U.S. Metropolitan Spatial Planning Infrastructures: Institutions, Models, and Tools

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Abstract

Institutions, urban computer models, and planning support tools are important parts of the institutional capacity for U.S. metropolitan regional spatial planning. This paper reports the results of a survey of metropolitan land use and transportation agencies for U.S. metropolitan areas containing populations over one million, collectively home to a majority of the U.S. population. The survey investigates (1) institutions focused on transportation and land use planning; (2) types of urban computer models used for spatial planning; and (3) spatial planning support tool capacity. The article finds that an institutional division between transportation and land use does not necessarily impede coordinated spatial planning or urban modeling. In addition, regions differ in their investment in large-scale models versus planning support tools. Finally, it documents the rapid diffusion of a new class of spatial planning support tools into practice. Based on the results of the survey, regions are divided into descriptive categories.

1. Introduction

The professional practice of spatial planning is a "public-sector-led sociospatial process through which a vision, actions, and means for im-

plementation are produced that shape and frame what a place is and may become" (Albrechts 2004)[1]. Spatial planning involves considering present and future patterns of land use and transportation, which researchers have increasingly viewed as inter-related urban sub-systems. The imperative to improve sustainability outcomes has led to a renewed focus on planning support tools and associated infrastructures. This study surveys the institutions, computer models, and digital tools created by regions for metropolitan spatial planning in the United States.

This study's units of analysis are regional governmental agencies concerned with metropolitan transportation and land use planning. For transportation planning, U.S. federal law requires metropolitan regions designate a Metropolitan Planning Organization (MPO) and provides funding to this organization for "continuing, coordinated, and comprehensive" planning activities. The organizations that carry this designation vary significantly in their size and activities, but in most cases do not have strong statutory powers over either transportation or land use.[2] In certain regions, separate organizations exist that are concerned with land use, and where found these were added to the study.

The study follows a metropolitan regional scale for several reasons. First, it is the scale of metropolitan labor markets (and therefore housing and travel), making it a logical scale for land use and transportation policymaking. In addition, environmentalists have argued the biophysical region (or sub-geographies like habitats or watershed) are logical units for environmental protection, although economic considerations have often dominated the environment in regional planning (Knaap and Lewis 2011). Second, regional agencies often develop specialized tools or services for use by regional municipalities, which can include tools intended to support local planning activities. Given the decentralized nature of government, many powers are devolved to the local level, such as local public services and land use regulation. Generally municipalities within a metropolitan region share a state regulatory context and regional priorities. This means regional entities can provide an economy of scale to provide local tools and services. Furthermore, regional policy entrepreneurs can find external funding to further reduce the cost for services (Feiock 2009). Together these forces make them the logical provider for a range of products and services, including planning services involving data and technology.

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1 I use the term "spatial planning" instead of "land use planning" since this definition differs from traditional American land use planning paradigms.

2 The generic term "organization" is used deliberately since they can take a range of legal forms, including state agencies and 501(c)3 nonprofit organization.

Therefore we should expect regional entities to be pulled in two directions. First, as regional-scale policymakers, they must analyze and plan for the region as a whole, and therefore often develop region-wide spatial strategies through visioning or scenario planning processes (For examples see cases described in Seltzer and Carbonell (2011), for a review of scenario planning Bartholomew (2007)). Second, as resource-constrained actors they must create services that meet the needs of municipalities, separate from organizational goals or priorities.

The tension between these perspectives meets in a new class of local spatial planning support tools that are being developed by many regions. These GIS-based tools are designed to support sketch-planning exercises by providing interactive representation, indicator calculation, and rule extrapolation. Although analytically simpler than large-scale regional models, they can overlap with these tools in their datasets, assumptions, indicators, and other parameters. This study is intended to help place these tools, the subject of a larger research project, into a regional perspective.

Within this general framework, an explicitly exploratory study was designed to answer the following research questions.

1. How have different U.S. metropolitan regions developed institutions, models, and tools to support regional spatial planning? What general types exist among these regions?
2. Which regions have adopted spatial planning support tools, and what are the key factors that explain this adoption?

2. Theory and Previous Research

This study is interested in the institutions, models, and tools developed by regional organizations, and beginning to explore how technologies are developed and used in professional practice. Several social theorists who argue that cities and regions develop specific capacities broadly inform the perspective applied in this study. Transportation researchers have generally focused on the assumptions and structure of the travel demand models themselves, although some scholars recognize how they are used in practice to influence institutions should also be studied. Finally, much of the similar work in this area has appeared as professional reports and white papers.

Social Perspective

In the field of urban education policy, Stone proposed the concept of "civic capacity," or the ability to create civic action. According to his definition, this involves the capacity to step outside the routine operation of running a school system and consider fundamental reforms. "Civic capacity is the conscious creation of actors seeking to establish a context in which extraordinary problem solving can occur" (Stone 2001). Briggs applied the concept to cases in planning, including a spatial planning process in Salt Lake City called Envision Utah (Briggs 2008). Although a useful description of the social dimensions of planning capacity, this perspective omits attention to the role of data, technical tools, and other elements of spatial planning practice.

Writing in planning, Healey proposes a knowledge infrastructure as one part of institutional capacity required for planning. She defines institutional capacity as "enhancing the ability of place-focused stakeholders to improve their power to 'make a difference' to the qualities of their place," and defines three dimensions: knowledge resources, relational resources, and its capacity for mobilization" (Healey 1998). Healey's concepts provide a useful starting point, but not have been widely applied in planning. Adopting her language, the objects of the study are the knowledge resources developed by the organizations – a combination of artifacts and staff capacity that can be deployed for specific purposes.

Finally, scholars in the field of science, technology and society (STS) argue technologies should be understood as sociotechnical infrastructures. In particular, Edwards has sketched a multi-scalar perspective that directly inspired the research design of the larger study (Edwards 2003). Edwards argues the theory and conclusions we draw about any particular technology or infrastructure depends on the scale of time and space we use, so the long-term perspective of infrastructure does not negate the many small decisions or steps that contribute to a seemingly inevitable state. Ferreira and Evans apply this perspective to spatial data sharing, arguing constructing "data pipes" whereby information is shared cannot be analyzed without integrating social and technical factors (Evans and Ferreira 1995). This theoretical stance admits the crucial role of technical artifacts as both object of study as well as part of social explanations.

Modeling Perspective

Much of the literature on transportation and land use modeling has focused on the structure, assumptions, and theories embodied within the models

themselves (For example, see Shiftan and Ben-Akiva (2011)). Lee critiqued large-scale urban models as not useful for policy (Lee 1973, 1994), and others have defended recent versions as much improved thanks to new data sources and refined throy (Wegener 1994). Other scholars, like Wachs, have discussed the ethical issues surrounding forecasting (1990; 2001).

Another emerging strand of research adopts broadly sociotechnical perspectives suggested above. For example, Gundmundsson argued transportation models should be understood using a variety of research about the use of knowledge in public policy, which argue for an expansive perspective on how models are "used" (Gudmundsson 2011). Guhathakurta has attempted to synthesize modeling with the communicative paradigm from planning theory (Guhathakurta 1999), or as storytelling (Guhathakurta 2002). This paper contributes to this literature by providing a description of which regions have institutionalized models, and which types of models they have adopted.

Professional Perspective

Several research reports and white papers provide complementary resources to this survey. The consultant Vanasse Hangen Brustlin, Inc. conducted a large web-based survey of 200 MPOs for the National Research Council, focusing on the state of practice of travel forecasting (National Research Council 2007). However, the report does not cover how the models were integrated into decision-making processes, or their relation to decision support tools.

Several MPOs have commissioned research reports on related topics. For example, the Atlanta Regional Commission commissioned a literature review and report on land use modeling (Bowman 2006). And the Sacramento Area Council of Governments commissioned a report on integrated land use and transport modeling (Sacramento Area Council of Governments 2001), also the topic of a Transportation Research Board report focusing on land use and public transit (Miller, Kriger, and Hunt 1999).

Finally, decision support tools have also been discussed in several relevant reports. A report from the Lincoln Land Institute describes some of the leading planning support tools (Holway et al. 2012). A report completed for two California state agencies concluded that traditional four-step travel demand models lacked sufficient sensitivity to evaluate smart growth land use proposals, advocating for applying elasticities from empirical research either in a spreadsheet model or using the planning support

systems INDEX or I-PLACE^{3}S (California Department of Transportation 2007).

3. Survey Methodology

A five-question survey was sent to all MPOs serving U.S. Census-defined Metropolitan Statistical Areas with populations over 1 million. A list of Metropolitan Statistical Areas and their Census 2010 population was obtained, and the corresponding MPOs were identified using a list from the Association of Metropolitan Planning Organizations.[3] A five-question survey was sent to the general contact email or through the general contact form, enclosed as Appendix B. In cases where these were not available, the message was sent to the designated managers in charge of transportation and land use planning, if available. Messages were sent on November 26, 2012. All MPOs who had not responded were sent a follow-up message one week later on December 4th. The final universe included 46 organizations, since some MSAs are served by the same MPO.

The overall response rate was 50%, however the response rate for medium and large MSAs (with populations over 2 million) was significantly higher than for MPOs in smaller MSAs.

Table 1. Response Rate Summary.

Size	Responses / Total	Response Rate
Large (population over 5 million)	6 of 9	67%
Medium (2-5 million)	11 of 16	69%
Small (1-2 million)	4 of 20	20%

[3] See the Association of Metropolitan Planning Organizations MPO Directory Listing online here: https://www.ampo.org/directory/

4. Results

Institutional Variation

In several regions, transportation and land use are functionally divided between two or more agencies, summarized in Table 2 below.

Table 2. Regions with Separate Land Use and Transportation Organizations.

Metro	Transportation	Land Use
New York	Metropolitan Transportation Commission	Regional Plan Association
Boston	MPO/Central Transportation Planning Staff	Metropolitan Area Planning Council
San Francisco	Metropolitan Transportation Commission	Association of Bay Area Governments
Austin	Capital Area MPO	Capital Area COG
North Carolina Research Triangle Region	Durham Chapel Hill Carborro MPO Capital Area MPO	Triangle J COG

These divisions seemed to prohibit the tightest integration between transportation and policymaking (found in several regions, as described below), however division alone did not prohibit all cooperation. In Boston, MAPC does coordinate with CTPS, the administrative home of the MPO as the agency is a voting member of the MPO. In Austin, CAMPO took the lead on a regional visioning exercise, and CAPCOG is the lead recipient of a regional planning grant loosely alighted with the result of the regional visioning exercise. The highest level of technical coordination among these divided regions was found among the three organizations in the Research Triangle region of North Carolina, which jointly operate a transportation model. New York City and San Francisco showed the least amount of coordination. Informants from these MPOs did not report cooperating with their land use counterparts, and a current regional land use vision does not exist for either metropolitan area.

MPOs reported varying levels of land use planning. Many conducted high-level planning using a scenario framework to consider alternatives (such as Boston's MetroFuture or Salt Lake's Envision Central Utah). Others described a more ambiguous role, sometimes both denying any role in land use in addition to describing land us planning projects. For example, New Orleans reported there was no coordination between land use and

transportation in their region, but then reported a variety of activities including supporting local comprehensive planning including "works closely with local planning directors to implement smart-growth strategies." Others, such as the Indianapolis MPO, reported only aggregating local land use plans to determine transportation needs.

Modeling

As summarized in the table included as Appendix A, transportation modeling capacity varies widely across MPOs. From the narrative responses, the MPOs were divided into four categories:

- Four-step travel model only
- Four-step travel model plus others
- Partially integrated land use and travel models
- Fully integrated land use and travel models.

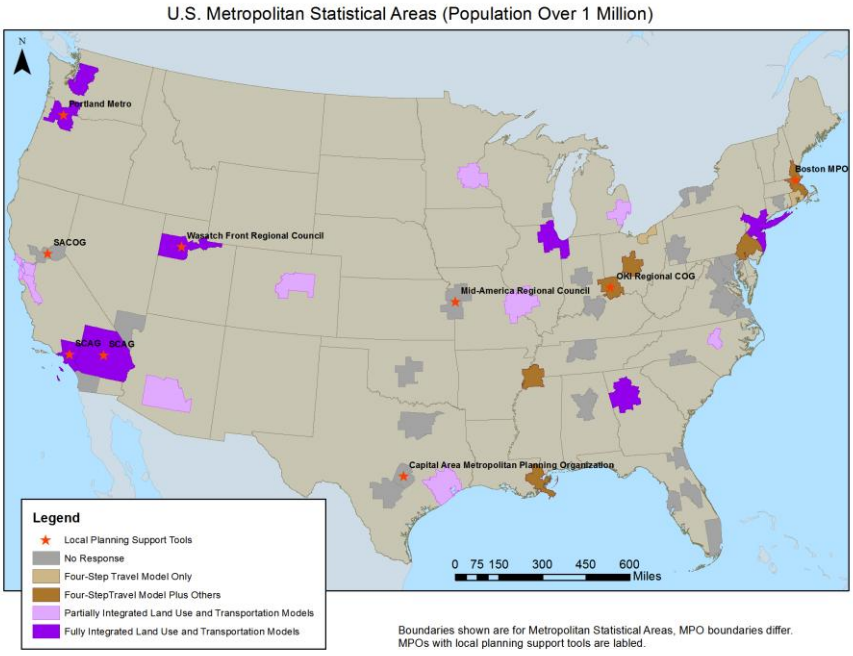

Fig. 1. Urban Modeling and Planning Support Infrastructures, U.S. Metropolitan Areas

Some regions reported using demographic or other forecasting models, as well as additional models on air quality if their region is in non-attainment status for particulate air pollution. Notably, advanced transportation modeling only partially overlaps with regions that have invested in planning support tools (described below). Those that have both include Salt Lake City, Portland, Oregon, and Los Angeles.

Local Spatial Planning Support Tools

The survey also asked about tools available to local spatial planning. For several reasons it may not have captured the intended information. First, the question was worded somewhat ambiguously, so the MPO staff might not know it referred to planning support tools. Because most of the early survey questions concerned modeling, in most cases technical staff were assigned to provide responses, there may be response bias by staff who are unaware of or didn't think of existing tools. However, the data from this survey question was supplemented with information from several additional sources. Many people involved in spatial planning support tools attended a conference in Portland, Oregon in November 2012 and have been participating in an informal community of practice involving monthly conference calls and other activities.[4] In addition, ongoing research to develop cases for the broader research project that is the context of this paper has resulted in the discovery of activities in several metro regions. Finally, during the survey process the website of each MPO was reviewed and some contained information about these tools.

Five regions have relatively mature planning support infrastructures.

- **Southern California Council of Governments (Los Angeles)** – Reported using Rapid Fire model developed by Calthorpe and Associates for their next regional transportation plan. The successor being considered is the Rapid Fire tool. These two focus on the impact of land use on VMT and greenhouse gas emissions. Although they did not respond to the survey, the San Diego Council of Governments (SANDAG) is also a leader in local decision support tools.
- **Wasatch Front Regional Council (Salt Lake City)** – Developing Envision Tomorrow +, a scenario planning tool that will be available next year for general use. This tool was created by Portland, OR-based Fregonese and Associates, but the University of Utah is heavily in-

[4] The Open Planning Tools Group, see http://scenarioplanningtools.org

volved in its development and will be its eventual home as an open source project.

- **Metropolitan Area Planning Council (Boston)** – Uses CommunityViz to develop project-specific decision support tools. The organization is exploring developing a more general scenario-modeling tool.
- **Sacramento Area Council of Governments** – Developed I-PLACE^{3}S, a web-based land use scenario and sketch-planning tool, and like SCAG is developing a web-based replacement.
- **Ohio-Kentucky-Indiana Regional Council of Governments (Cincinnati)** – Makes available a "OKI Fiscal Impact Analysis Model" to local governments that "enables fiscal comparisons of land use scenarios as land use planning (and even development activities) occur in a community."

The California MPOs have well-developed tools that have been used for many planning projects. Boston and Salt Lake City emerged from regional planning exercises, where the technology was first used. Cincinnati's responds to a focus on fiscal impacts of land use regulation.

In addition, the study found three regions where planning support tools are under development:

- **Capital Area Council of Governments (Austin, TX)** – Is using Envision Tomorrow as part of a HUD-funded Sustainable Places project. The project involves several demonstration sites, as well as funds for researchers at the University of Texas to collaborate with Fregonese and Associates on developing several additional "apps," including a fiscal impact tool.
- **Mid-America Regional Council (Kansas City, MO)** – Developing an Envision Tomorrow and other modeling tools as part of a HUD-funded planning project.
- **MetroPlan Orlando** - Although the agency did not respond to the survey, the organization issue a request for proposals in fall of 2012 for the "enhancement of existing land use performance measurement tool." The proposed tool would integrate with the existing travel demand model but create more precise estimates of the travel impact of smart growth and mixed use development by taking into account alternative modes.

Several regions viewed support tools as embedded within "technical assistance" services:

- **Chicago Metropolitan Agency for Planning** – Local Technical Assistance program, funded by a HUD Sustainable Communities grant, to "provide assistance to communities across the Chicago metropolitan re-

gion to undertake planning projects that advance the principles of GO TO 2040 (regional plan)."

- **Atlanta Regional Commission** – Makes available a set of "implementation tools," which include GIS layers, as well as regulatory standards, self-assessment checklists, and model codes.
- **Capital Area MPO/LPA (Raleigh, NC)** – Reported that they "conduct rolling regional studies to address detailed issues for different parts of our MPO. During these studies, MPO and consulting staff work closely with local planners and elected officials to facilitate a thoughtful planning process."
- **OKI Regional Cog (Cincinnati, OH)** – Provides a comprehensive plan guide document.

One region, Minneapolis, explored developing decision support tools using funding from a HUD Sustainable Communities grant but the project was abandoned. According to an informant there, they concluded the technology was too complicated to be easily deployed to municipalities or community organizations and have shifted investment towards other areas: "economic competitiveness strategic planning" as well as more advanced modeling.

The observed rapid and ongoing diffusion of this new class of tool suggests they can be analyzed as innovations that are diffusing in a population of regions as specified by Rogers theory of the diffusion of innovations (2003). An innovation is an idea that solves a problem, and diffusion is "the process in which an innovation is communicated through certain channels over time among the members of a social system." Several perceived characteristics of innovations explain their rate of adoption: relative advantage, compatibility, complexity, trialability, and observability (Rogers 2003). Although there are too few regions for a quantitative study, the available evidence strongly suggests new planning support tools and planning practices were developed by a small group, and it then spread to other regions through a diffusion process featuring a small group of change agents and opinion leaders. However, this theory also helps explain why diffusion has been strongly associated with proximity to existing users. This perspective will be explored further in subsequent research.

5. Regional Types

Three variables were used to construct a typology of regional modeling capacity: the level of planning support capacity, the institutional arrange-

ment (unified or separate agencies), and the size of the metro region. The "Average Joe's" category includes many regions that might shift to another category when and if they develop planning support system (PSS) capacity.

Table 3. Regional Typology

<table>
<tr><th></th><th colspan="2">High PSS Capacity</th><th colspan="2">Low PSS Capacity</th></tr>
<tr><th></th><th>Small/Medium</th><th>Large</th><th>Small/Medium</th><th>Large</th></tr>
<tr><td rowspan="2">Unified Agency</td><td>Minor League All-Stars (3)</td><td>800-Pound Gorillas (3)</td><td rowspan="2">Average Joe's</td><td>Sleeping Giants (9)</td></tr>
<tr><td colspan="2">Separate Agencies Making Lemonade (2)</td><td>Fragmented Metropolis (2)</td></tr>
<tr><td>Other</td><td colspan="4">Missing in Action (2)</td></tr>
</table>

High PSS Capacity Types

Regions with high capacity for planning support systems were divided into three categories:

Minor League All Stars – These are smaller metro areas that have a unified agency, and are among the most sophisticated agencies in the country. They are often geographically isolated from other metro regions and have developed a strong normative agenda for regional growth. They currently include Salt Lake City, Sacramento, and Portland. A potential city for this type is Seattle.

800-Pound Gorillas – These large metro areas have sophisticated, unified agencies, and often highly developed tools. Their normative agendas are less clear than the first group. They include Los Angeles, San Diego, and Sacramento. Potential cities include Denver and Chicago, where transportation and land use agencies were recently merged.

Making Lemonade – These regions are making due with existing resources: they have developed regional planning capacity despite institutional divisions. They include Austin and Boston.

Low PSS Capacity Types

Regions with low PSS capacity were divided into four categories.

Fragmented Metropolises – This category includes two large, wealthy metropolitan regions that are perhaps unique: New York and San Francisco. In these regions, transportation planning is highly technical and not linked to local decision-making. Land use planning capacity is limited, and performed by separate agencies (The Regional Plan Association or the Association of Bay Area Governments).

Sleeping Giants – This category includes large and medium regions with substantial technical modeling infrastructures but little decision support capacity. This is usually due because of an explicit or implicit assumption that local land use decisions should be made autonomously, and the role of the regional organization is to respond to land use with transportation and provide value-neutral services to the municipalities. They include Atlanta, Miami, Houston, Philadelphia, Dallas, Chicago, Minneapolis, Seattle, and Detroit.

Average Joe's – These regions have various sizes and institutional arrangements. They have not developed regional support capabilities yet, but if they did could be candidates for other categories. Category includes Phoenix, Denver, St. Louis, New Orleans, and others.

Missing In Action – These regions do not have a functioning regional entity. They include Cleveland (where the MPO is staffed by one employee of the city), and Providence, where the state Division of Planning performs this role. It may be possible additional MPOs that did not respond to the survey fall into this category. Without further investigation it is difficult to make any conclusions, given the variety instructional structures it may or may not indicate a lack of regional planning.

6. Conclusions and Future Research

Institutions

First, with regard to the first research question on institutions, data, and modeling. Multiple agencies pose challenges, but the evidence seems to suggest it is possible to coordinate across agencies. In addition, single organizations does not guarantee good integration between transportation and land use planning. Despite the minimal requirements, the availability of federal funds mean extensive technical modeling is completed for trans-

portation. Only a few regions have adopted modeling paradigms (activity-based, or integrated transportation and land use) that support land use modeling.

Decision Support Tools

Many regions are developing decision support tools tailored to regional issues and priorities. Where it exists, capacity is created through planning activities and requires an organization to have a normative consensus around regional goals. Put it other worlds, regions must believe in the need for alternatives from the current trends before they are willing to invest in a tool to help evaluate alternative proposals.

In addition, planning cultures play a role in the type of data and models cultivated. Transportation planning arose around questions of how to design freeway networks, and in some cities take into account passenger and freight rail networks. New management strategies like tolling have required changes to modeling strategies. These tools are sufficient for evaluating a small number of large infrastructure projects, viewing these as the locus for regional planning, as has happened in New York or San Francisco. Other regions more attuned to patterns of land development invest in much more detailed land use planning, including the land-constrained Portland and Salt Lake regions, where urban growth is confined within a fertile valley and must compete with agricultural uses. Relatively land-rich Atlanta, Detroit, and Boston do have environmental harms from sprawl, but other concerns predominate. These observations suggest a subtle relationship between geography, institutions, and planning cultures that will be manifested in the design choices of appropriate planning support tools for these regions.

Finally, state institutional and regulatory frameworks are crucial to understanding the regional organizations. Planning activities in California are heavily influenced by Senate Bill 375, which mandates spatial planning activities to cut greenhouse gas emissions (Barbour and Deakin 2012), and the state's mandate for every municipality to plan for housing. Similarly, Portland's innovative Metro was empowered by strong state legislation. In Massachusetts, the Chapter 40B affordable housing law incentivizes proactive land use planning by towns that do not have sufficient affordable housing by providing a remedy to local exclusionary zoning.

Future Research

Several subsequent research steps are anticipated. First, several responses were received late and have not been fully incorporated into this description. In addition, more detailed research is needed to expand and verify the information obtained from the survey by reviewing the technical documentation and websites provided in response. Second, additional informant interviews are planned to explore in more detail the existing tools, and begin to develop a developmental model to explain how and why regions develop planning support tools.

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Appendix A. Modeling Review

Metro	Four-Step Transportation	Activity-Based Model	Land Use Model	Other Models	Decision Support	LU-Trans Interaction	Specific Types (if mentioned)
New York		✓		✓		N	UrbanSim
Los Angeles	✓	✓	✓	✓	✓	Y	Transcad, PECAS, EMFAC-CARB
Chicago	✓	✓				Y	
Philadelphia	✓		✓			N	PTV VISUM, UPlan
Houston	✓					Partial	
Atlanta	✓	✓		✓		Y	CT RAMP
Boston	✓	*		✓	✓		CommunityViz
San Francisco	✓	✓				Partial	CT RAMP
Detroit	✓		✓			?	UrbanSim
Phoenix	✓		✓			Y	Transcad, Urbansim
Seattle	✓	*	✓			Y	UrbanSim
Minneapolis	✓					Partial	
St. Louis	✓		✓			Partial	TransEVAL, VISSIM, Synchro, aaSIDRA, LEAM
Denver	✓	✓		✓		Y	EPA MOVES (air quality)
Portland	✓		✓	✓	✓	Y	Metroscope, MOVES (air quality)
Cincinnati	✓					?	
Cleveland	✓					N	
Columbus		✓	✓			N	
Providence	✓		✓			Partial	ArcMap (LU)
Memphis	✓		✓			?	TransCAD and CommunitViz
New Orleans	✓						
Raleigh	✓		✓			Partial (one-way)	CommunityViz Allocation Model (LU)

Salt Lake City	✓	✓	✓	Y	Cube, UrbanSim (LU)

Appendix B. Survey Instrument

Regional Transportation and Land Use Modeling Infrastructure Survey

Instructions
This survey contains questions about the transportation and land use models available in your region for planning and project evaluation. Short answers are sufficient, and feel free to direct me towards websites or other materials that contain supplementary information. Please answer what you can and feel free to refer me to another agency or contact if necessary. If you indicate below, I will provide a summary of the resulting data at the conclusion of the study.

Questions
1. What models or standard analyses are performed on (a) regional transportation plans and (b) large transportation infrastructure proposals?

2. Is your agency also responsible for regional land use planning in your metropolitan region? If not, which organization(s) conduct land use planning at the regional scale?

3. Which models or standard analyses, if any, are performed on (a) proposed local or regional land use plans and (b) large-scale land use proposals?

4. What is the interaction between transportation and land use planning in your region? Are the models or analysis tools integrated or linked?

5. What tools and resources are available to local governments to conduct transportation and land use planning within your region? Do these tools contain or reflect regional forecasts, goals, priorities, models, etc.?

Thank you for your assistance.