Over the past two decades, geographic information system (GIS) technology has evolved into a valuable tool for the field of transportation planning. The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 and the Transportation Equity Act (TEA-21) of 1998 required transportation agencies to use information technologies, integrate with land use more directly, and offer more transportation options, among other things. They also meant that more funds were available for projects, research, and development involving intelligent transportation systems. As a result, many transportation agencies began using GIS to fulfill such mandates (Wiggins et al 2000).

The use of GIS for transportation (GIS-T) in planning applications is typically seen in the form of modeling scenarios to predict the effects of potential policy changes. These models are becoming increasingly more useful and complex. In 2004, Arampatzis et al presented a modeling tool that integrates several functions including not only multi-modal transport network and travel demand analysis and database management, but also assessment of energy consumption, pollutant emissions, and policy scenario simulation and comparison. The ability to perform all of these functions within the same tool is very important to transportation planners.

In a GIS environment, a variety of functions can be used to interpolate, analyze, and display spatial data related to transportation. Some tools use isochrones, or lines of equal travel time, have been used to combine accessibility measures and the space-time geography framework in a GIS setting (O’Sullivan et al 2000). Many GIS-T modelers create tools that are compatible with existing GIS operational environments to make use of existing technologies. For example, accessibility to particular modes of transportation by different populations can be modeled using an ArcView extension program called Accessibility Analyst (Liu and Zhu 2004). One of the challenges of GIS-T is adapting GIS software to work with traditional transportation planning models and methods (Trépanier and Chapleau 2001).

Integrating new technologies with traditional frameworks, or legacy data management, is one of the top research areas within the field of GIS-T. Other popular research topics include data interoperability (data quality and exchange standards), real-time GIS-T, large data sets, and distributed computing (making efficient use of increasingly ubiquitous computing resources) (Thill 2000).

A popular application of GIS in transportation planning is public transit networking and routing. Transit modeling uses a variety of GIS spatial analysis functions for identifying
nearest stops on a transit route, calculating distances between stops or between origin and destination points, calculation of temporal values over those distances, etc. (Choi and Jang 2000). Transit modeling tools also facilitate the integration of real-time global positioning systems (GPS) into transit authorities (Trépanier and Chapleau 2001). The Rhode Island Public Transportation Authority has recently installed GPS units as well as electronic fare boxes on their buses in order to enhance their transit service and collect better data. They hope to eventually provide real-time estimated time of arrival data to passengers waiting at bus stops by either displaying the information on a small screen or sending an automatic text message to their cell phones.

Many of these GIS-T concepts have even been applied to web-based transit applications, like Google Transit, for use by the general public. Because transportation has become such an important facet of our daily lives, we are seeing (and will continue to see) widespread use of transportation programs and gadgets intended for the general public. Some GIS researchers and developers are concerned that this type of mass market for GIS could result in irresponsible or incorrect use of spatial data (Wiggins et al).

Miller and Wu make an important distinction between accessibility and throughput, which they define as the amount of system flow. Many models measure the performance of a transportation system by measuring throughput, which assumes that traveler benefits are also based on throughput. However, traveler benefits are more closely associated with accessibility (Miller and Wu 2000), or the ease with which activities at one place may be reached from another via a particular travel mode (Liu and Zhu 2004). Therefore, transportation analysis should assess performance based on maximizing accessibility.

Integration of land use and transportation is a recurring theme in transportation planning in large part due to the enactment of ISTEA and TEA-21 in the 1990’s (Waddell 2003). Transportation interaction patterns can be highly variable between different geographic areas and different land use areas, therefore, it is important for transportation planners working with GIS to identify the spatiotemporal patterns underlying these complex geographic variations. Transportation planners can better understand and visualize the interaction between land use and transportation through manipulation of spatial, attribute, and temporal elements in GIS-based exploratory analysis systems (Shaw and Xin 2003).

Remote sensing plays a vital role in GIS-T. Aerial data is used to site intermodal facilities, identify right-of-way corridors, monitor change in land use over time, assess environmental health and impact, monitor traffic congestion and flow patterns, etc. (Wiggins et al 2000). It is necessary for transportation planners to continue working with remote sensing specialists to develop and identify the proper remote sensing and image analysis techniques for particular applications.
Thill (2000) outlines three functional groups that make up the GIS-T framework: data management, data manipulation, and data analysis or analytical modeling. Each group falls under the next, creating a hierarchical model in which data management is contained within data manipulation, which is contained within data analysis. This grossly simplified model could be used to describe any other type of GIS.

Applications for GIS in transportation planning have exploded in the past several years and will likely continue to grow. Advances in GIS have allowed for more efficient and portable spatial data storage, increased model accessibility, ease of database maintenance and updating, and cartographic display of model results (Arampatzis et al 2004).

