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# Survey on Analysis of Application of GIS for Traffic Management

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**ABSTRACT:** The deployment of GIS has attracted the interest of transportation software vendors who provide scheduling, vehicle tracking, and trip itinerary planning programs. In some cases, these vendors have developed their own mapping interfaces with GIS-type functionality. In other cases, they provide import and export programs to convert data into compatible GIS formats. These developments reflect in part the demands from the customers for mapping inter-faces. Over the years, Geographic Information Systems (GIS) technology has been implemented for a variety of purposes within the transportation industry. With this have come many new uses, benefits, and challenges. Geographic Information Systems (GIS) have long been recognized as a valuable tool for the representation and analysis of transportation system and related activities. Through the well-established vector data structure, GIS has provided an efficient means for organizing basic transportation related data in order to facilitate the input, analysis, and display of transportation related results. Section four provides a literature review of basic concepts of GIS and some publications about GIS applications in transportation and new GIS technologies used in these applications. The GIS database presents all the components related to routing and analysis of transportation systems, such as various modes of transportation, routes existed for these modes, road network present in the city, structure of the roads and routes, parking situation in the city etc.

**KEYWORDS:** Traffic Congestion, GIS Application, GPS, Traffic data analysis

## I. INTRODUCTION

Another interesting trend has been the convergence between geospatial technologies comprising GIS, GPS (global positioning system), and remote sensing technologies such as satellite images, LIDAR (Light Detection and Ranging), and products that orthodox rectify remote sensed data. This convergence is occurring in part because of IT compatibility and the overlap and complementarities between the technologies. Many users prefer the term “geospatial” to “geographic” information systems for these reasons

### 1.1. Background

The urban transportation systems are very complex in nature, due to the fact that they combine different modes of transportation over a limited space in high-density areas with increasing transport demand. With variety of information needed in the field of Transportation, Geographic Information Systems (GIS) is used as a valuable tool for the representation and analysis of transportation systems. GIS have proven to be an integral tool in addressing the needs of transportation systems. Through the well-established vector data structure, GIS has provided an efficient means for organizing basic transportation related data in order to facilitate the input, analysis, and display of results.

#### 1.1.1 Introduction

The GIS is one of the most innovative advances in the study of geography. Since its development in the 1970s, GIS has had a major impact on geographic analysis and on business practice in government and the private sector. Most transportation agencies now use GIS and Geospatial Information Systems for Transportation (GIS-T) is one of the largest users of GIS technology. The significant innovation that GIS provides is the ability to manage data spatially in layers and then overlay these layers to perform spatial analyses. Therefore, a roads layer can be integrated with a land use layer enabling a buffer analysis of the land uses within a given distance of the road. The capabilities of GIS have improved over the past three decades, and GIS now provide a wide range of tools for data management and analysis. In the early 1990s, GIS added specific tools for linear data management of transportation data that has proved to be extremely successful among transportation organizations.

### 1.1.2 Scope of GIS

Many have characterized GIS as one of the most powerful of all information technologies because it focuses on integrating knowledge from multiple sources and creates a crosscutting environment for collaboration. It combines a powerful visualization environment with a strong analytic and modelling framework that is rooted in the science of geography. This combination has resulted in a technology that is science-based, trusted, and easily communicated across cultures, social classes, languages, and disciplines. Transportation data encompasses a wide range of spatial data entities that are fundamental to many Geographic Information System and cartographic applications. Transportation data is normally considered a key element of base maps and served as essential reference data in this context. Besides its role as reference data, transportation data is at the core of applications, such as emergency response, routing, urban and regional planning, public transport, municipal service provision and general purpose mapping. Transport models are used for a wide range of purposes, from local traffic planning to managing infrastructure at a national level, as parts of other models (for example land-use models), and for providing the basis for evaluating the environmental impacts of traffic.

### 1.1.3 Urban Transportation in India

Indian cities of all sizes are facing the crisis of urban transport. Large cities are facing a rapid growth of personal vehicles (two wheelers and cars); and in medium & small cities, different forms of intermediate public transport provided by informal sector are struggling to meet the mobility demands of city residents. Several attempts have been made by planning authorities and experts to address these problems. Land use master plans prepared for most metropolitan cities have a brief chapter on urban transport.

However, planning and development of road infrastructure, regulations for private or public vehicles, licensing procedures, and operations of state transport undertakings continue to be in isolation. Despite increasing investments in road infrastructure, clean fuel policies, and metro construction in few cities, travel conditions for an average citizen have not changed. Therefore, with increasing urbanization and urban travel demands the business-as-usual scenario must change.

Urban travel demand has to be understood in the context of differentiated urban growth. Large differences in income levels and social disparities characterize our cities. This has led to the development of 'cities within cities'. Each level of the city with its own level of technology and land-use patterns exists in close geographical proximity with others of different patterns. This is reflected in travel and traffic patterns existing in cities.

The same road space gets used by modern cars, buses, along with locally developed vehicles for public transport (three wheelers), scooters & motorcycles, bicycles, rickshaws, animal and human driven carts. This requires careful understanding and innovative solutions to meet the diverse demands. Policy framework for optimal modal mix in this context should promote innovations in road designs, institutional modifications, vehicles designs and innovative financial schemes.

### 1.1.4 Transportation in Pune

Maharashtra is the most populous state in the Indian Union. It has a population density of about 166,052,859 as per the 2011 census. There is an average density of 689 persons per sq km i.e. 1,785 per sq mi. Pune is the biggest city in the state. The state has largest road network in the country. It boasts of 31 National Highways (NH), with a total length of 4,942 km (8.5% of total NH length in India). It has seventh highest road density in India (1,027 km per 1000 km<sup>2</sup> in 2002) and largest surfaced urban road network in the country (50,721 km, as on 2002). Cities of Mumbai Pune Nagpur are connected to number of National Highways. New expressways are coming up between Pune Mumbai.

### 1.1.5 Transportation in Maharashtra

Maharashtra is located at 25.45°N 81.84° E in the Western part of the India at an elevation of 98 metres (322 ft) and. Pune is located on the junction of National Highway 2 and 27. National Highway 2, A four lane access controlled bypass road of 84.7 km aided by World Bank is nearing its completion.

Pune has three bus stations catering to different routes - at Zero Road, Leader Road and Civil Lines. Direct bus service is available from Pune Mumbai

## 1.2 GEOGRAPHICAL INFORMATION SYSTEM (GIS)

GIS has been defined by many ways, by many people:

“A Geographic Information System is a facility for preparing, presenting, and interpreting facts that pertain to the surface of the earth. This is a broad definition, a considerably narrower definition, however, is more often employed. In common parlance, a geographic information system or GIS is a configuration of computer hardware and software specifically designed for the acquisition, maintenance, and use of cartographic data.”

“A geographic information system (GIS) is an information system that is designed to work with data referenced by spatial or geographic coordinates. In other words, a GIS is both a database system with specific capabilities for spatially-reference data, as well as a set of operations for working with data. In a sense, a GIS may be thought of as a higher order map.”

### 1.3 TRANSPORTATION

Transport or transportation is the movement of people and goods from one location to another. Transport is performed by various modes, such as air, rail, road, water, cable, pipeline and space. The field can be divided into infrastructure, vehicles, and operations.

Infrastructure consists of the fixed installations necessary for transport, and may be roads, railways, airways, waterways, canals and pipelines, and terminals such as airports, railway stations, bus stations, warehouses, trucking terminals, refuelling depots (including fuelling docks and fuel stations), and seaports. Terminals may both be used for interchange of passengers and cargo, and for maintenance. Vehicles traveling on these networks include vehicles of appropriate types such as automobiles, bicycles, buses, trains, trucks people, helicopters, and aircraft. Operations deal with the way the vehicles are operated, and the procedures set for this purpose including financing, legalities and policies. In the transport industry, operations and ownership of infrastructure can be either public or private, depending on the country and mode.

Passenger transport may be public, where operators provide scheduled services, or private. Freight transport has become focused on containerization, although bulk transport is used for large volumes of durable items. Transport plays an important part in economic growth and globalization, but most types cause air pollution and use large amounts of land. While it is heavily subsidized by governments, good planning of transport is essential to make traffic flow, and restrain urban sprawl.

## II. PROBLEM STATEMENT

Traffic congestion is one of the day to day activities in all developing cities. Due to traffic congestion lot of problems occurs, such as an increase in travelling time, decrease in speed, air pollution, etc., This study involves identifying the traffic volume in important junctions and analysing the causes of traffic volume with the support of Geographic information system (GIS). All important features are digitized in the study area. The prepared GIS thematic maps show the present traffic volume causes in the study area.

The study results present traffic volume scenario in important junctions in Pune. The prepared thematic maps show the causes of traffic congestion in the study area. Providing proper parking locations, alternating the routes and avoiding the establishment of new commercial zones in the study area may minimize the traffic congestion and also support the proper urban growth.

## III. OBJECTIVE

This research has the following main objectives:

1. To survey the transportation systems existed in Pune.
2. To prepare maps showing existing routes and stops for the city using GIS
3. To prepare GIS database based on the basis of survey for Pune transportation
4. To present components of transport systems in a GIS environment.
5. To analyse transportation system exists using GIS software
6. To suggest for applying GIS for the systems having spatial information's.

## IV. LITERATURE REVIEW

**Tripathy (2010)** analyzed the land use changes from 1929 to 2009 by utilizing satellite imagery of TM maps information for 1990, 1999 and Google earth imagery for 2009 and Survey of India topographic maps have been considered to generate the sheet. The study has created a land use/ land cover map of Korba area of Chhattisgarh for different time periods, here imageries of five distinction period taken into account (1929, 1970, 1999, 2005, 2009) point of time with a goal to identify the progressions that have occurred especially in the urban area, mining range, water bodies, and forests. From the result it can be concluded that amid a period of this 80 years forest area diminished from 4622.82 km<sup>2</sup> in 1929 to 2241.66 km<sup>2</sup> in 2009. The agriculture area expanded amid the period 1929-1970 demonstrating that non forest area was changed over into farming land amid this period. From 1970 onwards, mines and barren region expanded from nil to 527.72 km<sup>2</sup> in 2009. Amid the period from 1929 to 2009 mining and barren area expanded by 7.98% though forest area saw abatement. The variation in land cover was maximum for forest land as compared to others. Water body expanded amid this period. There was an increment in agriculture area because of



expansion in populace. Henceforth, such activities must be controlled to minimize the adverse impacts. The discoveries of the study could be valuable in formulating the Environment Management Plan for the area.

**Khan and Javed (2012)** conducted a study on Singrauli coalfields area as it is one of the coal mining regions where huge scale mining activities are going on. In this study multispectral/multi-temporal information of Indian Remote Sensing Satellite (IRS) LISS II geocoded (FCC) of two different time periods were used dated 4th May 1993 and LISS III of 4th May 2010 for thematic mapping. Survey of India topo sheet 63L/12 on scale 1:50,000 were utilized to create base map which was overlaid on the FCC for land use/ land cover mapping through visual understanding. Visual understanding of satellite imagery prompted the detection of 15 land use/land cover classifications for example dense forest, cultivated land, open forest, mining pits, wasteland, overburden dumps etc. . The ground truth check was done in key regions to redress the errors in created maps and after that land use/ land cover maps was finished. It has been recognized that the principle drivers which has expanded the rate of progress in land use/ land cover are primarily coal mining & industrial extension.

**Kumar and Pandey (2013)** had done an assessment of spatio-temporal land use/land cover changes in South Karanpura coal mine and surrounding area was done amid the period from 1992 to 2009. Land use/ land cover maps for the year 1992, 2004 and 2009 were produced through the visual understanding of ETM and IRS -1D LISS-III satellite images. The major changes are identified over agricultural area, coal mining areas and forests. The study uncovered that coal mining zone extended from 10.06 sq. km in 1992 to 21.29 sq. km in 2004 and further reduced to 19.40 sq. km by the year 2009 because of lessening of coal hold and decrease in the coal creation showing 92.84% zone increment in coal mining induced land utilization changes fundamentally to the detriment of cropland ( -38.67%) and dense forest (-71.85%). The coal mining range which was 10.06 sq. km in 1992 (3.6%) increments to 21.29 sq. km in 2004 (7.68%) and further reduced to 19.40 sq. km (6.9%) by the year 2009.

**Singh and Mahanto (2013)** had studied the land use/ land cover changes in the Jharia coalfield. Extensive growth of coal mining in the region is a major concern for sustainable environment. The study was done to identify land use changes between 1995 to 2008 utilizing topographical maps created by GSI, aerial photos & satellite images of IRS LISS IVMX satellite imagery of NRSC, Hyderabad. The information was received in 12 sheets covering the whole coalfield alongside computerized TIFF position. The land use changes had been recognized by image processing system ERDAS IMAGING 9.3, ArcGIS 9.3. Land use changes had been identified by image differencing & image rationing of NDVI pictures. It can be concluded from the study that rapid mining, extension of urban settlements diminish vegetation spreads lead to adverse effect of mining to environment in the Jharia coal field area.

**Choudhury (2012)** in his study concentrated on the utilization of Remote Sensing and GIS as a tool for change detection & analysis land use pattern of Talcher, Odisha a well-known hub of coal mining which contributes about 16.3% of the nation's aggregate store. The land cover changes in Talcher area was analyzed for the three unique years – 1973, 1990 and 2009. The LANDSAT MSS imagery for 1973 and LANDSAT TM imagery for the years 1990 and 2009 were utilized for the study. Land use land cover maps, NDVI maps of the range for the given time period had been made. From the study it was observed that the decrease in forest between 1973 and 2009 is around 43 km<sup>2</sup> and increment in mining range is around 34km<sup>2</sup> . In spite of the fact that the water body has diminished yet at the same time there is very little distinction. The aggregate increment in settlements adds up to 28 km<sup>2</sup> . Hence it can be concluded that substantial scale mining causes large scale deforestation as can be seen in Talcher territory.

**Mukti Advani, B.Srirama and S.K.Pathan(2015)** developed a GIS based model with an objective of minimizing travel distance and travel time of users. Constrains taken into consideration were impedance for intersections, type of road and speed.

**Ammar Alazab, Sitalakshmi Venkatraman, Jemal Abawajy, and Mamoun(2016)** Alazab examined the value of real-time traffic information gathered through Geographic Information System for achieving an optimal vehicle routing within a dynamically stochastic transportation network.

### V. METHODOLOGY

Flow chart of methodology is shown in Figure 1. The methodology is described in the subsequent section as under.

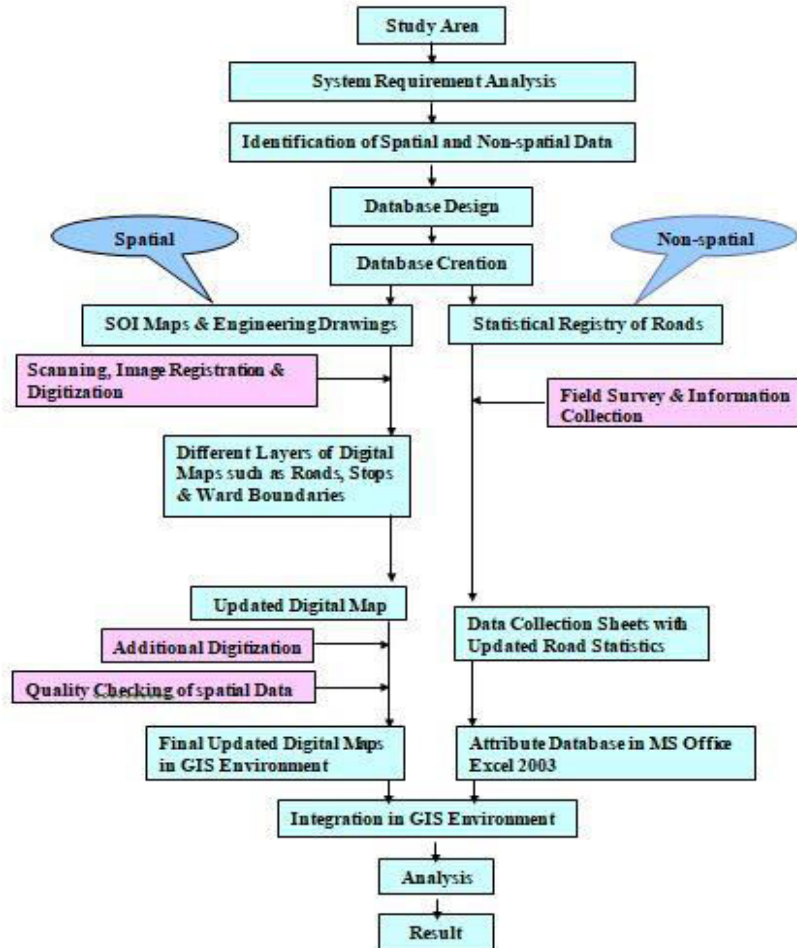


Figure 1: Flow chart for Methodology

#### 5.1 STUDY AREA.

A brief description of the characteristics is discussed in subsequent sections.

Pune City has been selected as study area, which has a complex road network and transportation system. It has various road network and transportation mode in the different part of the city. Main city has irregular roads where as Pimpri has a systematic road network.

Pune is situated at approximately 18° 32" north latitude and 73° 51" east longitude. The city's total area is 331.3 sq. km. By road Pune is 1,173 km (729 mi) south of Delhi, 734 km (456 mi) north of Bangalore, 570 km (350 mi) north-west of Hyderabad and 149 km (93 mi) south-east of Mumbai. Pune lies on the western margin of the Deccan plateau, at an altitude of 560 m (1,840 ft) above sea level. It is on the leeward side of the Sahyadri mountain range, which forms a barrier from the Arabian Sea. It is a hilly city, with Vetal Hill rising to 800 m (2,600 ft) above sea level. The Sinhagad fort is at an altitude of 1,300 metres (4,300 feet). The old city of Pune is at the confluence of the Mula and Mutha rivers. The Pavana, a tributary of Mula river and Indrayani river, a tributary of the Bhima river, traverse the northwest suburbs of Pune.

The Census of India (COI) 2011 has considered the city of Pune in three regions namely the Municipal Corporation of Pune (PMC), the City Outer growth (OT) and the Pune Cantonment (CB). The Municipal area of the city, 331.3 sq. km has a population of 3,124,458.



**Table 1: Population of Pune** (Source: Pune Master Plan data 2011 Map)

Year	Area	Total Population
2011	Municipal Corporation	3,124,458
	Municipal Corporation + Outer Growth	5,057,709

## 5.2 SYSTEM REQUIREMENT

### 5.2.1 Requirement of GIS

Transportation data are available in the form of traditional paper road maps, engineering drawings and road statistics registers. Voluminous and scattered data, maps in different formats and scales creates difficulty in accessing the statistical information of a map feature etc. So a need is felt to have a more scientific and systematic approach accessing the statistical information from these data.

In this context, the inherent capabilities of the technology offered in a GIS are looked upon as a valuable tool to successfully fulfil the specified requirements. A project for utilizing it to prepare a GIS based Urban Transportation System is conceptualized with the objective of creating a GIS database of roads & transportation that would induce efficiency and accuracy in analysing the Transportation system in Pune.

### 5.2.2 Hardware & Software Requirement

In this we study what type of Software’s and Hardware’s we require for the research work. There are following Software’s and Hardware’s used in the present work

#### 5.2.2.1 Hardware’s

Hardware are needed for scanning the maps, processing the work and displaying the result. Hardware’s which are needed for a GIS project are described as under.

##### Vidar Select P42

It is a scanner which is designed to give professionals the best in very high speed monochrome scanning with the additional option of quality colour scanning for special jobs. The scanner’s 42" imaging area handles oversize E-size/A0 engineering drawings, architectural sketches, blueprints, sepias, detailed maps, drawings and large colour posters.

High resolutions, easy maintenance, user replaceable parts and Automatic Thickness Adjustment Control (ATAC) are all combined in the Select P42 making it the perfect device for effective and reliable high-production scanning

##### HP DesignJet 500 (42)

It is a plotter which is used for plotting the map on paper. The HP DesignJet 500 (42") Plotter delivers clear, crisp images with rich and uncompromising image quality. This plotter delivers Hewlett Packard quality which has been the reason that the 500 series has been the bestselling plotter for several years.

In addition, HP Zoomsmart scaling technology allows easy printing from any Microsoft Windows application. The Hewlett Packard Designjet 500 is the perfect choice for graphics and technical professionals who want an all-purpose plotter that is smart, durable, and reasonably priced for their personal office or small to medium sized workgroup.

##### Personal Computer

A PC having Dual core 2.4 GHz processor along 4 GB RAM and 1 TB hard disk has been used. All of processing from Scanning to Displaying the result has been done with the help of this PC.

#### 5.2.2.2 Software

There are following software’s which are used in the GIS based applications:

##### Arc GIS 9.1

ArcGIS is an integrated family of GIS software products for building a complete GIS. It consists of four primary frameworks for deploying GIS:

(i) **ArcGIS Desktop**—An integrated suite of professional GIS applications comprised of three main software products: ArcView, ArcEditor, and ArcInfo.

**ArcInfo:** It is the most complete desktop GIS which includes all the functionality of ArcEditor and ArcView. There are following components of ArcInfo (ArcGIS Desktop) which has been used for the paper.

a. **ArcToolbox:** It was used for transformation of the projection system and mosaicing of maps

b. **ArcCatalog:** It was used for creating Feature datasets and Personal geodatabase.

c. **ArcMap:** It has been used for the registration (Georeferencing & Rectification) and digitization of the map.

(ii) **Server GIS**—ArcIMS, ArcGIS Server, and ArcGIS Image Server

(iii) **Mobile GIS**—ArcPad and ArcGIS Mobile for field computing

(iv) **ESRI Developer Network (EDNSM)**—Embeddable software components for developers to extend GIS desktops, build custom GIS applications, add custom GIS services and Web applications, and create mobile solutions.

ArcGIS Desktop includes an integrated suite of comprehensive desktop applications ArcMap, ArcCatalog, ArcToolbox, and ArcGlobe.

### Microsoft Office Excel 2010

In Microsoft Office Excel 2010, it is possible in the worksheet to group and act upon related data. A list on existing data or a list from an empty range can be created. When a range is specified as a list, it is possible to manage and analyze the data independent of other data outside of the list.

### MS Office 2010

It has MS Word, MS Excel, and MS PowerPoint etc. MS Excel was used for preparing the data sheet which was brought while surveying. MS WORD and MS PowerPoint were used for preparing the report.

## 5.3 IDENTIFICATION OF SPATIAL AND NON-SPATIAL DATA

After analysing the system requirement the entire system architecture is framed around the two major building blocks of a GIS enabled system: the Spatial and the Non-spatial data.

### 5.3.1 Spatial Data

Spatial data are available in the geographical form which contains the location and shape of geographic features. Maps use three basic shapes to present real-world features: points, lines, and areas (called polygons). Spatial layers that required to be incorporated into the system are identified and the work of spatial data creation for the transportation system is taken up in collaboration with Pune Guide Map (1:20,000 scale) as base maps, ward map and Google maps.

### 5.3.2 Non-spatial Data

Non-spatial data are in the attribute (tabular) form. These are the descriptive data that GIS links to map features. Attribute data is collected and compiled for specific areas like states, census tracts, cities, and so on and often comes packaged with map data.

When implementing a GIS, the most common sources of attribute data are our own databases combined with data sets you buy or acquire from other sources to fill in gaps. Attributes that required to be attached to the spatial data layers, and are thought of considerable significance while planning and monitoring of the transportation system, are identified.

## 5.4 DATABASE DESIGN

In this the requirements identified in the earlier stages are reviewed and used to design the database. There is no single correct procedure for designing database. The database design process is not linear. There are feedback loops between the conceptual and logical design and the physical design.

### 5.4.1 Conceptual and Logical Design

It determines database contents and how to logically organize the data in the database. This design is based on the concept of a shared database using the geodatabase. Conceptual design is a top-level concept of “how the database will work?” The logical design is a detailed layout that fills in the conceptual design in accordance with a specific data model.

### 5.4.2 Physical Design

It decides which source of data is used for the system. In this final layout of each geographic dataset and independent table is made. This design establishes a standardized naming convention for spatial, attribute, and related file data. This is a detailed translation of the conceptual design into a physical layout.

## 5.5 DATABASE CREATION

Database creation is a two-step process which is as follows:

### 1. Assembling the Database

The data we need for the project exists in the several places and in different formats. In order to conduct our analysis, we must find the data, get information about it, and copy it into the appropriate work space. ArcCatalog lets explore and organize data efficiency.



## 2. Preparation of Database for Analysis

We determine which layers are currently usable and which require additional processing for use in the analysis.

Some of the common tasks involved in preparing database for analysis include:

Checking data quality-making sure the data is accurate and up-to-date.

- Converting data between formats.
- Automating data by, digitizing, scanning, converting, or geolocating
- Defining coordinate systems
- Projecting layers in a new coordinate system
- Merging adjacent layers

### 5.5.1 Spatial Database Creation

SOI Maps, Engineering Drawing and Satellite images are taken up as base maps for the project. These maps are scanned and converted into different format like TIFF, JPEG as required.

Scanned map datasets don't normally contain spatial reference information (either embedded in the file or as a separate file). With aerial photography and satellite imagery, sometimes the locational information delivered with them is inadequate and the data does not align properly with other data we have. Thus, to use some raster datasets in conjunction with other spatial data, we need to align, or dereference, to a map coordinate system. Georeferencing raster data allows it to be viewed, queried, and analysed with other.

The general steps for georeferencing a raster dataset are:

1. Add the raster dataset that is to be aligned with the projected data in ArcMap.
2. Add control points that link known raster dataset positions to known positions in map coordinates.
3. Save the georeferencing information when the alignment (also referred to as registration) is satisfactory.
4. Optionally, permanently transform the raster dataset

### 5.6 INTEGRATION OF SPATIAL AND NON-SPATIAL DATA

Spatial data and the Tabular data residing in the MS Excel are integrated in GIS environment using ArcInfo.

### 5.7 ANALYSIS OF THE SYSTEM

Transportation system of the city is analyzed with the help of prepared database through attribute table. In this availability of transportation modes, its frequency, fleet size and road network are analyzed through the system developed for transportation using GIS.

## VI. CONCLUSION

Spatial information for the urban transportation system of Pune City has been created in the present research work. The information system also consists of demographic land-used details. An interactive approach has been framed in the GIS environment for analyzing the transportation system. Through the well-established vector data structure, GIS has provided an efficient means for organizing basic transportation related data in order to facilitate the input, analysis, and display of transportation related results.

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