The economy in the United States has declined drastically in recent years, causing a tough financial situation for the transportation infrastructure. Rhode Island funding for transportation projects and rehabilitation has plummeted, forcing the budget to be spread thin over several departments and current state transportation projects. The Rhode Island Department of Transportation (RIDOT) does not have the adequate funds necessary to repair roadways and bridges in the state. According to the American Society of Civil Engineers (ASCE) Rhode Island has the highest percent of structurally deficient bridges in the nation with 53% of state bridges in need of repair. There are a similar number (48%) of deficient major highways and state roadways in Rhode Island which are in desperate need of repair. There has also been an increase in vehicle travel on state highways of 12% from 1991 to 2001 as the population has also increased slightly.

Reductions in the costs associated with transportation in the state would serve to be beneficial for taxpayers and the state and federal economies. Any way in which the state could save money in the budget for transportation purposes would be a valuable improvement for the budget. Employing Geographic Information Systems (GIS) for automating transportation and routing purposes in the state has the potential to reduce costs and manpower. These could both be redistributed to other areas in need of that money and manpower, such as the repairs of roadways and bridges in the state. An automated system can be used in the place of many aspects of the state transportation systems operating on a daily basis.

GIS is a very useful tool for the storing of data in a database, implementing mathematical algorithms, use for linear referencing, managing topology, use for structural analysis, managing a user interface, and for creating cartographic map models (Adams 2002). All of these tools are beneficial for use in routing vehicles in a method that is user friendly, saves time, and contains all of the spatial data needed for the routing process. GIS has been developed in order to retain all of the feature attribute data necessary for decision making and routing vehicles. Roadway segments, bridges, tollbooths, gantries, roadway obstructions, and origin/destinations can all be stored in the GIS database and are also geospatially referenced in the system. Attributes for each of the elements of a roadway can be stored in GIS for roadway segments and the objects or nodes along the roadway segments. Bridge attribute data, such as clearances and loading capacities can be stored in the GIS network for routing oversize/overweight vehicles. Roadway attribute data, such as speed limit, length of roadway segment, and congestion of roadway can be stored in GIS and used for time optimal routing of vehicles. Real time data for temporary roadway obstructions, such as road construction or even highway incidents, can also be stored in the GIS database for
routing purposes (Jakimavicius 2006). All of this data is stored within the different layers in the GIS roadway network.

The application of GIS for transportation has been used for many different types of vehicle routing analyses in other states and countries. Some of the most common ways include: oversize/overweight vehicle routing, ship scheduling, detour routing, evacuation routing, public transportation, snow removal, dispatch and delivery, and even carpooling (Ray 2007). GIS can be used in order to find optimal routes for vehicles or vehicle fleets to take, based on certain, given constraints. Spatial Decision Support Systems (SDSS) such as Map-Route allow users to obtain optimal routes based on the constraints of a vehicle and a given time period (Ioannou 2002). This is useful for routing OS/OW vehicles and for vehicle fleets with time windows. Some of the aspects taken into account when evaluating routes are: minimizing route time, minimizing route distance, and minimizing the cost for the vehicle to travel the given route (Chang 2002).

GIS as an automated system has not yet been implemented for several of these forms in the Rhode Island transportation system. There are numerous ways in which Rhode Island could utilize GIS technologies for reducing costs, reducing state funded manpower, and for repairing roadway congestion.

Rhode Island could optimize time in routing public transportation buses and snow removal vehicles through the use of an automated GIS system. Saving time on these routes and finding optimum paths could allow for fewer vehicles to do the same amount of work as before. For snow removal, vehicles can be routing using the shortest path algorithm for vehicles (Osegueda 1999). GIS can store data for roadway segments to find the optimal route for the vehicle fleets in order to distribute vehicles in a fleet evenly. All of the nodes along a collection and delivery route can be stored and numbered and a shortest path algorithm can be applied to the GIS data to formulate a final route (Ioannou 2002). Finding the optimal route for vehicles and fleets is bounded by several factors which include: lowest cost, the specified time window (especially for public bus routing), and the number of collection and delivery points along a route. With all of the information stored in the GIS network, there is little room for human error.

Improperly routed oversize/overweight (OS/OW) permit vehicles cause thousands of dollars each year in roadway and bridge damage. Bridges are overloaded with these trucks and in turn require thousands of dollars in maintenance and repairs every year. Although the funds from OS/OW vehicle permits go to the state Department of Transportation, the cost for repairs is too high for permit fees to take care of. Permitting in Rhode Island is not a well structured system and is maintained by two independent departments: the Division of Motor Vehicles (DMV) and the Rhode Island DOT. Permit checking usually begins at the DMV where much time is taken to manual review a permit and the proposed route. If bridge analysis is necessary, the permit is then passed along to the DOT where a detailed bridge analysis takes place under the review of state engineers. This lengthy process can take several days and the permit can be rejected after all of that time. Route analysis through GIS can take under a minute to perform with all of the data properly stored within the GIS roadway network. With the use of a GIS system to properly route these vehicles, the damage to the roadway
infrastructure can be reduced. Automating the OS/OW permit process allows for less human error, a more accurate routing procedure, and a faster analysis time. Although the use of GIS for OS/OW vehicle routing and permitting has been developed, very few states have actually implemented the method into practice.

The future of developing GIS in transportation and vehicle routing seems to be the path in which many states are heading. Much research has been done to develop uses for GIS in transportation in the United States and abroad. With all that is known about the potential uses for a GIS routing system, the next most logical step would be to finally implement the system for use by Rhode Island and all of the other states. It would take the most funding initially to put the system in place for vehicle routing, but within a short amount of time the results will pay for themselves and the manpower could be reallocated to other parts of the budget. The economy in this country, especially in Rhode Island, is in such a desperate state that implementing a system that could save money and redistribute the budget is an important step that needs to be taken. As GIS for vehicle routing is developed, new methods and approaches for routing can be used to improve upon the older systems, allowing for more applications and a more simplified user interface.

ANNOTATED BIBLIOGRAPHY


In this article, it is shown how GIS based systems are used for the automation of Oversize/Overweight (OS/OW) vehicle permitting. To obtain a permit there are many aspects that must be included in order to allow proper assessment. The general requirements include: database, algorithm, topology, cartographic representation, linear referencing, structural analysis, and user interface. The Link/Site Model is based on every site or node in the traffic network being linked through roadway segments. Links are connections between two endpoint sites, while sites are the nodes of known points along the roadway. Restriction data can also be incorporated in the model, allowing for the permanent or temporary restriction of a route. Temporary restriction of a link in the route can be for the reasons of a construction project, bridge clearance or posted weight, special event, heavy congestion, or spring-thaw events. Once the site restrictions are in place, the optimal route can be determined and represented in a map.


The goal of this article was to show how GIS is utilized in order to create a programming model which is capable of routing and scheduling vehicles for use in solid waste
collection systems. The purpose of this analysis is to create an optimal path or rational route for the vehicle to follow during collection. The goals for this optimal route were to preserve current collection points, consolidate routes, and to distribute collection trucks in the fleet evenly. Three objectives were kept in mind for this route selection: to minimize total costs, distance, and time. GIS has routing and scheduling procedures built in which were used in this analysis, such as the “SPATIALORDER” and “COLLOCATE” commands. “SPATIALORDER” can determine the collection distance between each node on the route, while “COLLOCATE” can identify areas with certain amounts of waste to distribute trucks evenly in the fleet. GIS also uses the “cluster first, route second” approach which allows better utilization of fleet vehicles. GIS is a helpful tool for the storing of data, the user interface, and for creating map models for the routes the trucks must take.


