), factor analysis, contingency tables
Inferential spatial statistics:	spatial autocorrelation, trend surface
Inferential nonspatial statistics:	correlation, regression, analysis of variance, discriminate analysis
Overlay operators:	point, line, area object on/in point, line, area object.
Gravity model:	gravity model primitives using spread sheet capabilities where functional values can be computed from other values
Network indices:	compute network indices for connectivity, diameter, accessibility, and tree structures
Routing:	identify routes based on spatial or attribute criteria, such as shortest path, maximum utility, etc.
Significance tests:	T-test, chi-square, Mann-Whitney, runs
Simulation:	test the interaction of flows on the network over time, test modal choice over time
Model structuring:	a model structuring environment that provides linkages between parts of models perhaps through a special language

APPLICATION AND IMPLEMENTATION

From a technological standpoint, the results of this research provide a starting point for considering how the tasks of regional transportation planning under growth management intersect with current geographic information processing concepts and techniques. The issues identified demonstrate concerns regarding data sources and availability, and concerns regarding software capability. Currently, the knowledge base in both areas seems to be lacking or dispersed, based on the cross-section of input received from the workshop participants. This report's aim is to resolve this problem.

IMPORTANT ASPECTS OF THIS RESEARCH FOR INDIVIDUAL RTPO'S

From a management standpoint, the process diagrams (Figures 3 and 4) and task list (Table 2) developed in this report are applicable to a broad range of organizations, enabling them to better understand the nature of regional transportation planning problems and how geographic information processing technology can be applied. This information provides a starting point for the development of more detailed plans and programs to meet the needs of various organizations in the state of Washington.

Additionally, the general GIS functions described in Tables 4a-4e can be used to identify the important software functions available in some software to address specific transportation planning problems. However, each MPO and RTPO must assess these functions considering its own technological needs. In general, the value of this research in addressing these types of issues is primarily at the level of individual RTPO/MPOs.

IMPORTANT ASPECTS OF THIS RESEARCH FOR THE OVERALL PROBLEM

This research can make an important contribution at the intergovernmental level. It is at this level that further application and implementation of the concepts developed in this report could have the greatest effect on the regional transportation planning effort and the adoption of geographic information processing technology to support this effort. Specifically, this research identifies

concerns that represent significant obstacles to existing efforts to effectively implement regional transportation planning programs. Some of these obstacles include:

- an overall view of the problem,
- institutional barriers to data acquisition,
- understanding of the technologies, and
- the cost of the technology.

Many of the issues identified will determine the success of regional transportation planning efforts. Technical coordination of these issues is required for plan development. The need for coordination reflects the broader institutional difficulties associated with regional transportation planning. Table 5 documents the data issues identified in this research that lie at the center of regional transportation analysis and, consequently, at the heart of successful regional transportation planning.

Table 5. Data Issues Impeding Regional Transportation Planning

1. LAND USE - EXISTING

1.1 Property type for land use (from assessor)

- lack of data transfer policy
- lack of category (property type) conversion standards for land use types
- difficulty in aggregating property to TAZs -- sufficient geocoding to perform aggregation (e.g. centroids ---> TAZ; text descriptions ---> TAZ; address ---> TAZ)

1.2 Building Permits

- linkage with assessors files
- accuracy of permits, built vs. occupancy
- lack of category conversion standards
- actual number of units are often not identified
- data not available in digital form
- difficulty in aggregating building permit data to TAZs (as in the assessor data above)

1.3 Comprehensive Plans

- lack of categorical standards (e.g., low density means what?)
- residential density factors (number of persons/acre)
- commercial density factors (number of employees/acre)
- would like to see statewide agreement on density factors
- digital availability of plans
- aggregation into TAZs

2. EMPLOYMENT POPULATION - EXISTING

- non-availability of Employment Securities data
- Labor & Industries data quality? Missing self-insured organizations from file (completeness)
- City and county business licenses to cross-reference
- Alter legislation to move beyond barriers in Employment Security Data for regional transportation plan development.
- There is currently too much redundant effort to get employment information because ESD is not providing it.

Table 5. Data Issues Impeding Regional Transportation Planning (Continued)

3. EMPLOYMENT POPULATION - FORECAST

- Need historic databases
- Better locational characterization (detail); corridor and sub-area at the minimum

4. TRANSPORTATION NETWORK INFORMATION

- County Road Information System (CRIS) is maintained by the County Road Administration Board (CRAB). This database includes 14 different inventories of data related to the county road system. In its current form, it has no spatial registration other than road log mile points. It does include accident data from the State Patrol including contributing factors. The program is available to dump data from CRIS to an ASCII format for uploading into other programs.
- TIGER/line road network (U.S. Bureau of Census/Office for Financial Management) Considerable work is needed to clean data.
- Digital Line Graph (DLG) 1:24,000 road network (available from WSDOT, Branch of Geographic Services). Non-topological files.

5. JOURNEY-TO-WORK DATA

- Census Transportation Planning Package (CTPP) will be available from U.S. Bureau of Census and Federal Highway Administration. Data may be released too late to help with a substantial portion of the planning effort.

ACKNOWLEDGMENTS

The authors express their appreciation to the personnel of the many metropolitan transportation planning organizations throughout the U.S. who provided information for this study. Special thanks go to the personnel of the Regional Transportation Planning Organizations throughout Washington State who contributed their time during the workshops, making this study a creative undertaking. The authors would like to recognize the contributions of Elaine Murakami, Larry Blain, Garr Clark, and Glenn Miles for comments provided during the design and documentation of the workshop results. Last, but not least, the authors wish to thank Judith Lorenzo of the WSDOT Design Office (formerly with the Planning Office), as technical monitor, for allowing us the creative leash to draw these ideas together.

REFERENCES

1. Dueker, K. and D. Kjerne, 1989. "Multipurpose Cadastre: Terms and Definitions," in Technical Papers ASPRS/ACSM Annual Convention, American Congress on Surveying and Mapping, Bethesda, MD, April 2-7, 1989, pp. 94-103.

2. Nyerges, T. and K. Dueker, 1988. "Geographic Information Systems in Transportation," invited summary paper included in the Proceedings of the Eastern and Western Computer-Assisted Cartography Conferences in Transportation, published by the Federal Highway Administration, Planning Division, HPN-22, Washington, D. C., July (1988).

3. Nyerges, T., 1990. "Locational Referencing and Highway Segmentation in a Geographic Information System," ITE Journal, March, 1990: 27-31.

4. de la Berra, T., 1989. *Integrated Land Use and Transport Modeling*, Cambridge: Cambridge University Press.

5. Lewis, S., 1990. "Use of Geographical Information Systems in Transportation Modeling," ITE Journal, March, 1990: 34-38.

6. Nyerges, T., 1990. "Software Functionality for Geographic Information Systems in Transportation: Development of a State-Route Digital Highway Network for Washington State," Proceedings of the 1990 Geographic Information Systems (GIS) for Transportation Symposium, American Society of State Highway and Transportation Officials, U. S. Department of Transportation, Federal Highway Administration, San Antonio, TX, March 14-17 (1990): 281-302.

7. Nyerges, T., 1992. "Coupling Spatial Analytic Models and GIS," Proceedings of the 5th Spatial Data Handling Symposium, Charleston, SC, August 2-7. (1992). International Geographical Union.

8. WSDOT, 1991. *Workshop Manual: Land Use and Transportation Linkages.*

9. Nyerges, T., 1992. "A GIS Prototype Application for Monitoring Washington State Transportation Planning Studies," Olympia, Washington: Washington State Department of Transportation, Draft Technical Report No. WA-RD 285.1.

10. Nyerges, T., 1990. "Evaluating Geographic Information Processing Software for Processing TIGER Files," Final Report on Task 1, Joint Statistical Agreement between University of Washington and U.S. Bureau of the Census, March (1990). Contract JSA: 88-28.

11. Rhind, D. W. and P. A. Green, 1988. "Design of a Geographical Information System for a Heterogeneous Scientific Community," International Journal of Geographical Information Systems, 2(2):171-189.

12. State of Alaska, 1986. Bid Specification for a Digital Mapping System for the State of Alaska Department of Transportation and Public Facilities. Department of Administration, Bid No. 11451, Juneau, Alaska.

13. Guptill, S. (ed.) 1988. "A Process for Evaluating Geographic Information Systems," U. S.Geological Survey Open File Report: 88-105, U. S. G. S., Reston, Virginia.

OTHER REFERENCES

Dueker, K., 1987. "Multipurpose Land Information Systems: Technical, Economic and Institutional Issues. Photogrammetric Engineering and Remote Sensing," 53(10): 1361-1364.

Humphrey, T.F., 1990. Suburban Congestion: Recommendations for Transportation and Land Use Responses," Transportation 16:221-240.

Lee D.A., 1973. "Requiem for Large-Scale Models," Journal of the American Institute of Planners 39(3): 163-178.

Meyer, M.D. and E.J. Miller, 1984. Urban Transportation Planning, McGraw-Hill, New York.

Wilson, A.G., 1987. "Transport, location and spatial systems: planning with spatial interaction models" in Urban Systems: Contemporary Approaches to Modeling, Eds C.S. Bertuglia, G. Leonardi, S. Occelli, G.A. Rabino, R. Tadei, and A.G. Wilson (Croom Helm, London)

WSDOT, 1990. *Advanced Planning Task Force Report.*

APPENDIX A

EXAMPLE WORKSHEET:

ISSUES AND REGIONAL TRANSPORTATION PLANNING COMPONENTS

Figure A.1. Example worksheet: issues and regional transportation planning components.

Component Worksheet

Districts:_____ Cluster :_____

components of a regional transportation plan

issue concerns	regional goals & policies	intergovernmental coordination	regional transportation needs	LOS standards	Inventory of services	deficiencies	regional land use strategy	financial plan	system improv.& strategy plan

If an X appears in any cell of a column put an X in the respective cell below.

cluster issue title

APPENDIX B

SAMPLE TALLY

Appendix-B SAMPLE TALLY

WORKSHOP SUMMARY

Regional Transportation Plan Components

Issue/Problem

Group 1

	regional goals & policies	inter-govern-mental coord.	regional transp. needs	LOS standards	inventory of facilities services	de-ficiencies	regional land use strategy	financial plan	system improv. & strategy plan
(A1) Data Collection & Analysis	1	4	1	3	3	3	3	3	3
(A2) Guidelines	3	3	1	1	1	1	1	0	3
(A3) Elected Official Involvement	2	2	1	3	2	2	3	2	2
(B1) Data Inputs For Modeling	1	2	3	2	2	2	3	0	2
(B2) Staffing	3	2	3	3	2	3	3	3	3
(B3) Criteria	2	2	2	2	2	2	2	2	2
(C1) Data Requirements & Transfer	2	2	1	2	0	0	1	0	2
(C2) Consistency (Regional Plan)	5	5	5	5	6	6	5	5	6
(C3) Environmental Issues	3	4	4	0	0	0	4	3	3

Group 2

(A1) ID Roles, Respons.,& Coop	3	3	2	2	1	1	3	3	3
(A3) Information Dissemination (OFM)	0	3	0	2	2	1	2	0	0
(B2) Sources,Access,& Timely Data	0	3	0	0	2	0	3	2	3
(B5) Stand. of LOS/Tech.Criteria	1	2	0	2	1	1	0	0	1
(C1) Unifying Mult.Agency Priorities	2	2	1	0	0	0	2	0	2
(C2) Stand. Models/Format/Data	2	5	3	3	4	3	3	3	3