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CHAPTER - I
INTRODUCTION

"A Picture is Worth a Thousand Words"
Ancient Chinese Proverb

1.1 ROAD TRANSPORT-AN OVERVIEW:
Road Transport is the most convenient mode of transport in view of its obvious advantages such as flexibility, reliability, door-to-door services and eliminating the risk of delay and damage in trans-shipment. The capacity of the arterial system is stretched almost to a limit because of phenomenal growth in road traffic and vehicle population coupled with inadequate arterial road network. Economic growth has brought about a spurt in vehicle ownership, which together with the fast pace of urbanization has created tremendous growth in urban traffic. Urban population of India is projected to be 538 million by the end of 2021, which will be 37.1 percent of country’s total population.

The number of class-I cities is expected to rise to 781 by 2021. The total population in million plus (Metropolitan cities) cities, which was about 71 million in 1991, is projected to grow to 164 million by 2021[1]. Buses carry over 90 percent of the public transport in Indian cities. In general, the larger the city size, the higher the percentage of urban trips served by public transport in India: averaging 30 percent in cities with population between 1 and 2 million, 42 percent for cities with population between 2 and 5 million and 63 percent for cities with population over 5 million [2].
While the enormous potential of public transport in India remains to be realized, there is no traffic priority of any sort (lanes, signals, etc) for buses, which get hopelessly stuck on congested roads-ways with an average speed of 6-10 kilometer per hour in many large cities. The slowness, unreliability, danger and overcrowding of buses has forced many middle class passengers to shift to cars, motorcycles and scooters instead, leading to increased road congestion, increased vehicle operating costs, delays, air and noise pollution. The average two wheeler and car ownership levels in metropolitan cities are expected to grow to 164 million by 2021. Despite the fact that plan allocation to the roads have been low relative to other components of the transport system, the total road length increased from nearly 4 lakh kilometers in 1950-51 to nearly 3.34 million kilometers, in 2007. India has a road length of 2.6 kilometers per thousand persons and about 76 kilometers per square kilometer of land, which are respectively one tenth and one third of similar indices for developed countries [3]. About 35 percent of the villages are without a road link. Congestion and poor road condition have resulted in annual avoidable vehicle operating and fuel costs, which are estimated to be Rs. 15,000 crores [4].

Transport system of any country is one of the most essential assets for the development and is an index of the state of development of the country. Mobility enables us to separate home from work and visit friends and family, as well as to allow us to do business across a wider region. Mobility and accessibility at an efficient cost-effective level are essential for all economic
growth activities; the efficient transport infrastructure is a determinant of the success of economic improvement and national development. Road network of a region influences the socio-economic status of the people, land cost, land use activities, thus it can be rightly quoted as “Transport system is the wheel of social, economic development of the country”.

1.2 ROAD NETWORK IN INDIA:

India has the second largest road network in the world. However, the quality of roads is inappropriate and cannot meet the needs of efficient and fast moving transportation. National highways are the prime arterial routes. National highways are less than 2 percent of the network but carry 40 percent of the total traffic. The roads and highways in India account for about 85 percent of the total passenger traffic and about 65 percent of the total freight traffic in the country. Out of the total length of National Highways, 32 percent is single lane, 56 percent is 2-lane and 12 percent is 4-lane.

1.2.1 Categories of Roads:

Roads in India are divided into five categories for the management and administration purposes:

1. National Highways (NH)
2. State Highways (SH)
3. Major District Roads (MDR)
4. Other District Roads (ODR)
5. Village Roads (VR)
The breaks down of the roads under the above categories are as follows [5]:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Road Type</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>National Highway</td>
<td>66,590 Kilometers</td>
</tr>
<tr>
<td>2</td>
<td>State Highways</td>
<td>1,28,000 Kilometers</td>
</tr>
<tr>
<td>3</td>
<td>Major District Roads</td>
<td>4,70,000 Kilometers</td>
</tr>
<tr>
<td>4</td>
<td>Village and Other Roads</td>
<td>26, 50,000 Kilometers.</td>
</tr>
</tbody>
</table>

A Total of 3.34 Million Kilometers

Source: Annual Report 2006-2007, Department of Road Transport and Highways

Road network in India has been growing at the rate of 4 percent, while the passenger traffic has been growing between 12 to 15 percent; the cargo traffic is growing at 15-18 percent per annum. To meet this investment requirement the government has taken various reform measures [6].

