THE USE OF GIS AS A TRANSPORTATION MANAGEMENT SYSTEM

ABSTRACT: The goal of this paper is to present ideas in establishing a multifunctional GIS transportation management system/database for transportation officials to make more informed decisions regarding all facets within the Rhode Island transportation network. Discussion will touch upon items that would make up such a system in regards to data sources, data models, and analytical procedures. Types of transportation related management systems already in place will be mentioned and the future for GIS in the civil engineering practice will be discussed as well.

The American Society of Civil Engineers recently updated its national state-by-state report card for infrastructure conditions conducted in 2003. The findings show that 40% of the major roads in Rhode Island are congested, 54% of Rhode Island’s major roads are in poor or mediocre condition and the same percentage of bridges within the state are structurally deficient or functionally obsolete. These findings amount to congestion within the Providence area that costs commuters $583 per person per year in excess fuel and lost time. Also driving on roads in need of repair costs Rhode Island motorists $346 extra for vehicle repairs and operating costs per year. Aside from the growing need to improve the infrastructure, the bridge network within Rhode Island is a vital link to the entire transportation network. With many bridges in need of repair and nearing their design life a stable and reliable bridge management system is necessary. The use of a geographical information system has benefited several states in managing their bridge network together with their respective transportation/traffic networks. GIS is a powerful software package capable of providing intricate spatial data models and performing advanced network analysis to aid in managing bridge/traffic/transportation networks.

Rhode Island DOT, like many DOT’s around the country relied largely on blueprint drawings of highways and bridges before the advent of scanners and computers that were capable of storing large maps and structural drawings. Most of the DOT’s older highway maps and bridge drawings have been scanned and remain on a remote database. Information about bridges has also been scanned into a database, however, there is data that is missing or displaced. Information isolation is a problem and can easily occur when data that exists is hard or almost impossible to find. The process of recovering data needs to be updated and the use of a GIS is just the solution. The ability to have one single “point & click” data base that has all the information needed for an engineer to perform research and make appropriate informed decisions would save the state money and place its transportation system into the 21st century.

The goal would be to incorporate highway, bridge, traffic, and utility data onto multiple layers within a GIS. Each coverage could be fully equipped with links to various sources of data. Highway data could include geometric designs, pavement designs, pictures; bridge data could include foundation designs, structural designs (AutoCAD drawings), bridge composition, instrumentation (strain, deflection, etc.) data, pictures, movies; traffic data could include signal plans, traffic sign locations; utility data could include plans and drawings. The system architecture of a recently implemented bridge management system in Malaysia uses links within the GIS to access information such as bridge reports, AutoCAD files, picture and movie files (She 1999)

The use of a GIS as a transportation management system is already in use in parts of the country and world. Places such as New York, Texas, Wisconsin and South Dakota are just a few states that have a GIS based management system for their transportation networks (Adams, T.M. 2002). In both the city and county of Denver, Colorado a new GIS based system
was set up to handle the entire public infrastructure system. It was determined that a reliable bridge management system must contain bridge qualifications and characteristics and also a bridge’s geographic relationship to the infrastructure system (Rens 1999). Oklahoma recently dealt with a tragedy in which a barge traveled off course and struck a bridge pier causing four spans of a multi-span bridge to collapse (Adams, J. 2003). The tragedy cost 14 lives and knocked out a major east-west passage through the state. Within 2 hours of the accident the ODOT was able to use its GRIP system, a GIS based transportation management system, to find alternate routes over the damaged bridge.

In addition to setting up an intricate spatial model of the transportation network in Rhode Island, GIS can perform network analysis and build network models that could determine specific routes under restrictive conditions. A network may be defined as a set of connected features (centers). These features may be centers of demand, centers of supply, or both. These centers are connected to one more network links. The interconnected links create paths. In performing routing procedures there are often a number of alternate routes. Best route implied in truck routing is the path that minimizes any impact to the structural integrity of the system and potential to impose harm to the users of the system. Algorithms are the data models that create vehicle routes. In a case study in Texas Dijkstra’s algorithm was used in finding the shortest path for a vehicle (Osegueda 1999). Computational flow charts seem to give a well represented approach to writing algorithms to calculate vehicle routes given network and vehicle restrictions (vertical/horizontal clearances, weight, axle spacing, etc.).

For example, oversized and overweight trucks must apply for a permit from the Division of Motor Vehicles to carry its payload through Rhode Island. In turn the DMV requests that the DOT perform a route analysis of the vehicles start and destination points. Along the route are bridges that must be rated according to the gross vehicle weight of the truck. The rating ensures that the truck will not undermine the structural integrity of the bridge and will be able to pass under, over and through a bridge without clearance issues. If a bridge does not pass then the route taken must be altered and a new path must be load rated. The DOT allows up to 5 days for a single person to spend time on issuing only one permit. If the reviewing engineer has a problem with the permit it may end up going back to the customer for revision further extending the time allotment per permit (Adams, T.M. 2002). Using a GIS truck routing system would cut down engineering time and issue permits faster and more efficiently then the current system.

The future of GIS in civil engineering is only growing larger. The area of Transportation in GIS is an emerging field that promises to be dependent on each other in several years. I believe the increased use of GIS by the transportation community will spawn new editions of ARC software that will cater to transportation related needs. Engineers will enter an age where data will seem limitless. Quick yet informed decision making will save taxpayers money and benefit the overall body of the transportation network.
ANOTATED BIBLIOGRAPHY


A detailed look into Oklahoma DOT’s GRIP system which is a transportation GIS that provides access to all ODOT databases within the state. Current status and the history of how it was made is discussed. The beginning of the article was highlighted by a tragic accident in which a bridge collapse cost lives as well as created a major traffic problem. The bridge was a major east-west crossing and an alternative route(s) were needed. The article further discusses how GRIP was used in analyzing the alternative routes for traffic re-routing within 2 hours of the accident. An interesting portion of the article discussed the early stages of GIS in Oklahoma and the use of varying databases within state agencies. The need for a centralized database from all divisions of ODOT was apparent and eventually the system was changed. The GRIP system in Oklahoma is just another example of the valuable use of GIS within the transportation field.


This article discusses the general requirements for a GIS based truck permitting system for oversized and overweight vehicles. Requirements were based on a consensus of work performed in Texas, South Dakota, New York and Wisconsin. Algorithms have been proposed for network analysis and many considerations non-time based and time based or temporal considerations have been considered within the algorithm. The article is clear and concise and highlights the financial and time reducing benefits that a GIS based routing system has on a permitting agency. The latter portion of the article discusses the “platform” or programming software used in conjunction with ArcINFO 8 as the GIS tool for the project. The portion most interesting about the article is where the authors discuss the algorithm for restricting evaluation points prior to generating routes for the permit vehicle.


A prototype methodology was developed for the management of various highway infrastructure components. A GIS based software (ARC/INFO 7.04 backbone) called InfraManage integrates and implements GIS procedures to manage five highway components (pavements, bridges, culverts, signs, and intersections). This software integrates life cycle cost analysis, utility theory, and optimization techniques providing for reasonable engineering and economic decision planning. This article offers insight into combining more output parameters from a GIS based transportation management system. A sample study performed in Champaign County Illinois showed an optimization process for candidate improvement project presented using GIS.


GIS and expert systems are proposed in this piece of literature to aid in comparing candidate sites for road construction. Although the article is fairly old it discusses a new way of implementing GIS for use within the transportation field. Rather than a management system the GIS in this article was proposed for the purpose of road alignment and bridge selection. Spatial
mapping guided engineers in selecting routes for road alignment and bridge placement. Cost analysis was performed on various alternatives in aiding to create the lowest overall price a high public appeal. Within the article is an illustrative example showing the use of GIS and expert systems.


This is a very informative article discussing permitting of oversized and overweight vehicles using a GIS as a distinctive feature in the proposed approach. Routing macros are proposed that incorporate the use of a routine that executes Dijkstra’s algorithm to find a shortest path. The routing macro also finds a maximal-capacity path. An illustrative example is provided to show how the routing techniques are applicable. Pictures of computer output show different paths through a highway network dependent any restrictions (loading, vertical/horizontal clearances, etc.) on bridges along the route.


The paper discusses key points such as a brief description of GIS, the characteristics of a bridge management system (BMS), bridge inspection methodology, nondestructive evaluation (NDE) and BMS and deterioration modeling for bridges. The basics of GIS are explained (points, lines, polygons). An interesting portion of the article discusses in detail a pilot study data structure for the city and county of Denver. A description of the types of data that should be made available on a GIS to maintain a proper functioning BMS is further discussed. Authors point out that for a reliable BMS bridge qualifications and characteristics together with a bridge’s geographic relationship within the infrastructure must be known. This paper complimented the subject topic of this paper by supplying evidence of a working BMS through the use of GIS in the U.S.


Another article describing the development of an integrated prototype GIS based bridge management system. The interesting part of this article is the use of a GIS based BMS in the country of Malaysia. Currently the country is on track to become a developed nation by 2020 and an essential part of their success is an efficient management system for the country’s transportation and bridge infrastructure. U.S. BMS systems, mainly PONTIS and BRIDGIT, were discussed. Architecture and associated programs utilized in conjunction with GIS are mentioned as well. The article gives a good example of what is proposed in this report regarding what types of information should be available for bridges such as bridge reports, AutoCAD drawings for as-built or structural drawings, video, pictures. Once again this article among many highlights the benefits of the GIS management system.

Additional Sources: