CHAPTER 2
LITERATURE REVIEW

2.1 INTRODUCTION

A literature review is a body of text that aims to review the critical points of current knowledge including substantive findings as well as theoretical and methodological contributions to a particular topic. Literature reviews are secondary sources, and as such, do not report any new or original experimental work. Also, a literature review can be interpreted as a review of an abstract accomplishment. Most often associated with academic-oriented literature, such as a thesis, a literature review usually precedes a research proposal and results section. Its main goal is to situate the current study within the body of literature and to provide context for the particular reader.

2.2 LITERATURE REVIEW- GIS AND OPERATIONS RESEARCH

Weigel and Cao (1999) applied GIS in conjunction with Operations Research (OR) techniques to solve technician dispatching and home delivery problems at Sears, Roebuck and Company. Sears used a vehicle routing and scheduling system based on a geographic information system to run its delivery and home service fleets more efficiently. Although the problems to be solved can be modeled as vehicle routing problems with time windows (VRPTW), the size of the problems and thus practical complexity make these problems of both theoretical and practical interest. The authors constructed a
series of algorithms, including an algorithm to build the origin and destination matrix, an algorithm to assign resources, and finally algorithms to perform sequencing and route improvement. The combination of GIS and OR techniques improved the Sears technic and is patching and home delivery business. It (i) reduced driving times by 6%, (ii) increased the number of service orders each technician completed per day by 3%, (iii) reduced overtime by 15%, (iv) helped to consolidate routing offices from 46 to 22, and (v) achieved annual savings of $9 million. The success of this application also suggested a promising link between GIS and OR techniques. It also helped ESRI, the GIS consultant for the project develop ArcLogistics, a low-cost PC-based routing-and-scheduling application that brings high-end functionality to small organizations who were previously unable to afford this technology.

Ammar Alazab et al (2010) reported that the value of real time traffic information gathered through GIS for achieving an optimal vehicle routing within a dynamically stochastic transportation network. They present a systematic approach in determining the dynamically varying parameters and implementation attributes that were used for the development of a Web based transportation routing application integrated with real time GIS services.

Mezyad Alterkawi (2001) expressed in his paper “Application of GIS in Transportation Planning: The Case of Riyadh, the Kingdom of Saudi Arabia” as illustrating applications of Geographic Information System in Transportation planning in general and introduce a symbolic case study of Riyadh city, the capital of Saudi Arabia.

Another example of the application of GIS coupled with OR for decision support can be found in Camm et al (1997) who analyzed the North American operations supply chain of Proctor and Gamble, more specifically
its product sourcing and distribution system. The authors disaggregated the problem into a warehouse location component and a product sourcing and distribution component and proposed a methodology which merged integer programming and network optimization within a (MapInfo) GIS framework. By dividing the problem into two major components, simpler models could be applied. As a result of this study, P&G was able to consolidate its North American facilities by 20 percent which saved $200 million in pre tax costs every year.

2.3 GIS FOR VEHICLE ROUTING AND ACCURATE DISTANCE CALCULATIONS

Campbell et al (2001) presents a new distance approximation approach that is useful in commercial transportation contexts. The motivation for the authors was to develop a simple and accurate distance approximation for use in an interactive GIS-based decision support system (DSS) for urban snow disposal. The hybrid approximation reduces data requirements and improves travel speed by eliminating local road details, but it maintains accuracy and incorporates obstacles by including the major roadways in a reduced network. The authors report results of an application in Montreal, Canada using a particular local distance approximation function, but the approach could easily be used with shortest paths or a more complex distance function for local travel. Utilizing an improved travel distance model, the snow disposal DSS provides strategic and tactical benefits. Because travel cost is approximately proportional to travel distance, and travel cost comprises a major component of total snow disposal costs, having a more accurate distance model leads to system designs with lower costs. The savings result from better utilization of existing equipment and from a reduction in the amount of equipment required. The ability to respond in real-time to contingencies with the DSS also allows for better tactical decision-making.
Finally, the availability of an interactive tool for snow disposal design allows for a more structured and timely evaluation of different levels of service (for example, setting the deadline for clearing all snow to 60 hours, rather than 48 hours) or changes in operating conditions. For example, closing snow disposal sites along water bodies has been recommended to reduce negative environmental impacts of snow disposal.

Closure of such sites (which are generally inexpensive to operate) would require using more expensive sites, or opening new sites. The hybrid approach may provide advantages in a variety of different situations. For example, the shortest path in the complete urban road network may not be a realistic route when not all local neighborhood streets can be used by the vehicles of interest (for example, large trucks). This may be due to infrastructure constraints, environmental concerns, or legal conditions. Also, calculation of shortest paths in a very large network may be too time consuming for an interactive decision support environment. Another advantage is that obstacles, which may reduce the effectiveness of analytical approximations, can be incorporated explicitly in the reduced network. Miller, Wu and Hung (1999) define time-critical logistics (TCL) as the time-sensitive procurement, processing and distribution activities. Transportation networks that contain these logistic systems act as a confounding factor. This paper reports on the development of a GIS-based decision support system for dynamic modeling of congestion and routing in a TCL scenario.

The system predicts network flows at detailed temporal resolutions and determines the departure time and shortest path required for a shipment to reach its destination by a given deadline. The GIS provides effective decision support through its database management capabilities, graphical user interfaces and cartographic visualization. The model developed in this paper also helps to simulate various scenarios of network disruptions. Tarantilis and
Kiranoudis (2002) presents a spatial decision support system (SDSS) which use heuristics to solve the vehicle routing problem. The architecture of the SDSS integrates a relational database management system within a GIS (ARC/INFO of ESRI) framework. The authors report that the GIS framework allows efficient representation of the transportation network of Greater Athens, Greece, and allows for the fast implementation of routing routines which solve real-life computationally intensive vehicle routing problems quickly. Hwang contains an overview on GIS-interacted logistics and has developed a new three dimensional GIS distance based delivery and tracking system. The same work also contains comparative research on the vehicle routing problem based on various distance metrics within a GIS framework.

2.4 GIS AND SITE LOCATION

As mentioned earlier in the introduction, one of the key strategic decisions pertaining to any logistics network configuration includes site selection. For example, site selection is critical for planning a real estate development project. Different mathematical and statistical models have been proposed in the literature to support real estate developers in selecting suitable sites for development projects. Li et al (2005) presents a new approach that uses Data Envelopment Analysis (DEA) within a GIS framework to determine optimal site locations for real estate projects. A GIS helps users to organize and combine the spatial, temporal and economical information. The DEA method builds in the query for selecting locations by maximizing the ratio of outputs to inputs.

The GIS approach is able to solve site selection problems visually, while the DEA method is argued to be objective. The paper has demonstrated an application to illustrate this user-friendly system by selecting locations for a residential building project. Vlachopoulou et al (2001) recognize that the warehouse site selection decision is not merely the question of choosing sites.
It involves the comparison of the spatial characteristics of a market with the overall corporate and marketing goals of the firm. The authors present a geographic information system-aided process for the warehouse site selection decision and demonstrate the use of the process with a practical example. Various factors likely to affect customer service and costs are defined and subsequently integrated into an overall evaluation.

The location of base stations (BS) and the allocation of channels are of paramount importance for the performance of cellular radio networks. Also cellular service providers are now being driven by the goal to enhance performance, particularly as it relates to the receipt and transmission of emergency crash notification messages generated by automobile telematics systems. Based on these premises, Akella et al (2005) proposes a mixed integer-programming (MIP) problem, which integrates into the same model the base station location problem, the frequency problem and the emergency notification problem. The purpose of unifying these three problems in the same model is to treat the trade-offs among them, providing a higher quality solution to the cellular system design. Some properties of the formulation are proposed that provide more insight into the problem structure. An instance generator is developed that randomly creates test problems. A few greedy heuristics are proposed to obtain quick solutions that turn out to be very good in some cases. To further improve the optimality gap, the authors develop specialized heuristic techniques that build on the solution obtained by the greedy heuristics. Finally, the performance of these methods is analyzed by extensive numerical tests within a GIS framework and a sample case study is presented.