1.2.1.1 Government Initiatives:

1. Launch of an ambitious National Highway Development Programme (NHDP), involving a total investment of US $ 54.1 billion up to 2012, has been established.

2. Starting Bharat Nirman programme that aims to cover every village of over 1000 population or over 500 in hilly and tribal areas with an all-weather road. To achieve the targets of Bharat Nirman, 1,46,185 kilometers of road length proposed to be constructed by 2009.

3. Permitting 100 percent foreign direct investment (FDI) under the automatic route for all road development projects.
4. Private parties allowed to develop service and rest areas along the roads entrusted to them.

5. Investors in identified highway projects permitted to recover investment by way of collection of tolls for specified sections and periods.

1.2.1.2 Private Sector Participation:

Galloping resource requirement along with concern for managerial efficiency and consumer responsiveness has led to an active involvement of the private sector via both construction contracts and build-operate-transfer (BOT) based on either toll or annuity basis.

1. Reliance Energy has three contracts to four-lane 400 km of highway, and is already working on four-laning five National Highway projects in Tamilnadu, covering 400 km at an estimated cost of over US$ 762.42 million.

2. The consortium of Maytas Infra Private Limited and Nagarjuna Construction Company Ltd will four-lane the highway from Tindivanam and Pondicherry, at an estimated cost of US$ 70.09 million.

3. Lanco Infratech has the contract to four-lane two highways in Karnataka at an estimated cost of US$ 247.41 million.

4. Ten-laned multi-corridor project (at a cost of US$ 110.72 million) is being executed by a consortium of three private companies, to connect Bangalore to Electronics City, the hub of IT industries.

During the financial year 2007-08, a length of 2995 km (under NHDP Phase-V) (estimated cost of US$ 4.83 billion) for six-laning, and 3278 km of National
Highways (estimated cost of US$ 5.24 billion) for four and six lanes has been identified.

1.2.1.3 International Participation:
With the government dismantling longstanding barriers and encouraging private investment, global players are keenly interested in this booming segment. 86 contracting and consulting firms from 27 countries are already participating in various projects of the NHDP. Companies such as Turkey Limak, Thailand Italthai, Korea Baelim, Russia Dyckerhoff, Germany Widmann AG, Malaysia IJM Construction, SDN and Road Builders and Japan Kajima and Taisei are undertaking projects floated by the NHAI and other infrastructure projects of various state governments.

1.3 ROAD NETWORK IN KARNATAKA:
Karnataka is situated approximately between the latitudes 11.5° and 18.5° North and the longitudes 74° and 78.5° East. Karnataka the eighth largest state in the country has a total geographical area of about 1, 91,791 square kilometers, accounting for over 5.8 percent of the total area of the country. There has been about 10-12 percent increase in traffic each year on the National highways and about 12-15 percent growth in annual traffic on the State highways. The traffic on Village roads and other District roads has also registered an increase of 10-12 percent per annum [7]. Road network in Karnataka as at the end of March 2005 is as below:
Table -1.2  
Road Network in Karnataka

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Road Type</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>National Highway</td>
<td>3,973 Kilometers</td>
</tr>
<tr>
<td>2</td>
<td>State Highways</td>
<td>17,222 Kilometers</td>
</tr>
<tr>
<td>3</td>
<td>Major District Roads</td>
<td>30,975 Kilometers</td>
</tr>
<tr>
<td>4</td>
<td>Other District Roads</td>
<td>1,634 Kilometers</td>
</tr>
<tr>
<td>5</td>
<td>Village, Irrigation, Forest Roads</td>
<td>88,154 Kilometers</td>
</tr>
</tbody>
</table>

Source: Karnataka road Development Corporation limited /Road policy

Out of the total road network in Karnataka, which is 1,41,958 kilometers, the Public Works Department (PWD) is responsible for the maintenance and development of the National highways, State highways and Major district roads adding to 52,170 kilometers, which is 37 percent of the total road length. The remaining 89,788 kilometers of the village and other roads are being maintained by the Zilla Panchayats (Rural Development and Panchayat Raj Department) [8].

1.3.1 Road Network in Dharwad District:

Dharwad district, the study area for research has the following road length:

Table- 1.3  
Road Network in Dharwad District

<table>
<thead>
<tr>
<th>Thaluka</th>
<th>NH</th>
<th>SH</th>
<th>MDR</th>
<th>Total Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dharwad</td>
<td>80</td>
<td>189</td>
<td>126</td>
<td>345</td>
</tr>
<tr>
<td>Hubli</td>
<td>80</td>
<td>41</td>
<td>120</td>
<td>241</td>
</tr>
<tr>
<td>Kalghatgi</td>
<td>33</td>
<td>59</td>
<td>74</td>
<td>166</td>
</tr>
<tr>
<td>Kundhagola</td>
<td>0</td>
<td>37</td>
<td>106</td>
<td>143</td>
</tr>
<tr>
<td>Navalgund</td>
<td>46</td>
<td>94</td>
<td>128</td>
<td>268</td>
</tr>
<tr>
<td>Dharwad District</td>
<td>189</td>
<td>420</td>
<td>554</td>
<td>1163 Kilometers</td>
</tr>
</tbody>
</table>

Source: Public Works Departments Roads in Karnataka
1.4 URBANIZATION AND TRANSPORT:
Urbanization and industrialization are the important features of the growth of any town. Urban transport system, which is a crucial component of urban infrastructure, provides access to opportunities; supports urban economic activities and facilitates social interactions. India is a rural based country; the growing population migrates to the nearby cities to have better living standards. This process of migration from rural places to cities has pushed the city limits in the outward direction that results in the transport of people from outward fringes to the inner core. Rapid increase in city population increases the traffic. Poor transport not only constraints urban economic growth, but also degrades quality of life, mainly through congestion, pollution, accidents and community severance. The extent to which Indian cities contribute to macro-economic performance and poverty reduction will be closely linked to how efficiently their transport system move people and goods upon which their socio-economic activities depend.

1.5 PUBLIC TRANSPORT IN INDIA:
Public transport is the backbone of urban transport in most of the Indian cities. The number and size of the cities has increased significantly. Although circumstances differ considerably across cities in India, certain basic trends, which determine transport demand such a substantial increase in urban population, household income, industrial and commercial activities are the same. Public bus operations are regulated by the state transport authorities,
which have few skills or capacities in dealing with the intricacies of urban bus operations. Fares are typically set at the state level, mostly on an ad hoc and political basis not commensurate with principles of pricing, cost recovery. Under the political influence, the state governments are often forced to keep bus fares at affordable prices, and this seriously undermines the financial viability of bus operations.

The increasing traffic on city roads with large portion of two wheelers and mixed traffic conditions have placed heavy demands on the urban transport system, leading to undesirable effects such as congestion along the urban road, environmental impact such as air and noise pollution, energy cost, increase vehicle operating cost, land take, causalities, delays and money required to build infrastructure [9].

The undesirable side effects of urban transport have influenced most developed countries to move away from the “Build it and they will come,” infrastructure-incentive and capital intensive transport strategies, towards more balanced and sustainable transport solutions. Here Intelligent Transport Systems (ITS) comes into picture and it holds the promise of sustainability. Public transport organizations in India can make use of these kinds of Intelligent Transport System (ITS) for better management.

Intelligent Transport Systems (ITS) is the name given to application of computers and communication technologies to transport problems. Intelligent
Transport Systems have a potentially important contribution to make in improving mobility of travelers. These technologies are making a particularly strong impact in the public transit system, through enhanced traveler information services, more efficient systems operations and maintenance, new integrated management systems, and safety and security improvements.

Japanese have initiated the whole modern day notion of ITS with work carried out in the 1980s. The United States was also addressing the application of ITS at an early stage in the course of the Electronic Route Guidance Project (ERGS) in the 1970s. The European Union picked up the theme, and referred to it as Road Transport Informatics. In the course of time the name of this technology subjected to many carnages until USA had given a name called ITS to it. Intelligent Transport Systems include wider application of technology to transit systems as well as private car and highways. Benefits given by ITS to any transportation system by introducing it are improved safety, improved traffic efficiency, reduced congestion, improved environmental quality, energy efficiency and improved economic productivity. Private travelers, commercial road users, and the public sector are continually searching for new and faster travel routes. Without quality and dynamic data, route selection is often a guessing game. Customers want real-time information to help them select the best route from the available routes at any given time. They need to know traffic speeds, road conditions, time taken (travel time) to reach from one place...
to another and the cost (travel cost) associated with the travel, location of hospitals, rest rooms, restaurants, ATMs, etc.

With advanced travel information, drivers and travelers make informed decisions and are better equipped to plan their route and estimate their travel time, choose the route best suited for them. Fast and accurate information translates into several benefits for the customer such as reduction in travel time, reduction in stress levels, the avoidance of congestion, and perhaps the most important benefit the avoidance of unsafe driving conditions [10].

1.6 INTELLIGENT TRANSPORT SYSTEMS:

An Intelligent Transport System utilizes advanced technologies, frequently Geographic Information Systems (GIS) to improve both the efficiency and safety of transport system. GIS-based ITS applications need advanced information and communication technologies like Data storage and processing equipments, wire line and wireless communication systems, Global Positioning Systems (GPS) etc.

Transportation service providers employ ITS to provide traveler information, lower costs, decrease travel times, and provide more convenient routes and schedules. Such technologies include location software, equipment (automatic vehicle location [AVL] and geographic information systems [GIS]), computer-aided dispatch (CAD), mobile data terminals (MDTs) or mobile data computers (MDCs), coordination and integration software. Integration software may be
used to coordinate fare payment and billing operations, passenger counting, vehicle location, or other functional and operational requirements.

One of the most visible benefits of improved transportation operations and coordination is increased flexibility for the transit rider in scheduling and taking trips. Flexibility provides riders options for scheduling appointments, such as medical, personal, and reverse commutes. With the right data, agencies can determine which routes need vehicles with specific design characteristics, such as wheelchair loading and restraint systems, and can provide flexibility in the schedules for these routes. For low-income travelers, flexibility is needed also for accessing crucial stops such as childcare locations and shopping centers.

Another key benefit to improved operations and coordination is reliability. Reliable transportation benefits older clients and clients with disabilities who do not want to wait for long periods of time, nor do they want to miss medical appointments. Reliability also is important for low-income populations to meet job commitments. Coordination of functions and services among agencies and within a single agency is critical to ensure flexibility. Coordination of services might involve fixed-route transit; para transit providers, and non-transit options.

The benefit to users is that they only need to understand one system and make arrangements (e.g., reservations, payment) with a single agency. Among transit
agencies, traveler information systems are one of the most commonly deployed ITS technologies that directly benefit passengers. These technologies provide trip and general services information to travelers. Information may be static or real-time and may be tailored to suit a particular traveler’s needs. Depending on the application, information can be provided using the Internet, telephone, fax machine, and electronic signs or audio enunciators at kiosks, at transit stops, or in vehicles.

Information provided over the Internet can be accessed by personal computers, personal digital assistants (PDAs), Web-enabled cell phones, and electronic kiosks. Information provided over the telephone can be automated using interactive voice response (IVR) or voice recognition systems. Information may also be disseminated using telecommunications device for the Deaf/Teletype (TDD/TTY) equipment. Accessible and easily understood traveler information can include operating hours, service area and routes, schedules, fares, location of the nearest transit stop, transfer options, accessibility information and availability of transportation-assistive devices such as wheelchair lifts, and the estimated arrival time of the next transit vehicle. Automated communication systems on transit vehicles visually display and audibly announce the vehicle route and destination and the location of the next stop [11].

Thus Intelligent Transport Systems are identified as the means to achieve sustainable and environmental friendly transportation for the 21st century.
Many governments are appreciating the benefits of ITS and deploying them in their regions. As a first step, National ITS architectures were designed by the respective nations, to provide overall guidance to ensure deployment strategy, systems compatibility and interoperability. ITS architecture defines user services, physical subsystems, information flows between subsystems, and communication requirements for deploying ITS applications.

As many new technologies arise, ITS technologies are undergoing an evolutionary process. This presents the greatest challenges of deploying ITS systems integration. Challenges presented by ITS deployment include standardization, addressing security and privacy concerns, institutional and inter-agency barriers, availability of funding, public-private partnership. ITS technologies are user service centric and have been driving ITS development across the world [12].

One of the new types of information technology of interest is the Geographic Information Systems (GIS). These systems provide relatively complex relational database and interface features designed to facilitate the handling of all type of geographic data. GIS provides an integration of spatial and non-spatial data within a single framework. In the area of transportation, GIS has the ability to model individual road elements and intersections, and to analyze route between two points in a network.
GIS provides an intrinsically logical, visually oriented display of information. As many users are far more interested in, and more attuned to, their quantitative information under consideration than in the methods used to retrieve it, this visual interface is a critical element in the system. Additional information management tools contained in GIS like numerical analysis models, and decision support systems, provide gateways to the application required by the users.

1.7 DECISION SUPPORT SYSTEMS:

Decision Support Systems (DSS) is a well-established area of information systems (IS) application. Academic research in the DSS field dates from the work of Gorry and Scott-Morton (1971). While there are many definitions of DSS, there is general agreement that these systems focus on specific decisions and on supporting rather than replacing the user's decision-making processes. Definitions of DSS also emphasize the need to support semi-structured and unstructured decisions. Also, there is a general consensus in the definitions of DSS that interface, database and model components are usually required to fully support decisions.

1.7.1 DSS Definitions:

A Decision Support System (DSS) is a computer program application that analyzes business data and presents it so that users can make business decisions more easily. It is an "informational application" (to distinguish it from an "operational application" that collects the data in the course of normal business
operation). Typical information that a decision support application might gather and present would be:

1. Comparative sales figures between one week and the next
2. Projected revenue figures based on new product sales assumptions
3. The consequences of different decision alternatives, given past experience in a context that is described

A Decision Support System may present information graphically and may include an expert system or artificial intelligence (AI). It may be aimed at business executives or some other group of knowledge workers.

Decision Support System is an information environment, including data stores and access tools, specifically designed for reporting and analysis. DSS are expressly designed to support individual and collective decision making by making it possible to apply decision models to large collections of data. These systems are designed to support the decision-making process, rather than render a decision. - Bruce Bahlmann

Decision Support System, refers to an interactive computerized system that gathers and presents data from a wide range of sources, typically for business purposes. DSS applications are systems and subsystems that help people make decisions based on data that is culled from a wide range of sources.

Decision Support Systems (DSS) are a specific class of computerized information system that supports business and organizational decision-making
activities. A properly designed DSS is an interactive software-based system intended to help decision makers compile useful information from raw data, documents, personal knowledge, and/or business models to identify and solve problems and make decisions.

Typical information that a decision support application might gather and present would be:

1. Accessing all of your current information assets, including legacy and relational data sources, cubes, data warehouses, and data marts
2. Comparative sales figures between one week and the next
3. Projected revenue figures based on new product sales assumptions

**Decision Support Systems** (DSS) are defined as interactive computer-based systems intended to help decision makers utilize data and models in order to identify, solve problems and make decisions [13]. Their major characteristics are:

1. DSS incorporate both data and models;
2. They are designed to assist managers in semi-structured or unstructured decision-making processes;
3. DSS support, rather than replace, managerial judgment;
4. They are aimed at improving the effectiveness—rather than efficiency—of decisions.

**Shim states that** DSS are typical computer technology solutions that can be used to support complex decision-making and problem solving.
1.8 DECISION SUPPORT SYSTEMS AND GEOGRAPHIC INFORMATION SYSTEMS:

From the period since DSS came to prominence there has been considerable growth in the importance of geographic information systems (GIS). This growth in GIS reflects the decreased cost of the required technology and the increasing availability of appropriate spatial data. Recent improvements in mainstream computer technologies facilitate this spread of the use of spatial data. These include inexpensive gigabyte sized hard disks, large high-resolution colour monitors, graphics accelerators and CD-ROM storage [14].

Within the GIS field there is increasing interest in the use of GIS software to provide decision support. While an increasing number of GIS based applications are described as being DSS, these descriptions suffer from a lack of agreement on what exactly a DSS actually constitutes. As Maguire (1991) points out, some authors have argued that a GIS is a DSS. Many GIS based systems are described as being DSS on the basis that the GIS assist in the collection or organization of data used by the decision maker. However these differences of definition also reflect the differing needs of decision makers who use spatial information. For many of the current spatial decisions support system (SDSS) applications, the main information requirement of the decision makers is for relatively structured spatial information. GIS techniques are beginning to have an impact on DSS applications. The survey by Eom, Lee and Kim (1993) identified marketing and routing as important areas of DSS application. Keenan (1995) proposed a classification of routing problems with
respect to their spatial content and the usefulness of a spatial decision support system (SDSS).

Spatial Decision Support System (SDSS) can be considered as an important subset of DSS, whose potential for rapid growth has been facilitated by technical developments. The availability of appropriate inexpensive technology for manipulating spatial data enables SDSS applications to be created. The benefits of using GIS based systems for decision making are increasingly recognised. In a review of GIS, Muller (1993) identified SDSS’s as a growth area in the application of GIS technology.

Peter Keenan in his article “Using a GIS as a DSS Generator [15]” suggests three categories of decision maker who may find that SDSS can make a contribution to their decisions. The first group is in the traditional areas of application of GIS, in disciplines such as geology, forestry, and land planning. In these fields GIS was initially used as a means of speeding up the processing of spatial data, for the completion of activities that contribute directly to productivity. In this context the automated production of maps, in these disciplines, has a role similar to that of data processing in business. The second group of decision makers, for whom SDSS can make an important contribution, is in fields such as routing or location analysis. Although the spatial component of such decisions is clear, DSS design has in the past been driven predominantly by the management science models. In the future these models will be incorporated into GIS based SDSS, providing superior interface
and database components to work with the models. This synthesis of management science and GIS techniques will provide more effective decision-making. Keenan (1995) has argued that the use of GIS techniques can extend the range of decision support for vehicle routing problems, allowing consideration of path constraints that have not been comprehensively modeled in the past. Routesmart (Bodin, Fagan, Levy, and Rappoport, 1992) is a good example of the use of GIS for a routing application.

The third group of decision makers who will find SDSS important include those where the importance of both spatial data and modeling is somewhat neglected at present. In disciplines such as marketing, additional possibilities for analysis are provided by the availability of increasing amounts of spatially correlated information, for example demographic data. Furthermore the geographic convenience of product supply relative to customers' locations is an important tool of market driven competition. The availability of user friendly SDSS to manipulate this type of data will lead to additional decision possibilities being examined which are difficult to evaluate without the use of such technology (Grimshaw, 1994).
Table - 1.4
Three Categories of SDSS Users

<table>
<thead>
<tr>
<th>Phase</th>
<th>Description</th>
<th>Traditional Tools</th>
<th>Spatial Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early</td>
<td>Compute,&quot;crunch numbers&quot;, summarise, organize</td>
<td>Early computer programs, management science models</td>
<td>Computerized cartography</td>
</tr>
<tr>
<td>Intermediate</td>
<td>Find, organise and display decision relevant information</td>
<td>Database management systems, MIS</td>
<td>Workstation GIS</td>
</tr>
<tr>
<td>Current</td>
<td>Perform decision relevant computations on decision relevant information; organise and display the results. Query based and user-friendly approach. &quot;What if&quot; analysis</td>
<td>Financial models, spreadsheets, trend exploration, operations research models, decision support systems.</td>
<td>Spatial decision support systems</td>
</tr>
</tbody>
</table>

Source: Using GIS as a DSS generator, Peter Keenan.

Spatial Decision Support Systems will be an increasingly important subset of DSS in the future because of the importance of spatial information in variety of decision-making situations. GIS software is becoming increasingly suitable for use as a generator for a SDSS. As GIS designers gain a greater awareness of decision-making possibilities, their systems will be designed to facilitate interaction with models. GIS software provides a sophisticated interface for spatial information. Even limited functionality GIS software will provide the ability to zoom and to display or highlight different features. GIS provides
database support that is designed to allow for the effective storage of spatial data. Furthermore GIS software provides a link between the interface and database to allow the user to easily query spatial data. If models can be incorporated in such systems than a useful decision support tool can be designed.

A large number of models and modeling techniques have been developed to support decision makers. Many of these are of interest to potential users of spatial decision support systems. For SDSS techniques to be of interest, real world problems need only to have a spatial component in one aspect of the decision-making. The models in the problem may operate on non-spatial (attribute) data in the SDSS. However the data set to be used for the modeling process may be identified by spatial operations. For example spatial analysis may determine the number of potential users of a new shop; this could provide data for use in a financial model or optimization model. Conversely the outcome of a non-spatial model may identify spatial operations that need to be performed. For instance a vehicle routing algorithm may produce truck routes, spatial techniques could then identify the areas affected by noise resulting from the increased traffic.

One possible example of the use of modeling is in selecting a facility location. There might be a number of criteria for such a decision; some of these would be spatial in nature. For instance, a school might need to be located near to the districts from which potential pupils would travel. A refuse disposal facility, on
the other hand, might need to be located away from populated areas. GIS based spatial operations could be used to provide an index of suitability for sites for such a facility. The decision maker might have a variety of other factors to weigh up, however, and techniques such as multi-criteria decision-making such as the analytical hierarchy process (AHP) might be used to reach a final decision. This type of approach could be combined with the use of GIS techniques. Where a traditional model is used to rank the alternatives, spatial operations might be needed to identify the impact of the decision, for example to identify those affected by the location of a new facility.

A good example of a combination of spatial and non-spatial factors arises in vehicle routing, a well-established area of DSS research. In this case GIS techniques could be used to evaluate the suitability of paths that vehicles should take. This might mean that elevation data would be used to identify sections of the road network with steep gradients. The results of such an analysis could then be used by traditional management science based vehicle routing algorithms. For instance a GIS could be used to model flooding along the banks of a river. The information derived from the GIS about the likelihood of flooding could provide the bulk of the information needed for some types of decision, such as land use planning. Planners could then restrict development of the low-lying land, which is liable to flood. However for emergency evacuation modeling, in an area already inhabited, the output from the GIS might become the input to further modeling based on the routing of emergency
vehicles. In this case the routing algorithms need to be able to interact effectively with the GIS. Another routing scenario that requires complex SDSS functionality is that of the routing of hazardous goods. In this category of problems the object of the routing process may be to avoid passing populated areas or to avoid areas where accidents might occur due to steep gradients or strong winds. GIS techniques can be used to identify streets, facilities close to a route. This information might from the basis of an analysis of demand for a bus route, or an indication of those potentially affected by the transportation of dangerous goods. Given the advances in computer technology in general and GIS techniques in particular, SDSS will be an important component of DSS applications in future. GIS is of interest, not because of its use of the latest technology, but because it allows decision-makers incorporate a spatial dimension in their decision-making [16].

1.9 DIFFICULTY FACTOR:

Public transport is essentially a service where customers hire the services of the bus and its driver for the duration of the journey. The journey is, in essence intangible (i.e. transportation); inseparable (i.e. customers must be present to avail themselves of the services); heterogeneous (i.e. the quality of the journey may vary); and is perishable (i.e. if the customer misses the bus the service opportunity has been missed).
From the customer’s perspective, additional key cost include timings, time of journey, physical, sensory and psychic. Hence, decision maker needs to take into consideration the total value that a customer will place on the perceived benefits of using the service minus all the perceived costs that the customer would incur in using the service.

\[ \text{Value} = \text{Benefit} - \text{Cost} \]

\[ \text{Value} = \text{Benefit} - (\text{Monetary cost} + \text{Non-monetary cost}) \]

\[ \text{Value} = \text{Benefit} - (\text{Ticket price} + \text{a x time of travel} + \text{b x distance} + \text{c x road type} + \text{d x seating} + \text{e x driving} + \text{f x air-condition} + \text{g x emergency handling}) \]

In the above equation a, b, c, d, e, f and, g are the weightages given to different parameters. In bus transport, there are several non-monetary costs the passengers incur because of the difficulty that is involved while traveling like:

1.9.1 Time of Travel:

Time of travel is affected by congestion and length of travel. To reach from A to B there would be different routes and each of these routes has different travel length. Traffic congestion is an important factor that makes time the more relevant cost driver, particularly during peak periods. Traffic congestion can be called as “difficulty” the passengers would face because of traveling during the peak hours. Shifting the demand from the peak hours to non-peak hours i.e. either before or after the peak hour can reduce this difficulty.
To encourage passengers to travel during non-peak hours, service providers can charge less than the normal charges. Traffic congestion reduces average vehicle speed and increases the time and cost per service kilometer. Similarly, by providing different routes between A and B, the time of travel can be manipulated. Running the bus on less congested roads increases the average vehicle speed and reduces the cost and time per service kilometer. Thus, the time of travel is one of the factors, which cause difficulty to the commuters. Based on time of travel, differential pricing can be worked out.

1.9.2 Physical Effort:

Physical effort is needed to stay balanced while standing or sitting in a bus because of bad roads. Speeding around corners, braking hard, accelerating while passengers are trying to find a seat increases costs. Types of roads, i.e., good or bad roads also contribute to the difficulty which intern leads to increased cost.

1.9.3 Mental Costs:

Passengers experience these costs when having to share their mode of transport with others. Losing one's balance because of reckless driving, being forced to sit with quarrelsome co-travelers, fear for personal safety in case of bus failure, tyre burst, etc., increases this cost. Thus we can say safe driving practices and emergency handling capacity of the driver are factors that contribute to the difficulty factor.
1.9.4 Sensory Costs:

Passengers may experience the noise of the bus and the presence of other passengers. Uncomfortable seating, location of the seat in the bus, bus interiors and exteriors, bus size, lack of air conditioning adds up the sensory costs. All these factors contribute to the difficulty experienced by the passengers.

Thus difficulty factor [DF] is the function of distance; time of travel; road type; size of bus; seating; driving; AC; emergency handling.

Mathematically Difficulty Factor (DF) can be represented as below,

\[ DF = f \left\{ \text{distance; time of travel; road type; size of bus; seating; driving; AC; emergency handling} \right\} \]

\[ DF = f \left\{ a \times \text{time of travel} + b \times \text{distance} + c \times \text{road type} + d \times \text{seating} + e \times \text{driving} + f \times \text{air-condition} + g \times \text{emergency handling} \right\} \]

By manipulating the difficulty factors in terms of cost, transport operators can implement differential pricing strategy to improve revenue generation by having ideal passenger mix. Some customers do not mind facing more difficulty if only the price is low. Some other customers do not mind paying more to reduce difficulty during travel. Therefore Transport Companies can adopt differential pricing as a tool to shift customer density from highly congested route to lower congested route. This can lead to better capacity utilization and results in better profitability.
1.10 DIFFERENTIAL PRICING:

Differential pricing is the practice of charging some customers or clients more, while charging others less, for the same product or service. Virtually every industry and most companies engage in some form of differential pricing. For example, the airlines have a range of fares they charge customers based on when and how they make their reservation, whether they want to fly first or business class or coach, or whether they are willing to stay over a Saturday night. And many passengers fly free by using frequent flier miles.

Differential pricing can be used in one of five ways. First is by time of service usage. A restaurant that charges less for a meal at lunch than for dinner is using differential pricing based on time of usage. Bharat Sanchar Nigam Limited\(^1\) use differential pricing for Internet services when they charge different prices for daytime and nighttime.

Differential pricing can be based on the time of reservation. Airlines use this system. The price charged is based on when the airline seat is reserved. Passengers who reserve their seat 30 days in advance will pay less than passengers who reserve their seat four days in advance.

The time of ticket purchase can be used to implement differential pricing. This method is normally used in services where customers do not make reservations. Many entertainers will allow tickets to be purchased in advance at a lower price than at the door.

\(^1\) Service Marketing – Govind Apte; Oxford University Press.

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Differential pricing can be based on different target markets. For example Zoos, Museums charge less for children under 12 than they do for adults. Similarly Indian railways charge senior citizen 30 percent less than they do for non-senior adults.

A final method of differential pricing implementation is by location of consumption. Thus spectators attending a concert by legendary singer Lata Mangeshkar’s would pay more to sit on the front row seats than people at the back row seats.

1.11 NEED FOR GEOGRAPHIC INFORMATION SYSTEMS IN TRANSPORTATION:

Transportation agencies are currently faced with ever-increasing demands for information to support more effective decision-making throughout their organizations from engineering at the individual level to statewide planning and management. Furthermore, the broad environmental and economic development problems that confront all the society today require data sharing and cooperation among multiple government agencies at all levels.

In the past, information systems and database development within most transportation agencies and other government agencies, has often been application or even project specific. This causes problems with the integration at the functional-area level, let alone the agencies level or interagency level. All the data managed by transportation agencies, in general are or can be and
should be, geographically referenced. Integrating data by location has been inhibited by the wide variety of location-referencing methods. The very nature of GIS is to manage locational-referenced data. A well-designed GIS can serve as a translator among referencing systems and thereby bring about integration, without forcing complete reorganization of data collection and referencing methods. New demands for integrated information systems are being made, new technologies are being introduced that greatly impact the collection and management of data. These technologies include satellite positioning and imaging systems, electronic data collectors and notebooks, advanced photogrammetric systems, data sensing and telemetry systems, communication networks, low-cost computing engines, distributed and cooperative computing, client server network architectures, Internet, and others in addition to GIS. To take the greatest advantages of these technologies, they must be viewed as a part of a larger whole. Strategies must be developed for orchestrating comprehensive integrated systems design [17].
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