References


Annotated Bibliography


This paper presents an interesting modeling tool known as a decision support system (DSS) that uses GIS to evaluate transportation policies. The tool features several integrated functions including multi-modal transport network and travel demand analysis and database management, assessment of energy consumption and pollutant emissions, and policy scenario simulation and comparison. The DSS tool is implemented with MapInfo, which serves as a central repository for the basic network data, as an intermediate storage space for scenario parameters, and as the user interface. The GIS database stores a host of attributes including topographic, toponomastic (street names), physical, transport and transit information. In this paper, the use of the DSS is demonstrated using policy scenarios for Athens, Greece. However, the tool is designed to be applicable to any geographic location by entering regional data into the GIS database. The authors emphasize the role of GIS in providing realistic representations of multi-modal transportation networks, user-friendly interfaces and effective visualization of network equilibrium solutions.


The introduction of this paper provides a brief overview of the potential applications that GIS could have for transportation planning, explaining that GIS is usually only used for mapping fixed transportation infrastructure. Choi and Jang argue that GIS software must be enhanced in order to be useful for transportation planning. However, having been published eight years ago and given the rapid pace the GIS technology is being advanced and utilized, it is likely that many of the proposed applications are being used with more success. In fact, the other articles I have reviewed have presented tools that go well-beyond simply mapping static transportation infrastructure. The paper goes on to detail a method of integrating GIS with widely used transportation modeling software to model transit-oriented travel demand. Using spatial analysis and dynamic segmentation, the tool is able to identify nearest stops to a given point along a transit line as well as Because this tool can be used with the legacy urban transportation planning systems, the authors expect this tool to be useful for planning agencies in other cities.

Liu and Zhu present an ArcView extension program called Accessibility Analyst that creates accessibility models for urban transportation planning. They define accessibility as the ease with which activities at one place may be reached from another via a particular travel mode. Accessibility Analyst provides four main functions for transportation planners: data preparation, travel-impedance measurement, accessibility measurement, and visualization. The authors demonstrate the tool’s capabilities by modeling before and after accessibility scenarios for a proposed mass rapid transit system in Singapore. After calculating accessibility values for defined geographic zones, accessibility surfaces are displayed as 2-D isoline maps and 3-D views where higher peaks represent higher accessibility values. The authors note that the strengths of this tool are its ability to relate transportation and land use, evaluate the efficiency of transportation networks, transportation infrastructure planning, facility planning and the impact assessment of transportation policies.


After years of experience involving extensive origin-destination surveys in Montreal, Trepanier and Chapleau present an object-oriented GIS (OO-GIS) to link transit and road networks using a totally disaggregate approach. The city of Montreal has been testing this method in order to improve the use of GIS in mapping, bus interlining, user information, origin-destination surveying, and infrastructure management. There are four types of objects in object-oriented GIS: static objects (e.g. boundaries), dynamic objects (e.g. buses, cars), kinetic objects (e.g. streets, transit routes), and system objects (e.g. road networks, transit networks). In an OO-GIS, data must be georeferenced, classified, and related. Unlike traditional GIS where streets were recognized as a sequence of arcs, this OO-GIS defines streets as whole objects while maintaining information on each section. This application is highly beneficial for transit agencies which need to plan bus routes on existing road networks.


This article focuses on transportation planning in the larger context of land use planning. UrbanSim is an Open Source modeling program developed by the Oregon Transportation and Land Use Model Integration Project that integrates land use,
transportation, and environmental planning. Input data includes a parcel file, a business establishment file, integrated Census data, and GIS overlays for traffic zones, environmental, city, county, and urban growth boundaries. After the user applies choices and constraints, input data are processed through a set of data integration tools to produce a data model which is then displayed in a GIS environment. Data can be aggregated to Traffic Analysis Zones, allowing for simulation of new transportation policies over time. To illustrate the implementation of UrbanSim, Waddell describes the first full application of UrbanSim in Eugene-Springfield, Oregon. After 15 years of model simulation starting from 1980, simulated results were very similar to observed data. In addition to simulating values, the UrbanSim can also predict changes in values over time, although not as accurately as values alone. The program is limited in its predictions; for instance, it cannot predict large-scale events such as the downsizing of a major factory or the opening of a new mall in the region, as was the case in the Eugene-Springfield example.


Wiggins et al provide a broad contextual framework for the use of GIS in transportation planning and management by describing implications of policies enacted in the 1990s. Parts of this legislation required transportation agencies to incorporate information technology systems as well as more direct land use considerations in their planning processes. That, combined with increased funding for intelligent transportation systems projects, research and development, prompted many agencies to begin utilizing GIS. The authors go on to describe a few scenarios that illustrate where we are (or where we were in 2000) with respect to GIS and speculate on where we’re going. Some of the “where we’re going” predictions have or are beginning to manifest, like increased use of web-based transit planning programs, increased availability and affordability of high quality data, and increased use of cellphone and internet mapping and GPS applications by the general public. On the other hand, several of the authors’ predictions have not yet manifested. None the less, discussion of these scenarios leads to several research and educational challenges. Research challenges include data sharing, integration of multiple sources of data at a variety of scales, accuracy and currency of data, and the transition to a mass market for “spatially enabled consumer toys”. As far as I can tell from this literature review, progress has been made in each of these areas but they still remain key issues in the GIS-T field. The authors emphasize the importance of GIS-T education in advancing the field by discussing challenges like supporting infrastructure, access and equity, alternative designs for curriculum content, professional GIS education programs, and accreditation and certification. Many of these points are valid for GIS in general, not just GIS-T.