Miliotis et al (2002) have developed a hierarchical location model for locating bank branches in a competitive environment. The authors have combined demand-covering models with a GIS to capture various
geographical, social and economic criteria as well as local competition concerning the demand for banking services. The hierarchical location model involves first solving a location set covering model to determine the minimum number of bank branches followed by solving a maximal covering location problem to maximize demand coverage for individual branches. The use of a raster-based MapInfo GIS helped in organizing large volumes of data and also in transforming all the useful information to input files for the demand covering models very efficiently. The GIS framework allowed for the simulation of alternative scenario in central Macedonia, Greece, and produced useful displays for the efficient planning of financial networks. On a related note,

Nasirin and Birks (2003) presents exploratory case studies reflecting IS implementation experiences of three major British retailers for store location purposes. Finally, Church contains a review of existing work that forms the interface between GIS and location science and discusses future research directions involving both GIS and site location. The author concludes that demand for better location model functionality in GIS software will grow and the success of many site location applications in the future will be intimately linked to GIS.

2.5 GIS AND WAREHOUSE MANAGEMENT

Warehouse management is a key part of the overall problem of logistics management. Johnston, Taylor and Visweswaramurthy (1999) describe a geographical information system (GIS)-based software system for managing and integrating multi-facility warehousing and production systems that are distributed within a relatively large geographical area. The development of the software system is motivated by a unique warehousing environment at the Pine Bluff Arsenal in Pine Bluff, Arkansas. The arsenal scenario is characterized by a novel set of highly limiting warehouse
constraints. Although motivated by this unique problem, the software system has been designed to maximize technology transfer capability into diverse general warehouse settings. The paper presents motivation, describes features, and demonstrates the efficacy of operations using the software system. The system is verified and validated in a case study setting. It is demonstrated that the GIS platform offers unique capabilities that enhance problem solutions. In conclusion, the paper offers a contribution to the literature by presenting the use of GIS as an integration strategy in an exciting new area of application.

2.6 OTHER MISCELLANEOUS APPLICATIONS

Gardner and Cooper (2003) suggested a need in the supply chain literature for a mapping convention or set of mapping conventions that will help executives to instantly recognize the kind of map being considered and some knowledge of the database underlying the map. This paper proposed a definition of a supply chain map that indicates boundary setting and a strategic view compelling reasons to create a map were suggested. The need for a supply chain mapping convention was demonstrated. These conventions were necessary for instant recognition of the type of map and the purpose of the map, yet they permit customization by the user. Based on a review of the literature and discussions with managers, the authors called for the development of a managerial mapping procedure for developing and modifying a strategic supply chain map. Finally, the paper suggested a methodology to strategically determine future supply chain configuration and the progression from what the current structure is to what a redesigned supply chain should be. Scientific research into GIS applications in asset management and territory optimization aspects of logistics management does not seem to exist.

Salim et al (2002) outlines the use of GIS in conjunction with Artificial Intelligence techniques for asset management in a transportation
context. This involves the allocation of resources, including personnel, equipment, materials, and supplies. This paper presents heuristic based AI methodologies to optimize transportation asset management procedures. Specifically, the authors outline and illustrate a GIS-based intelligent asset management system using the case study of snow removal for winter road and bridge maintenance in Iowa, USA. Summarizes a majority of the literature reviewed in this report in terms of the logistics sub-problem addressed and the GIS software used towards development of the solution framework.

2.7 NETWORK ANALYSIS USING GIS

The representation and analysis of both infrastructure (gas, electrical, water) and transport networks (road, rail, bus) in GIS requires specific data models and analysis methods. This course will introduce the concepts that underpin network analysis in modern GIS, along with their application to real world network problems. Participants will learn how to construct full network models from standard spatial datasets and become familiar with the tools required to check and ensure their integrity. Network analysis procedures will be presented and applied to real world networks, e.g. finding the shortest optimal route between locations.