This article introduces a Decision Support System (DSS) called Map-Route, which enables users to obtain routes based on the constraints of a vehicle and a given time period. The users of this DSS are schedulers and dispatchers who need this software for routing vehicles in an urban area. When dispatchers have issues such as Vehicle Routing Problems with Time Windows (VRPTW), the Map-Route software is able to generate an optimal route for the collection or delivery vehicles. The optimal route is based on the route that is constrained by the lowest cost, the specified time window, and the number of collection or delivery points along the route. Map-route is specifically designed for vehicle fleet routing for collection and delivery of a given area. Routes are determined by numbering each location (node) along the route, using a shortest path algorithm, and then formulating the final route map. During this process, the preferred path information is input for consideration, since the algorithm may yield results that are not preferable for reasons other than distance or time constraints. A DSS such as this has the potential of saving a great deal of time and money for schedulers who need to be concerned with time restrictions in their collection or delivery system.


Rational routes are determined by three constraints: the shortest travel route, the fastest travel route, and the alternative route using traffic flow. Mathematical models are presented in this article to calculate the three given constraints. GIS is used as a means of identifying the rational vehicle routes for the three settings for shortest route, fastest route, and an alternative. The user of GIS then develops a map with the marked rational route for use by the carrier. GIS may also be used when vehicles are required to be at a specific place at a specified time, such as in urban transport systems. With GIS, a driving time and traffic flow data can be assigned to street segments along the transportation network. Also the traffic directions can be assigned to street segments in
conjunction with the driving time of the segment. A database can also be used to supplement the GIS rational routes with real-time information about traffic conditions and events that may effect the driving time or even the intended route.


This article describes the ways in which GIS can be used for transportation systems for the purpose of routing vehicles. Routing of vehicles must be done during highway incidents and other events in which vehicles must be routed away from a hazardous area. The planning for a hazardous event is crucial for mapping vehicle routes to be used in the case of an emergency. The decision support areas covered in this article include: risk assessment, routing and scheduling, emergency preparedness, evacuation planning, and incident management. All of these actions are done in advance to an event which is not ideal for the transportation network. Emergency response and evacuation planning are determined based on the predicted outcome of the events. This rational routing of vehicles can be used for many useful scenarios, such as real-time traffic congestion or natural disaster evacuation. The development of this system is useful for the public, industry, and for government agencies. The system is intended to reduce the cost of an incident while also improving upon the efficiency and the safety for the people involved.


Routing process for identifying feasible truck routes for Oversize/Overweight (OS/OW) vehicles is described in this article. Routing an OS/OW vehicle is based on either the shortest span or maximum capacity paths. The method used for finding the optimal routes is based on a five step process. The original route must be selected, all bridges along the route are identified, the data for each bridge is found, an analysis of each bridge is performed, and the alternative route is recommended. This process has been simplified with the use of a GIS routing system so that manual analyses are not required. The routing algorithm is used in conjunction with GIS to formulate the optimal route. The Equivalent Distributed Load (EDL) method is used for determining whether or not an OW truck can pass over a given bridge using Bridge Load Formulas (BLF). The bridges which do not pass the load analysis are removed from the possible routing choices for the individual truck being analyzed.

Oversize/Overweight (OS/OW) vehicles need permits from the Delaware Department of Transportation to pass through the state. When applying for a permit, vehicles must submit an origin and destination to obtain a travel route that can be approved by the DelDOT. This article describes the application of a Spatial Decision Support System (SDSS) to properly route these vehicles. SDSS can be used to create map outputs for the carrier to use on the route and can be used to store and manage the spatial data for routing the OS/OW vehicle. A routing algorithm is introduced for the purpose of using GIS and the SDSS to evaluate the rational route for the vehicle to use. This routing algorithm can also be used for not just OS/OW vehicles but also for car-pooling, snow removal, ship scheduling, and for dispatching delivery trucks. Origins, destinations, temporary obstructions, and road obstructions are georeferenced and stored in GIS. These georeferenced nodes are fit into the routing algorithm and will be met by the vehicles on their routes. With this routing system, vehicles can be permitted much more quickly with the use of an automated system and use less manpower in the routing analyses.

ADDITIONAL SOURCES: