

DEVELOPMENT OF TRAFFIC SIGNS AND FACILITIES ASSET MANAGEMENT SYSTEM

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Abstract

The Road Asset Management System has a lot of potential in developing countries because it not only helps to assess assets, but also to protect them by taking appropriate action at the correct moment. National, state, and municipal governments in Pakistan, in particular, confront a significant problem in maintaining the functionality of existing transportation assets while simultaneously funding network expansions to meet expanding demand. While transportation officials spend a lot of time and money building new highways, transit stations, airports, and pedestrian and bicycle facilities, some estimates suggest that the country will spend more money in the coming decades preserving and improving existing infrastructure than building new ones. Asset management is a proactive and methodical strategy to ensuring that physical assets are properly maintained, upgraded, and operated through the course of their useful lifetimes. It focuses on resource allocation and utilisation business and technological strategies, with the goal of improving decision-making through the use of high-quality data and well-defined objectives. The traffic Signs Inventory Database is extremely useful for traffic sign maintenance and administration on the road. The effective inventory system will aid in safe driving, and the existing inventories will assist the responsible authorities in efficiently managing the signs. The information on traffic signs for a road section between Babu Sabu junction to Kareem block was collected using GIS software. The primary goal of GIS software is to collect data on the number of signs, their position, type, and current state. This information will assist transportation organization in tracking and monitoring indicators on a regular basis.

1. Introduction

This chapter introduces the background of the development of signs and facilities of an asset management system. The chapter also introduces the problem statement, significance and the objective of the research. Afterwards, we review the previous studies carried out for asset management system. The thesis organization also shows at the end of the chapter.

1.1 Background

Transportation networks are constantly evolving and becoming more complex. Asset management gives transportation professionals

new ideas and resources to help them make smart decisions that result in better quality and lower costs. Since information is so important to successful asset management, each organization must decide how much information is enough, which will be determined by its priorities and willingness to take risks. It is not cost-effective – or even feasible – to have 100 percent certainty about any decision; finding the right balance between assurance and cost is one of the most important aspects of every asset management program. Transportation authorities are constantly using asset management principles to define different investment strategies and

maximize the use of public funds. Pavement and facilities construction and maintenance account for a significant portion of transportation budgets. Public authorities are working to upgrade the operations elements of their highway networks in order to improve the safety and reliability of transportation systems. For the safety of road users, the Traffic signs provide information to aid in the smooth and orderly movement of traffic. Traffic Signs must be visible, detectable and understandable by users from a far in accordance with their goals. Signs in the road provide drivers with the details they need for controlling their car, they need guidance and direction. Traffic signs are an important half of the road system, and a road with poor signage or signs that are not well maintained is insufficient. Road users rely on traffic signs for information and direction, and route authorities rely on them for efficient route network activity, group enforcement of traffic laws, traffic control, and road safety. Signs should deliver their message to drivers in a simple and timely manner. The message should be simple and easy to comprehend. A well-informed driver would be more comfortable, less nervous, and less likely to make bad decisions that could result in a car accident. The size, color, and shape of a sign, as well as the legend, which may include words, symbols, and arrows, may provide information to road users. Uniform Traffic Control Devices Manual (MUTCD) FHWA [1] proposes five guiding principles for road signs to ensure efficient and safe traffic flow: fulfil a need, drive focus, convey a clear and simple message, command respect from road users, and provide sufficient time for proper response. Because of the ambient sunlight, signs are usually well lit and easy to read throughout the day. At night, the scene shifts drastically. It's difficult to read insufficient or faded signs at night, particularly for older drivers, and this is thought to contribute to vehicle crashes, injuries, and fatalities. Nearly half of all traffic deaths, according to previous estimates, occur at night. Retro reflectivity is one of the most important sign evaluation variables for nighttime driving, as determined by a coefficient of retro-reflection (RA) expressed in Candela per lux per square meter (cd/lx/m²).

The ability of a surface to reflect light back into its source is known as retro-reflectivity.

The ratio of luminance from the legends to the background is known as contrast. Brightness refers to the intensity of radiating or reflecting light, while contrast is the ratio of luminance from the legends to the background. The angle created by a light beam from a vehicle's headlights hitting a sign surface and the line formed by the retro-reflected beam toward the observer's eyes is known as the observation angle. The angle formed by the normal to the sign surface and the illumination axis (from the vehicle headlight) is known as the entrance angle. The rotational angle is the angle at which the retroreflective material/surface is oriented during testing. Reflective sheeting is a single film made up of many layers of materials glued together by a machine. Face film, glass bead plate, adhesive layer, release layer, and liner are the layers used in a standard reflective sheet construction. Glass bead and micro prismatic reflective tapes are the two most common styles. Beaded sheet reflects light with "microscopic glass spheres," while prismatic sheet reflects light with a "array of prisms."

1.2 Problem Statement:

For the provision of new traffic signs and facilities we need existing data regarding signs in order to fix location, position, shape and size of signs. Thus, by avoiding issues of installing new traffic signs and facilities, we need to analyze the existing data in the GIS for better asset management. The data of existing inventories are available with higher authorities like department of transportation but may not be as helpful as GIS based collected data. It is not helpful only in data collection but also helps in safe and efficient transportation system.

1.3 Research Objective:

- Development of the traffic data in the form of traffic signs.
- To collect the existing traffic signs data by use of the Geographical Information System (GIS).
- The invention of the data base for future road asset management system.

- To analyze and evaluate the GIS data base for future road asset management.
- To carefully examine the suitable position, location, size and shape of the traffic signs.
- Traffic signs and facilities standardization through testing and grading
- Using Traffic signs and facilities database for Optimization and maintenance of traffic signs and facilities.
- Frame work design for GIS based Signs and facilities asset management system.

1.4 Significance of the Research:

For the safe and efficient transport system it is necessary to have all the useful information on existing traffic conditions and assets. It is quite helpful to manage the traffic condition and operate the transport system with minimum road accidents and reduce any other hazards regarding traffic. The asset management will not only help in safe and efficient traffic management but also a guide for geometrical design of a road segment where traffic accident is usual.

Because signs are so crucial for public safety, a comprehensive sign management programmes with current inventory data are an essential aspect of a transportation agency's asset management operations. Despite this, many agencies continue to gather sign data in spreadsheets, making it impossible to maintain data integrity and effectively use the data to maintain an inventory of properly positioned, well-functioning signs. A modern sign management system can help authorities/agencies not only improve public safety but also improve business processes by Establishing maintenance methods to get the most out of sign assets and the staff that keep them in excellent working order. A sign management system can also help agencies achieve Federal Highway Administration (FHWA) regulations for sign retro-reflectivity, which is a vital measure of an asset's visibility and, hence, its capacity to promote safety.

1.5 Asset Management

The process of planning and controlling the acquisition, operation, maintenance, renewal, and disposal of organizational assets is known as asset management. This procedure increases

the asset's delivery potential while lowering costs and hazards. Over the asset lifecycle, proper maintenance and deployment of technology, people, and procedures ensure a positive capital enhancement.

1.5.1 Categories of Asset Management

The asset management are divided into sub-categories i.e. physical, financial, and contractual asset management. The details of each category are described below.

1. Physical asset management

Fixed asset management, inventory management, infrastructure management, and public asset management are all examples of physical asset management.

2. Financial asset management:

The process of managing procurement, formulating an investment strategy, controlling budget and costs, and handling cash, bonds, and stocks is referred to as financial asset management.

3. Contractual compliance

Contractual compliance improves the efficiency of activities such as IT asset management, digital asset management, contractual maintenance, and intangible asset management.

1.5.2 Components of an Asset Management System:

Any country's economic and social well-being depends on careful planning and coordination of local public infrastructure. Assets, public infrastructure, and services allow us to offer a diverse range of lifestyle options and maintain high living standards. To protect an asset, one must be conscious of the quantity and nature of the asset at any given time. In order to preserve the asset, one has to be aware of the quantity and quality of the asset at any moment of time. To preserve the road asset or to minimize the rate of deterioration, the assets are needed to be monitored regularly and the pavement health, therefore, needs to be updated regularly in a system. Asset management is a proactive and systematic approach to successfully sustain, upgrade, and operate physical assets over the course of their

useful lives [2]. It focuses on business and technical strategies for resource allocation and utilization, with the goal of improving decision-making through the use of high-quality data and well-defined objectives. It represents a holistic approach to system management and success.

The Components of Asset Management System are as follow:

- ❖ GIS database
- ❖ Pavement Information System
- ❖ Traffic Information System
- ❖ Pavement Management System
- ❖ Cross Drainage Information System

1.5.3 Elements of an Asset Management System:

The Elements of Asset Management System are as follow:

- ❖ Explicit identification of performance goals and measures;
- ❖ Ensuring that programmes, projects, and services are delivered in the most efficient manner possible;
- ❖ Informed decision-making based on high-quality data and analytic tools
- ❖ Monitoring of actual performance and costs, and use of this feedback to improve future decisions; and monitoring of actual performance and costs, and using this feedback to improve future decisions
- ❖ Identification and evaluation of a wide range of options.

Other tools, such as HDM-4 or other GIS software, can work on their own, but they can also be used in conjunction with the Road Assessment Management System (RAMS). The proper linkage of these tools and all of the above-mentioned RAMS components is critical to RAMS' efficacy. The interconnectivity of various information systems enables for budget forecasting and prioritization of road sections for normal maintenance and improvements.

1.6 Road Asset Management System:

The road assessment management system (RAMS) is a road maintenance planning tool with a database that records and provides data on short and long-term road repair. The technique is also used to develop budgets and

maximize the economic returns on road network investments.

In developing countries, the Road Asset Management System has a lot of potential because it helps to not only calculate assets but also to protect them by implementing effective steps at the right time. In the Pakistan, in particular, national, state, and local policymakers face a major challenge in maintaining the functionality of existing transportation assets while also financing transportation network expansions to meet rising demand. While transportation officials devote a lot of time and effort to constructing new highways, transit stations, airports, and pedestrian and bicycle facilities, some estimates suggest that the country will spend more money in the coming decades preserving and improving the current transportation infrastructure than building new ones.

Asset management is a proactive and systematic approach to successfully sustain, upgrade, and operate physical assets over the course of their useful lives [2]. It focuses on business and technical strategies for resource allocation and utilization, with the goal of improving decision-making through the use of high-quality data and well-defined objectives. It represents a holistic approach to system management and success.

1.7 Transportation Asset Management Committee

The Transportation Asset Management Committee of the Transportation Research Board (TRB's) brings together practitioners and researchers to discuss current asset management practices across all modes of transportation, establish research needs, and promote dialogue and broad dissemination of knowledge through meetings, seminars, conferences, and publications.

1.8 AASHTO Subcommittee on Asset Management

Both AASHTO and FHWA place a high priority on asset management. The Task Force on Asset Management was established by AASHTO in 1997 to address the increasing interest in the concept. In 2003, AASHTO leadership sought to give asset management a

more permanent place in the AASHTO committee system.

The task force was disbanded, and the Standing Committees on Planning and Highways, as well as other relevant committees, formed a Subcommittee on Asset Management. The Standing Committee on Planning passed a resolution in May 2004 urging AASHTO to continue developing and implementing sound asset management principles as a top priority. The AASHTO Subcommittee on Asset Management introduced a Strategic Plan for the years 2004–2010. The strategy calls for a broad-based, proactive approach to completely implement transportation asset management strategies and applications. The strategy also lays out a method for AASHTO, FHWA, and state DOTs around the country to advance the state of the practice. Many states are already actively incorporating asset management in their day-to-day operations, according to the strategic plan. The goals emphasize the advancement of asset management techniques, analysis methods, and research subjects, such as economic assessment tools and trade-off analysis methods. The strategy emphasizes the importance of engaging and exchanging knowledge with policy and technical decision makers, as well as elected officials, about the advantages of using asset management concepts and techniques in the planning process, from target setting and investment decisions to operations, restoration, and maintenance.

1.9 Asset Management through Geographic Information System (GIS)

A geographic information system (GIS) is a system for creating, managing, analyzing, and mapping various types of data. GIS connect data to a map by combining location data (where things are) with several forms of descriptive data (what things are like there). This lays the groundwork for mapping and analysis, which is employed in science and nearly every sector. Users can utilize GIS to better comprehend trends, relationships, and the context of their location. Improved communication and efficiency, as well as better management and decision-making, are all advantages.

The first phase in creating an asset management system is identifying the road network in satellite imagery and creating a layer in GIS software that contains the road alignments. Problems in developed countries include: In most developing countries, satellite images are unreliable, and road names and start-end positions often vary from satellite databases. The alignments on the ground also indicate consistent offsets from the satellite images. As a result, ground-truthing of the same becomes critical. The road alignments are captured in GPS devices in order to do so. An individual travelling along the road with a GPS system records the longitudes and latitudes of the road alignment (center line) in the GPS device. The captured data is then transferred to a computer, where the alignments are translated to .shp format using GIS software. Even with standard GPS systems, alignments are not always correct, and certain offsets are always present. High-end GPS systems, such as the Differential Global Positioning System, can help to minimize this offset (DGPS).

Geographic Information System (GIS) Uses

The uses of geographic information system are as follows;

- ❖ Geographic information systems (GIS) technology aids in the planning, construction, and administration of communication networks for our phones, as well as the infrastructure needed for Internet access.
- ❖ Road networks and transportation infrastructure are managed and built using geographic information systems (GIS).
- ❖ Geographic information systems (GIS) are used to determine effective routes for medical emergency vehicles to travel between emergency sites and medical care facilities like hospitals.
- ❖ Businesses utilize geographic information systems (GIS) to plan where new stores and restaurants should be located. Marketers utilize GIS to figure out who they should target and where they should advertise their products.

2.Literature Review

This chapter has been made to identify the basic thoughts of asset management system to traffic signs and facilities. The studies

performed earlier on the asset management system has been described in this chapter.

2.1 General

To the analysis of numerous literatures, some of which describe traffic facility and signage asset maintenance and management methods. And how to keep pavement marking assets, signage, culvert asset management, bridge asset management, and road infrastructure assets in good working order. To facilitate our study there is different literature presents which helps for better understanding of traffic signs and facilities asset management system.

2.2 Background on traffic signs and facilities Asset Management system:

H. Guler et al: A Modern technology were addressed in this study, and some GIS applications were implemented in the TCDD on railway assets, stations, segments, traffic accidents, repair and renewal work, and railway operations (freight and passenger) [3]. Compared to traditional ground-based survey approaches, airborne automated terrain mapping and photography data collection systems provide many distinct advantages. This cutting-edge technology can now perform 0.3-meter (1-foot) interval contour mapping and capture high-resolution picture images. This airborne, contact-less method for topographic surveying will truly revolutionise the future of surveying, digital mapping, and accurate GIS databases, as well as their applications for infrastructure and asset management, thanks to its speed, protection, performance, and digital formats. One of the major issues facing railway companies in both developed and developing countries is track maintenance and repair [3]. Transportation infrastructure is the key to economic growth and, as a result, a stable economy. It is one of the largest and most important investments made in any country, at any level of development. GIS may be used to assess the position of an event or asset, as well as its relationship or proximity to other events or assets, which may be a key factor in making design, construction, or maintenance decisions. The aim of this paper was to show how GIS can be used to analyze track conditions and provide decision support for permanent

way M&R projects. For conducting numerous evaluations, creating more efficient operating plans, and seeking solutions to several management issues, it is critical to create a comprehensive, easily understood, and visually appealing database relating to rail freight transportation. According to the findings of this report, a well-designed GIS framework will effectively assist transportation professionals with traffic safety studies [3].

Elizabeth Allison Harris et al presented a study which uses a sign asset management simulation based on inspection and sign data gathered in the field to examine some traffic sign retro reflectivity maintenance methods. The simulation compared 30 sign asset management scenarios in terms of annual sign maintenance costs and the proportion of traffic signs that did not meet the proposed FHWA standard. According to the simulation findings, higher sign repair costs resulted in a lower proportion of noncompliant signs. Even with relatively low maintenance costs per sign, lower percentages of noncompliant signs were identified in some situations using the visual night time inspection process. The number of noncompliant signs was reduced by 10% or more when the maintenance cost per sign was increased by 10%. Since Type I signs have a higher life-cycle cost than Type III signs, it is recommended that DOTs adopt a 100% Type III sign replacement policy. DOTs should set their own minimum retro reflectivity requirements and allocate an appropriate annual budget for sign replacement. The sign asset management simulation created as part of this study could be tweaked to enable it to be used by other DOTs [4]. He concluded that the

FHWA-HOP-05-006 The had prepared three asset management methods compared in this section – for signal systems, infrastructure assets, and IT assets – all follow the core concepts outlined in Section 2.0, and aim to optimize the productivity and effectiveness of available resources in order to meet performance objectives. From a high level, the basic functions of all three asset management techniques are the same: inventory management, performance tracking, defining

shortcomings, assessing alternatives, and resource allocation. However, a closer examination of asset management techniques for these three asset groups shows significant variations in focus and methods. This is due to variations in asset characteristics as well as the decision-making context of device users. The capabilities covered by infrastructure and IT asset management are combined in the signal system asset management specifications. Since signal systems contain IT assets such as computer hardware, software, and communications equipment, and other signal system components (such as controllers) have similar management requirements, there are clear parallels between signal systems and IT assets. As a result, the data content of IT asset management systems can be used to further define data specifications for signal system IT properties. Signal system management software is starting to incorporate the real-time monitoring and discovery features of IT asset management systems. Signal device asset management may benefit from the same types of quick-response what-if capabilities as IT asset management – for determining the consequences of equipment replacement and enhancements, as well as the relationships between hardware, software, and personnel requirements (analogous to the physical, system, and personnel elements of signal systems). Many aspects of infrastructure asset management are important to SSAMS requirements. To begin, some components of a signal system (e.g., structures/poles) can be dealt with using deterioration modelling and lifecycle costing analyzes built for the infrastructure domain. The practice of monitoring output not only from a business/resource usage standpoint, but also from a consumer or customer standpoint is entrenched in infrastructure management, and it is needed for signal system asset management (and all public sector transportation assets) as well. Many of the same approaches used in infrastructure asset management are used to calculate the impacts of signal system changes on consumers, and some of the performance metrics are similar (safety, travel time). Finally, both signal systems and facilities need substantial taxpayer funds to maintain and

upgrade, and asset management systems must ensure that resource allocation decisions are made with transparency. As a result, signal systems need the same discipline and methods used in infrastructure asset management for systematically identifying shortcomings, assessing alternatives, and allocating resources using well-defined prioritization methods [5].

G. Bonin et al The study outlines the development of a custom Road Asset Management System (RAMS) that will manage the approximately 23'500 kilometers of roads that make up Kazakhstan's main network of roads. The development of a new Road Asset Management System is a difficult job that necessitates the participation of many people. awareness of the state-of-the-art in terms of equipment and procedures, as well as an appreciation of the needs of the stakeholders. Understanding the existing protocol in use and being able to make the method "useful" to all parties concerned is critical to making its use truly fruitful. It is critical to communicate the system's capabilities and requirements, as well as to include all stakeholders in using it in their daily activities and, as a result, to continually improve it. The most significant benefits of using the RAMS in the RoK would be the availability of a structured, quick, and always accessible source of data for road properties, as well as the ability to generate more accurate, comprehensive, and useful analyzes, including budget allocation optimization, that are currently unavailable [6]. He concluded that the creation of a new Road Asset Management System is a difficult task that necessitates a thorough awareness of the state of the art in terms of equipment and procedures, as well as an understanding of the needs of the stakeholders. Understanding the existing technique in use and being able to make the system "useful" to all parties involved is critical to making its use truly fruitful. It is critical to describe the system's capabilities and requirements, as well as to engage all stakeholders in using it in their daily activities and, as a result, to continuously improve it. The most significant benefits of using the RAMS in the RoK will be the availability of a structured, fast, and always available source of data for road

assets, as well as the ability to produce more reliable, detailed, and useful analyzes, including budget allocation optimization, that are currently unavailable.

Adey, Bryan T et al A full high-level method for automating road asset management is described in this study. It should be used by road asset managers who are developing their own more comprehensive mechanism to ensure that all stakeholders agree on the activities and reasons for which they are involved in the management of road assets. The use of this process to create more comprehensive processes would aid in the success of future attempts to automate all or part of road asset management. There are eight basic sub processes in the proposed process. Road asset management is a critical process that necessitates a significant amount of human activity and is subject to human interpretation. This process would become increasingly automated over time, allowing humans to get the most out of their infrastructure while reducing the amount of human effort needed to do so. To allow this automation of road asset management, the entire high-level process outlined in this paper will be used. It should be used by road asset managers who are developing their own more comprehensive mechanism to ensure that all stakeholders are on board with the activities and why they are being done [7].

Cesar et al According to the study, countries have taken various approaches to road management in terms of decentralization, funding sources, management structure, and modal accountability. Various systems can be effective in helping countries achieve their goals. China, Brazil, Croatia, and the Slovak Republic, for example, have all used effective strategies to create expressway networks. Smaller countries, as predicted, have a lower degree of decentralization. Larger countries, such as Brazil, Russia, and Ukraine, would, however, likely benefit from greater decentralization. In terms of funding, roughly half of the countries examined have not used toll collection and will possibly benefit from it (except where traffic levels are relatively low). In

the other half of the countries surveyed, the management system is largely public; these countries will likely benefit from more private sector participation. In order to control the country's road infrastructure, New Zealand has given a fascinating example of experimenting with the division of responsibilities by role between several institutions. It had two independent departments for about a decade, one to administer highways and the other to provide funds. In 2008, the two organizations combined to "provide an integrated approach to transportation planning, funding, and delivery," among other items. In each of the countries examined, a specified Ministry of Transport is in charge of establishing checks and balances for good governance and fiscal risk management, as well as establishing overall transportation and roads policy [8].

Yichang et al The aim of the critical evaluation of the representative algorithms produced for traffic sign inventory is to demonstrate the results using real-world data and to identify the flaws in the algorithms and to advocate for the use of algorithms that support existing practice in state DOTs. Real data obtained from various transportation authorities and collected using the GTSV is used to objectively evaluate both the automated traffic sign detection and recognition algorithms using video log images and smartphone LiDAR. The findings show that state DOTs can use these automated algorithms in their existing operating procedures to provide a reliable and efficient inventory process [9].

- More than 75% of traffic signs were correctly identified using video log images obtained from LaDOTD and the city of Nashville for the automated traffic sign detection algorithm using video log images.
- Using the video log images obtained by the Georgia Tech Sensing Vehicle, more than 81 percent of stop signs and more than 96 percent of speed limit signs were correctly identified by the automated traffic sign recognition algorithm. More than 94 percent of traffic signs were correctly identified using the LiDAR data obtained by the Georgia Tech Sensing Vehicle in the automated traffic sign detection algorithm using mobile LiDAR.

However, the evaluated representative algorithms have described a number of technological challenges, including:

- Due to lighting changes, discontinuous borders, and a variety of other factors, approximately 25% of traffic signs cannot be identified using an automated traffic sign detection algorithm using video log files. In addition, the evaluation results reveal a high number of FP cases. Due to the established FN and FP incidents, fully automatic traffic sign identification remains a challenge at this time. To identify the undetected FN cases and delete the excessive FP cases, a manual analysis of the entire dataset is still needed.
- Due to lighting problems, there are still some FN cases for both stop signs and speed limit signs in the automated traffic sign recognition algorithm using video log images. More significantly, since only a small number of traffic signs can be identified automatically, a manual analysis of the entire dataset is still needed to recognize MUTCD codes for other traffic sign forms.
- Due to low retro reflectivity, occlusion, non-compliant traffic signs, and overhead signs, there are still some FN cases for the automated traffic sign detection algorithm using mobile LiDAR. Several FP cases are often known because they have retro reflectivity similar to traffic signs. Adding image-based algorithms to the mix could help reduce the number of FN and FP cases. However, a manual analysis of the entire dataset is still needed at this time to recognize undetected FN cases and delete FP cases [9].

In conclusion, while the evaluated representative algorithms have the potential to be applied to current traffic sign inventory operating procedures, the found FN and FP cases still require manual analysis of the entire dataset. As a result, on the one hand, there is a need to improve the individual algorithms' efficiency. A new enhanced traffic sign inventory protocol is proposed in Section 5 to quickly solve these obstacles and optimize the use of existing automated methods in current state DOT practice. Current automated processes, as well as potential enhanced ones, may be integrated into the protocol in a flexible

manner. Although no firm conclusions can be drawn for the improved technique due to the small number of testing samples, the preliminary evaluation shows a significant improvement in processing time (more than 40%) over the standard manual process.

The introduction of automated methods based on video log images and mobile LiDAR has resulted in a faster processing time for traffic sign inventory.

2.2 Arrangements for Managing and Financing roads

An examination of the road management and financing mechanisms used in a number of countries (China, Croatia, Brazil, Slovenia, New Zealand, the Slovak Republic and the United Kingdom). These countries have chosen road network management strategies that are tailored to their individual needs and situations. For a few years in the 1990s, Brazil decided that a distinct Ministry of Transport was unnecessary, and instead established a Ministry of Infrastructure that was responsible for multiple sectors including transportation, housing, energy, and mines.

However, this resulted in a loss of concentration on each of the sectors, prompting the reinstatement of a distinct Ministry of Transportation. Nevertheless, there are still a few countries (for example Croatia, Georgia) that have a Ministry of Infrastructure with responsibility for transport among its functions.

2.3 Road Agency Management Systems

Performance management systems are used by some mature road organization, such as the United Kingdom Highways Agency and the Swedish Road Administration, to demonstrate accountability to elected officials and the general public. Road agencies can use performance management to:

- (i) set goals and performance targets to manage, explain, deliver, and adjust their road budgets and internal activities;
- (ii) set effective and achievable performance levels based on input from the public, elected officials, and business community; and
- (iii) demonstrate good governance and accountability.

The U.K. Highways Agency uses a variety of performance indicators, including:

- a. Reduce the number of individuals killed or badly injured on the core network by a third (to 2,244) by 2010, compared to the 1994-98 average of 3,366.
- b. Road Maintenance: Keep the strategic road network safe and reliable while delivering value for money by achieving the following goals: I maintain a road surface condition index of 1001 within the road renewal budget; and (ii) keep benchmark unit costs for maintenance renewals at or below inflation.
- c. Customer Satisfaction: Increase Road user satisfaction by at least 0.25 percentage points over the 2008-09 level.

2.4 Monitoring and inventory of traffic signs

In recent years, the rate of motorization has accelerated, resulting in increased traffic. Furthermore, autonomous vehicles are being developed, and vehicles with conditional automation are expected to start driving on highways by 2019.

Environment detection, perception, and prediction – the ability to recognize a vehicle's environment using sensor data – is one of the most difficult tasks for advanced driver assistant systems (ADAS). ADAS systems use a range of sensors and cameras to monitor their surroundings, find themselves on the road, and assist them in driving safely.

Cameras, for example, can recognize road signs, while Lidar and Radar sensors can detect road boundaries and identify lane lines. These changes have ramifications for road users as well. Road markings and signs must be inventoried on a regular basis, and their condition must be reliable in order for humans and automated vehicles to trust them.

Surface qualities like as skid resistance, evenness, texture, and degradation are measured using high-speed cameras. Others for monitoring and inventorying road signs and other emerging equipment are well established. There aren't any markers. The state of these two road assets has received very little attention thus far its goal. The purpose of this article is to examine various methods and devices for

collecting inventory and condition data on road signs. as well as insignia from all around Europe. The measurement systems and experience are described, as well as the gaps in the present methodologies. In addition, the inventory data required at the project and network levels is specified. These findings offer techniques and systems for gathering condition and inventory data for road signs and markings when taken collectively.

There are well-established traffic-speed systems for monitoring road surface qualities such as skid resistance, evenness, roughness, and surface flaws today, but high-speed systems for monitoring and inventorying road signs and road markings are relatively uncommon. Road operators have traditionally paid minimal attention to the status of these two asset types in compared to their other assets, and their location and quantity are frequently unknown [10].

Road operators are paying more attention to inventorying road signs and markings. Current manual methods are limited, and approaches that can be employed in high-speed traffic and cover the entire network are needed. Using image-based methodologies and LiDAR technology, the provided methods illustrate the ability for data collecting to thoroughly cover a network in an acceptable amount of time. While most assessments are currently done by hand, the use of image analysis algorithms shows that this process has a lot of potential to be automated. Robustness and completeness are still being researched and developed, although automated methods are already reducing the amount of manual work required. In comparison to road surface attributes such as skid resistance or surface flaws, the process of evaluating the state of road signs and road markings is still in its infancy. Even having a complete inventory of these assets is rare among road operators.

The cornerstone for effective budgeting and life-cycle assessment of road signs and markings is a full inventory as well as knowledge of their condition. The reliance of ADAS and autonomous automobiles on these assets emphasizes the need for continuous good condition of road signs and markings across a network.

2.5 Manual Inventory of Road Signs

Technology advancements in recent years have resulted in the creation of a variety of technologies that use cameras or laser scanners to photograph road infrastructure at high speeds. This allows for the collection of video material swiftly and safely, which may subsequently be processed at the office by skilled employees. Several projects [11] have published measurement strategies for gathering inventory data of road signs and markings at traffic speeds, according to the literature study.

According to several studies (Greenhalgh et al., 2012), this technology has the ability to give inventory data for road signs while travelling at high speeds. However, there are certain drawbacks to the method: road signs are not identified and recognized due to deterioration, covered by other road signs or vegetation, or the sign's orientation as shown in Figure 1. Another drawback is that direction-giving road indicators are not identified. As a result, more research is required to develop and validate the procedure [12].

2.6 Video Based Inventory of Road Signs



Figure 1 Illustration of True positives, false positives & false negatives using image based algorithm (Balali V. et al 2015)

Mobile laser scanning has advanced dramatically in terms of accuracy and scan rate in recent years. The scanners normally have a 360° field of vision and are connected to an INS-GNSS navigation system that collects the scanner's and vehicle's location and attitude. Scanning ranges of up to 200 meters are possible. The outputs of these systems are 3D point clouds that depict the corridor around the survey vehicle's path. Because scanners collect data at a constant rate, point density varies with

distance from the scanner and survey speed, and can reach 50 points on a 10x10 cm square for current systems. Each point represents the laser echo's strength (reflectivity) or color information (for systems that are coupled with digital cameras) [11]. Road signs and their locations can be automatically detected using intensity values, which describe the quantity of light reflected by the surrounding surfaces, because their retro-reflective material is easy to detect due to its high intensity. This makes it

easier to follow the image-analysis process (as mentioned above), because the analysis' "area of interest" may be focused down to high-intensity areas.

2.7 Summary

Road operators are paying more attention to inventorying road signs. Current manual methods are limited, and approaches that can be employed in high-speed traffic and cover the entire network are needed. The effective budgeting and life-cycle assessment of road signs and markings is a full inventory as well as knowledge of their condition. Image-based approaches and LiDAR technology have the potential to cover an entire network in a reasonable amount of time for data collecting. While most assessments are currently done by hand, the use of image analysis algorithms shows that this process has a lot of potential to be automated. Robustness and completeness are still being researched and developed, although automated methods are already reducing the amount of manual work required. In comparison to road surface attributes such as skid resistance or surface flaws, the process of evaluating the state of road signs and road markings is still in its infancy. Even having a complete inventory of these assets is rare among road operators [13].

3. Traffic signs Inventories and data base

This chapter includes the collection and evaluation of existing and new inventories. The data collected is used to form a data base for traffic signs. Various method has been adopted to form data base. Some of the data base preparation systems like Google street view, Geographical Information system and others methods have been discussed.

3.1 Traffic Signs inventories

Transportation inventory management systems require a current record of the number, form, location, and condition of high-quantity low-cost highway assets such as traffic signs. Although databases like Google Street View provide street-level images of all traffic signs and are updated on a regular basis, their capacity for creating inventory databases has yet to be fully realized. The main advantage of such

databases is that once traffic signs have been identified, their spatial coordinates can be calculated and visualized on the same site.

Geographical information system (GIS) is another basic information database for traffic management. It contains both static and dynamic information, such as road network, road width, classification, road name, and primary location, as well as traffic organization, traffic jams, black spots, and police deployment. This method is intended for basic traffic police officers who need to be able to grasp as much information as possible. The system's key functional objectives are listed below.

- Basic traffic police lochus may gather and manage violation and traffic accident data on a single platform, which will satisfy the needs of law enforcement officers dealing with traffic infractions and accidents.
- Realize jurisdiction over vehicles or drivers, and establish a mechanism for updating and maintaining vehicle and driver information, as well as traffic safety information from units in the jurisdiction area, so that basic-level police officers can quickly gain a comprehensive understanding of the current traffic safety situation.
- Realize computerized account management for the work of the battalion and lochus of basic-level police officers.
- Realize an associative query of vehicle, driver, and violation information, as well as accidents. In addition, an integrated query system for traffic management data was established.
- Establish a reliable system for disseminating information, monitoring operations, and evaluating results.

The Intelligent Traffic System (ITS) is a software that unifies control, administration, and decision-making. It is based on geographic information systems (GIS).

It is intended for use in a modernized traffic command center. It strengthens the relationship between road, vehicle, driver, and traffic supervisor by utilizing advanced information process technology, navigation technology, wireless communication technology, automatic

control technology, image analysis technology, and computer network technology, resulting in an omnidirectional real-time, accurate, and effective traffic management system [14]. However, ITSs are currently limited in terms of data sharing, and data processing integration is difficult to implement.

GIS-based basic traffic management system as a key component of ITS. With Visual C++ and MapX integration, and it is use to manage road and traffic information for Traffic police. It is built on a geographical spatial database and serves as an ITS data exchange platform. This basic traffic management system has been integrated with vehicle registration system, driver license management system, and traffic rule violation handling system, among others, to realize queries and maintenances of various basic data such as vehicles, drivers, and important units, and to ensure law-enforcement management on the road by sharing with source data [15].

3.2 Detection and classifying traffic signs

Several vision-based driver assistance systems that can identify and classify signs (on a limited basis) have become commercially accessible in recent years. Nonetheless, for traffic sign identification and classification, these algorithms do not benefit from Google Street View photographs. This is due to the fact that these systems must operate in real-time, and so high frame rate approaches such as optical flow or edge detection are inapplicable to the comparatively coarse temporal resolutions found in Google Street View photos [16]. By using a computer vision approach based on joint Histograms of Oriented Gradients and Color to process images extracted from the Google Street View API, traffic signs were identified and categorized into four categories: warning, informative, stop, and regulatory signs [17]. With the help of computer vision approach, we can detect the location and position of traffic sign inventories on different segment of highway. A data card was also developed, containing information about the location and nature of each detected traffic sign. Finally, a number of data mining interfaces were added, allowing for better inventory control of traffic signs. The proposed

approach has the potential to deliver inventory information on traffic signs in a timely manner and fit into current DOT (Department of transportation) inventory management systems, based on the reliability of performance demonstrated by studies and the cost effectiveness of collecting information from Google Street View imagery. The most likely position of each traffic sign was calculated using the discriminative classification scores from all photos that see a sign and displayed on Google Maps using a heat map. The proposed method would enable DOT practitioners to meet the demands of installing new traffic signs and other infrastructure, maintaining existing signs, and performing potential replacements in accordance with the Manual on Uniform Traffic Control Devices, as the roadway networks continue to develop and expand (MUTCD). The report cards, which include latitude/longitude, roadway number, traffic sign sort, and detection/classification score, make it easier to review unique sign information in a given area without having to dig through vast databases. These spatiotemporal representations give DOTs details about how various types of traffic signs deteriorate over time, as well as useful condition data for predicting sign replacement plans [17]. The method can also automate the data collection process for ESRI ArcView GIS databases. In recent years many data mining and visualization methods are developed that analyze and map spatial data at multiple scales for roadway inventory management purposes (Ashouri Rad and Rahmandad 2013). Examples are predicting travel time (Nakata and Takeuchi 2004), managing traffic signals (Zamani et al. 2010), traffic incident detection (Jin et al. 2006), analyzing traffic accident frequency (Beshah and Hill 2010; Chang and Chen 2005), and integrated systems for traffic information intelligent analysis (Hauser and Scherer 2001; Kianfar and Edara 2013; Y.-J. Wang et al. 2009). (Li and Su 2014) developed a dynamic sign maintenance information system using Mobile Mapping System (MMS) for data collection. (Mogelmose et al. 2012) discussed the application of traffic sign analysis in intelligent driver assistance systems.

3.2.1 Traffic sign detection and categorization using Google Street View pictures

Balali and Golparvar utilize **Histogram of Oriented Gradients (HOG) + Color** with a linear **Support Vector Machines (SVM)** classifier to detect and classify traffic signs because they demonstrated that this method has the greatest performance [9]. We do not make any assumptions about the 2D placement of traffic signs in the photos, unlike state-of-the-art approaches. Rather, candidates are selected in each image and passed on to several binary discriminative classifiers to

detect and categorize traffic signs using a multiscale sliding window that visits the whole image pixels. As a result, the approach examines each image independently, reducing the amount of False Negatives (FN – missing traffic signs) and False Positives (FP – accepted background regions). Each sign is assumed to be visible from at least three angles. If the detection boxes (from the sliding windows) in three successive photographs have a minimum overlap of 67 percent, the sign detection is judged effective. This constraint is achieved by applying homography Transformation to bend the image after and before each detection [11].

3.2.2 Using a histogram of oriented gradients (HOG) and color to characteristic detections

The core notion is that the distribution of local intensity gradients and color can be used to characterize the local shape and appearance of traffic signs in a given 2D detection frame. The form attributes of traffic signs can be represented using Histogram of Oriented Gradients (HOG) descriptors, which build a template for each category. By recording the local variations in picture intensity, these HOG features are computed over all pixels in the candidate 2D template retrieved from the Google Street View image. For each detection window, the resulting features are concatenated into a single big feature vector called a HOG descriptor [11]. A detection window slides over each image, visiting all pixels at several spatial scales, to account for the effects of scale – i.e., the distance of the signs from the camera– and effectively identify the testing images using the HOG descriptors.

3.3 Roadway inventory management through data mining and visualization.

Many data mining and visualization approaches for analyzing and mapping geographical data at many scales for roadway inventory management have been developed in recent years [18]. Predicting travel time, managing traffic signals, traffic incident detection [19], traffic accident frequency analysis, and integrated systems for traffic information intelligent analysis [20] are some examples.

Li and Su developed a dynamic sign maintenance information system using Mobile Mapping System (MMS) for data collection [21]. Zhang and Pazner presented an icon-based visualization technique designed for co-visualizing multiple layers of geospatial information. A common problem in visualization is that these methods require adding a large number of markers to a map which creates usability issues and the degraded performance of the map [22].

3.4 Locate traffic sign images using Google Street View

One of the case studies uses Google Street View (GSV) to locate the existing inventories of the road in The Melton local government area (LGA) was considered as the study region because all of Melton's GSV imagery was acquired in 2014 or later, implying that Google's current fleet captured the images and that their solution would be suitable. Furthermore, Melton was ruled ineligible because, according to the City of Melton's Asset Management and GIS Coordinator, the existing sign asset dataset is "considerably insufficient," and any information on asset locations would be useful. Furthermore, Melton was considered since the existing sign asset dataset was highlighted as being significantly deficient by the City of Melton's Asset Management and GIS Coordinator, and any insight into asset locations would be of interest. Because only the position of the GSV image for each street is saved, for asset management, a sign would not be precise enough. Each image must be photographically processed as part of the system.

3.4.1 Establishing a dataset for training

The street sign dataset for the City of Greater Geelong includes the position and sign type for every street sign in the Greater Geelong area. Only Stop and Give Way signs were included in this dataset. Road crossings were found inside the GIS and the nearest GSV picture facing the sign's direction was retrieved to create training imagery. Images that would not contribute to the creation of a training data-set were manually eliminated because there can be no total guarantee that the COGG's street sign dataset and the sign's existence in GSV imagery is 100% at all places. There were 500 Give Way signs and 500 Stop signs in the final training dataset. By putting bounding boxes around the signs in the training picture, the annotation software RectLabel (Kawamura, 2018) was used to annotate them. As proposed by Stallkamp et al. (2011a, 2011b) and Cireşan, Meier, Masci, and Schmidhuber, bounding boxes with a 10% margin around the street signs were utilized to allow edge detectors to function correctly within the object identification models (2011). Because the class and bounding box coordinates lead the model to look for similarities between the same classes in multiple images, the annotation process is an important part of supervised machine learning (Chen & Lin, 2014).

3.4.2 Obtaining GSV pictures for the research area

While obtaining GSV imagery in the Greater Geelong area was reasonably simple due to the precise street sign positions being known, it was more difficult in Melton because street signs are only known to be around intersections. As Stop and Give Way signs were discovered approaching junctions, a 12-meter circle was drawn around each one, with the intersections

of each road serving as potential street sign locations.

Each of these coordinates was then used to create a GSV metadata request, which returned the coordinates of the closest GSV image. The bearing towards the intersection was then calculated using the GSV location. GSV photos were requested with a bearing 30 degrees to the left and right of the initial bearing because GSV images have a limited field of vision. A total of 1191 possible sites had a GSV image within 10 meters of the desired location, for a total of 2382 images in the working imagery dataset.

3.4.3 Identify and classify traffic signs in GSV image

In a GSV image, identify and classify traffic signs. Given that only the GSV image's location for each street is stored, For asset management, a sign would not be accurate enough. As part of the system, each image must be photo-grammatically analyzed to determine the distance and direction of the street sign inside it. as seen in Figure 2. GSV's R7 capturing equipment was used to capture the photographs (Elphel.com, 2018), with an 8.8 m pixel size in the photos with a focal length of 5.1 mm and images available through the API To begin, the street sign's center is offset from the image frame's center. The center was measured in mm (1). The offset angles were then calculated using inverse trigonometry (2). To determine the bearing from the GSV vehicle to the sign, this offset angle was added to the GSV bearing (3). The distance between the sign and the car can be estimated by computing the ratio between the street sign classes in physical space and image space, as well as adding Google's street view camera lens parameters (4).

$$\text{offset (mm)} = (\text{sign length mean (px)} - \text{image focal center (px)}) \quad (1)$$

$$\text{offset}(\theta) = \arctan\left(\frac{\text{offset (mm)}}{\text{focal length}}\right) \quad (2)$$

$$\text{sign bearing}(\theta) = \text{offset}(\theta) + \text{GSV vehicle bearing}(\theta) \quad (3)$$

$$\text{range (m)} = 1000 \times \text{focal length} \left(\frac{\text{sign height (m)}}{\text{sign height (px)} \times \text{pixel size}} \right) \quad (4)$$

Because GSV image locations are given in latitude and longitude, the offset must be calculated in meters by converting the coordinates to a projected coordinate system.

Sign Easting (m)

$$= \text{GSV vehicle Easting (m)} + \text{range (m)} \times \sin(\text{sign bearing } (\theta)) \quad (5)$$

Sign Northing (m)

$$= \text{GSV vehicle Northing (m)} + \text{range (m)} \times \cos(\text{sign bearing } (\theta)) \quad (6)$$

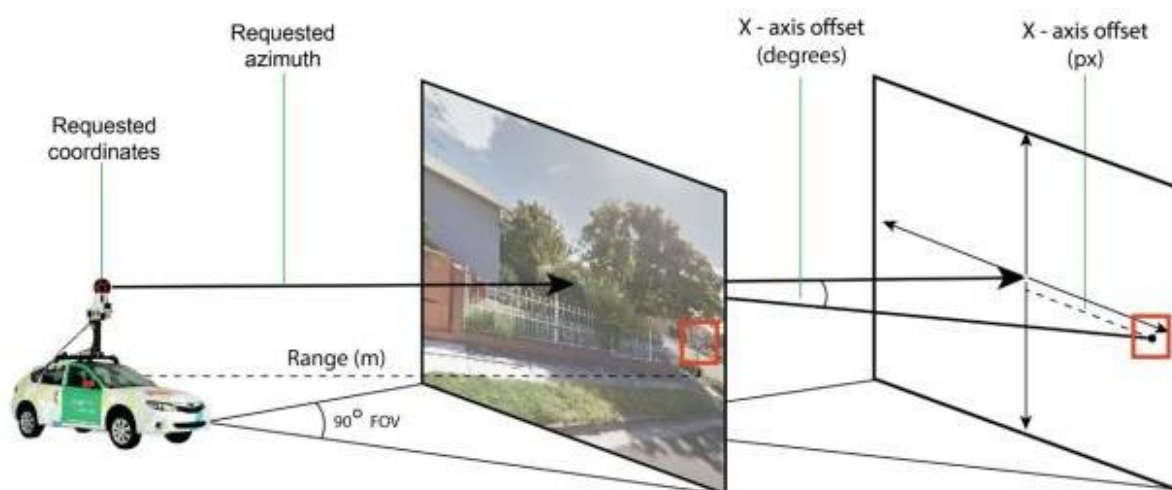


Figure 2 Photogrammetric localization system outline

3.5 Data collection through GIS Software

The usefulness of a particular inventory technique is determined by the type of data to be obtained, such as position, sign type, spatial measurement, and visual measurement of material properties. Since data is still collected and processed manually in both of these situations, inventory databases cannot be updated rapidly or regularly. Field inventory processes, photo/video records, an integrated GPS/ GIS mapping system, and aerial/satellite imagery are currently used for data collection and analysis. However, applications for

detecting, classifying, and locating U.S. traffic signs in Google Street View Images have never been tested. There is a general lack of automation when it comes to combining data collection, analysis, and visualization. More research is needed, in particular, on the development and regular updating of traffic sign databases, the availability of mining techniques, and the spatiotemporal interaction with this data. A new framework is implemented in the following section that has the ability to overcome existing limitations.

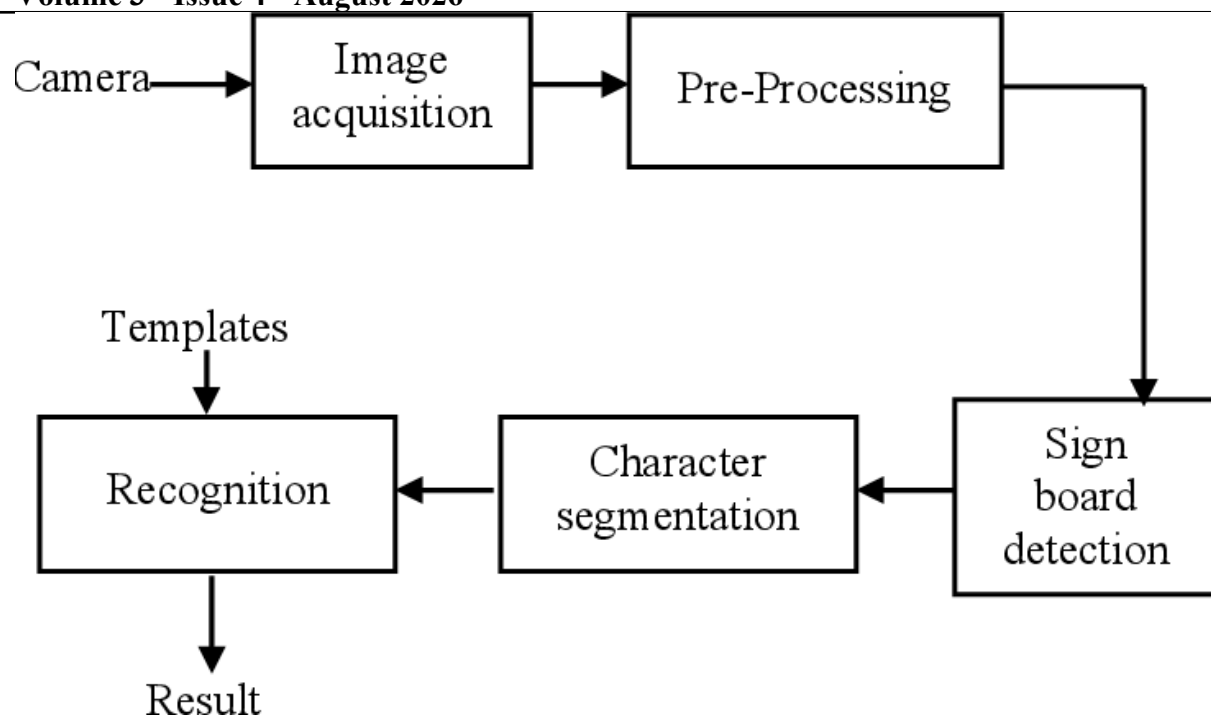


Figure 3 Block Diagram

Recognition of speed limit from traffic signs using Naïve Bayes classifier which can help the user to detect and locate various traffic signs on highway sections for limited speed of the vehicles.

Automatic traffic sign detection and recognition is a research subject for a variety of applications including driver assistance, inventory management, and autonomous driving. Poorly maintained traffic signs deteriorate over time, losing their colors or being distorted as a result of age, making the job more difficult. The issue is primarily a developing-world issue that has received little attention in the literature on automatic traffic sign detection and recognition. We present a novel versatile Gaussian mixture model-based technique with an automatic split and merge strategy to address the degradation problem. This adaptive scheme functions as a preprocessing phase that makes it easier to locate traffic signs in a real-world scenario with some degradation. To recognize the contents of the symbol, a multiscale convolutional neural network with a dimensionality reduction layer is proposed. Since there is no existing benchmark dataset for this reason, we gathered a number of images containing partially degraded signs from the well-known German

Traffic Sign Detection Benchmark (GTSDDB) and supplemented them with manually and naturally degraded traffic sign images taken from the authors' home country's longest highway. Our proposed methodology outperforms many state-of-the-art and recent methods for detecting and recognizing degraded traffic signals, according to experimental results.

Road operators are paying more attention to inventorying road signs and markings. Current manual methods are restricted, and methods that can be used in high-speed traffic and cover the entire network are needed. Using image-based methods and LiDAR technology, the presented methods demonstrate the ability for data collection to fully cover a network in a reasonable amount of time. Although most assessments are still made by hand, the use of image recognition algorithms shows that this method has a lot of potential to be automated. Robustness and completeness are still being researched and developed, but automated methods are still reducing the amount of manual work required. In comparison to road surface properties such as skid resistance or surface defects, the method of evaluating the condition of road signs and road markings is still in its infancy. Also having a complete

inventory of these properties is rare among road operators. The basis for meaningful budgeting and life-cycle evaluation of road signs and markings is a full inventory as well as awareness of their condition. The reliance of ADAS and autonomous cars on these assets emphasizes the need for consistent good condition of road signs and markings across a network.

3.6 SUMMARY

Many systems have functions such as the traditional functions of electronic maps, basic traffic information maintenance and inquiry, and data sharing with other transportation systems, and is based on component-oriented GIS, framework including network environment and functions of a basic traffic management system, an important component of ITS. These systems have significant impact on the efficiency and decision-making capabilities of traffic enforcement officers. This basic traffic control system has been enhanced with GIS. With this system, Transportation department may automatically and scientifically collect and update road traffic signs information, cars, and driver data under their jurisdiction. Users may quickly comprehend how to use this technology, especially with the help of a visible digital map. The system's framework and functions are shown, and then the network environment and data exchange model are solved. The future development path of this system is to utilize a data mining model in it and present the results to users on a map.

4. Testing and grading for traffic signs and facilities

This chapter has been made for the testing and grading of traffic signs and facilities. The chapter covers the different tests and grading used for the traffic signs and facilities. The chapter also covers different tests performed in different countries.

4.1 Tests on shape, size, location and Orientation of Traffic signs

For autonomous vehicles, accurate identification and recognition of horizontal and vertical traffic signs can be problematic. As a result, we've looked into anomalies of the

subject, there are traffic signs. Since a highly accurate environment detection is needed to safely navigate an autonomous vehicle. However, there are many problems with the sensors recognition's ability.

The driver of a human vehicle uses auditory, visual, and haptic relations to detect the vehicle's and its environment's actions. If the degree of autonomy rises, the car uses environmental sensors to sense its surroundings. The car would be safer on the road if the sensing is more precise and reliable. One of the most important aspects of this article's calculation is that the more effectively the horizontal and vertical traffic signals are understood, the better. There may be a conflict between the appropriate rules and advancement of new technologies. Aside from conducting experiments, there are ethical concerns with autonomous vehicles. As a result, it is critical to create a single decision-making mechanism that applies to autonomous vehicles across countries. Some points are outlined in the current Vienna Convention on Road Traffic statement, which would explicitly state that a vehicle must always be driven by a human driver. The other issue is determining who is responsible. Who is to blame, for example, if an accident happens when the vehicle is operating autonomously. Of course, there are suggestions about how they should be grouped, and these are likely to continue to evolve [23].

For object recognition, color delivers a wealth of information. Color-based segmentation allows for accurate separation of material boundaries. The main information offered to road users is represented by colors on road signs. Colors can help with recognition because they are distinguishing aspects of traffic signs. Furthermore, color processing can reduce the number of erroneous edge points generated by low-level image processing procedures.

The aim of this study is to demonstrate how to put current recognition systems to the test. The findings of studies and the conclusions taken from them are summarized first, with a focus on vertical and horizontal traffic signs. The significance of experiments in both a simulation and a real-world environment. The outcome of a previously conducted test is then

presented, which was further established using an existing traffic sign anomaly classification table. Expecting a working test procedure to emerge from the measurement findings. The results of these experiments will then be used to aid in the creation of recognition systems.

4.1.1 Shape based detection of the Traffic Signs

When colors are lacking or difficult to identify, shape-based techniques could be an useful substitute. Shape-based approaches should be able to avoid problems with calling colors for sign recognition while also being robust enough to handle in-plane transformations like translation, scaling, and rotation. These strategies have taken a lot of work to develop, and the results are highly promising. The authors of the following paper-reviewed articles employed shapes as the primary source of information to detect traffic signs:

Piccioli and Parodi used prior knowledge of the sign's supposed position in an image to detect road signs. To extract the desired shape, a Canny edge detector was used to the search zone, and geometrical analysis was performed on clusters of edge-points. By template matching, the innerregion of each candidate was compared to a database of signs. To recognize circles, the edge pixels were correlated with an appropriate set of circular masks. Edges in vertical, horizontal, and oblique segments were grouped together to detect triangles [24].

Aoyagi and Asakura proposed using simply brightness to detect traffic signs. After removing the noise with a smoothing filter, the item is extracted from the backdrop by applying the Laplacian filter. A particular threshold is employed to generate the binary image, and detection is performed by genetic algorithms with the ability to search for the circular pattern that is provided as gene information [25].

Puntavungkur et al. created an autonomous road sign recognition system. Using affine geometric correction, a zone of interest including the road sign is defined. The application of sign identification based on grey-scale image processing is used. The normalized Euclidean distances between the target image and the template images are calculated, and the

sign is represented by the template with the smallest value [26].

4.1.2 Color and Shape based detection of the Traffic Signs

It is feasible to use both strategies to detect traffic and road signals by using a mix of color and shape. Each method has its own set of advantages and disadvantages. An adaptive hybrid strategy, on the other hand, can use one technique in certain situations and the other in other situations. Even if this adaptive strategy isn't used, integrating color and shape in any sign detection system has the benefit of utilizing data from both sides of the problem. Because color and shape both communicate information that should not be overlooked, it is also possible to avoid a slew of issues and drawbacks.

Jiang and Choi employed Fuzzy rules to convert the color image to a grey-scale function, and then used a binary image to detect any landmark in the enhanced color image, which was enhanced using hue invariance. To detect the red and blue colors, they used the Nrgb color space, thresholds, and fuzzy rules. The three corners of triangles are extracted to identify warning indications, which are considered here. To detect these corners, a fuzzy technique is constructed by establishing two member functions that indicate the chance of pixels inside two masks forming a corner. In the same way, the other two corners are recognized. Damaged signs cause a difficulty with the masks, therefore they are repaired [27]. Fang et al. created a method for detecting and tracking road signs that converts color images from a video camera into the HSI system. A two-layer neural network is used to extract color information from the hue. An edge detection approach collects gradient values in certain color regions to create an edge image, which is then passed to a second two-layer neural network to extract shape data. To create an integration map, color and shape features are integrated using a fuzzy technique [28].

Shirvaikar developed an autonomous system for detecting and interpreting road signs. To produce binary pictures of candidates' pixel locations, the system used RGB color space and spectral feature analysis of the images under

evaluation. A spatial feature analyzer is used to test candidate regions. The area in pixels, aspect ratio, and fill factor are all used to identify the most likely indications. The results are refined using a relational feature analyzer. Stop, yield, and speed restriction signs are all detected in real time by the system [29].

4.2 Methodology of the Test:

The calculation is made because traffic signs will be necessary for autonomous vehicles in the future. Evaluation will be done for different tests and grading used for the traffic signs and facilities. A traffic sign anomalies classification table created in a previous study was used for the test. The current test was created for a BMW device that recognizes road signs. Internal camera view is another recognition system which is used to detect and identify Traffic Signs. The results of both assessments will be analyzed, and the next test for multiple vehicles will be prepared to compare the results [30]. The aim of this study is to demonstrate how to put current recognition systems to the test. The findings of studies and the conclusions taken from them are summarized first, with a focus on vertical and horizontal traffic signs. The significance of experiments in both a simulation and a real-world environment. The outcome of a previously conducted test is then presented, which was further established using an existing traffic sign anomaly classification table. Expecting a working test procedure to emerge from the measurement findings. The results of these experiments will then be used to aid in the creation of recognition systems.

4.3 Structure of the test environment:

Many traffic signs trigger issues for both drivers and recognition systems, potentially leading to accidents. Not all signals are detected by current recognition systems, and they often make errors in recognition. Many factors influence the vehicle's camera's sensing capacity. Figure 4 represents the internal camera view which is used to detect and identify Traffic Signs. The classification table was created to account for the flaws in real-time traffic signs as well as the sensor vulnerabilities in vehicles. The aim of the test is to improve the road sign recognition sensors by identifying more important errors. The aim of the test was to see how much a mistake affects and impairs the camera's ability to recognize objects.

In the winter, the calculation began at 13:00 and lasted until 15:30. We had to pay attention to the light conditions and the sun from the standpoint of the results. The time of day for the test was chosen purposefully so that the most important condition could be tested for identification. The classification table includes the following criteria. If a traffic sign is obscured by a tree or a column, it is said to be visible. The precision in which a clear traffic sign or a very dirty one can be seen. When looking at the height, deformity, colors, and stickers on a traffic sign, the term "recognizability" comes to mind. The sign's location indicates that it is not at the proper height. When there is too much or opposing material, simplicity should be observed. Photos and internal-view camera images were used to continuously record the measurement. The camera was mounted inside the vehicle and displayed the road signs as well as the detection indicator.



Figure 4 Internal camera view from traffic sign and recognition feedback

It was possible to draw the conclusion that the need for traffic signals needed to be addressed. Perhaps the numerous sensor flaws can be mitigated by using additional sensors at the same time. As a result of the experiments, sensor fusion can be concluded to be the best option for accurate and secure detection.

It has also been able to take measurements and produce findings that warrant further research. For a real test, the numerical value of the degree of anomaly, for example, must be

determined. Furthermore, faster tests are needed. It's important to find a test solution that is repeatable, as these types of tests are difficult to do. In the future, these will be used to assess the test procedure for different vehicles as well as the effect of anomalies. Figure 5 represents traffic signs anomalies in the test region. As a consequence of the comparable findings, new conclusions on how to improve systems and build autonomous vehicles can be drawn.



Figure 5 Traffic Sign Anomalies in the test environment

4.4 Road sign recognition Tests and traffic sign anomalies:

For autonomous cars, precise detection and recognition of horizontal and vertical traffic signs can be problematic. As a result, we

investigated traffic sign irregularities in the subject. Because a highly precise environment recognition is required to properly navigate an autonomous vehicle. However, there are numerous issues with the sensors' capacity to

recognize objects. A test using a previously built anomaly classification table is shown in this article. The table divides the signals into five kinds of true abnormalities that can cause issues with recognition systems. The tests in this article emphasize the limit values and circumstances that make identifying the traffic sign difficult. Typical issues include the environment, weather, and visibility conditions, as well as various traffic circumstances. The test was conducted in Hungary on the ZalaZONE, SMART city track. The research could assist build a key test environment for traffic signs in the future, which could aid in the development of autonomous car systems. It can be used to test and validate environmental recognition systems [31].

For the type-approval of automated or self-driving vehicles with automated functions, traditional vehicle dynamics tests are insufficient. For the new functionality to work, validation and verification tests must be written. The human driver, the vehicle, and the interface between them must all be

modelled in conventional cars. It's also a good idea to examine the environmental sensitivity and decision-making algorithm of networked and automated cars. These tests differ from traditional ones in that they can generate a wide range of scenarios, and the decision-making of complex algorithms is influenced by a variety of circumstances [31].

The Hungarian government planned in 2016 to construct a test track for driverless vehicles. The 250-hectare test track was constructed in Hungary's western region. (See Figure 2) Aside from regular tests, the test track should feature sections where all highly automated, networked cars, and autonomous functions can be tested. It is critical that the various functions and their tests match the automotive industry's criteria. High-speed parts, a dynamic track, and a smart city segment should all be included in the testing grounds. As a result, you can test automated cruise control (ACC), environmental sensors, path following controllers, and GNSS-based platooning functionalities [31].

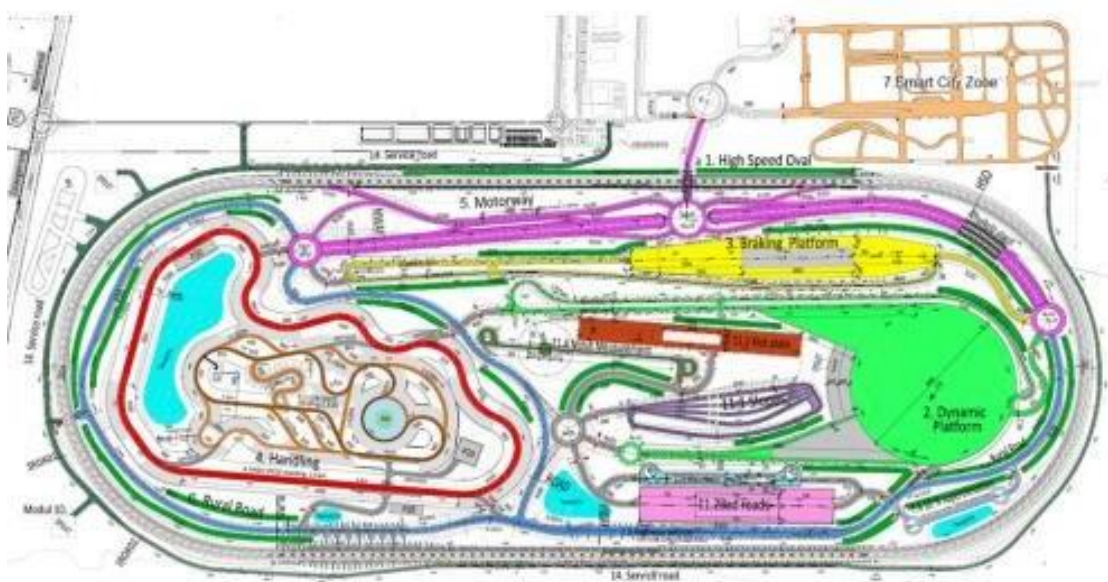


Figure 4 Test track in Zalaegerszeg for autonomous vehicles

The test track includes autonomous vehicles for urban tracks, which include crossroads with signs, streets, parking spots, and buildings, as well as specialized equipment (such as moving obstacles). Here, too, smart city aspects are

accomplished (realistic buildings). Rural roads will be used to test vehicles at lower speeds, and the road's shape will be a problem for autonomous systems. It is located on a general highway road where high-speed autonomous

functions like as lane-keeping and changing can be tested. The vehicles can be tested on a variety of different terrains, each with its own set of characteristics [31].

These tests were useful in that they tested the basic test scenario, but they will need to be improved. When the outcomes statistic displays some useful information, it is necessary to try more and more automobiles. In the autumn of 2019, there may be other options with various vehicles and identification technologies. These measurements will aid in the development of a repeatable scenario for autonomous systems. With comparable outcomes, more inferences about how to improve systems and produce autonomous vehicles can be reached [31].

It has also been able to take measurements and produce data that require more research. For an actual test, the numerical value of the degree of abnormality, for example, must be determined. Furthermore, faster tests are required. It's important to develop a test solution that is repeatable, as these types of tests are difficult to do. In the future, these will be utilized to assess the test process for many vehicles as well as the impact of anomalies. As a result of the comparative results, new conclusions about how to improve systems and produce autonomous vehicles can be reached [31].

4.5 Automatic Traffic Sign Detection:

The major goal of this research is to create a reliable TSDR system using an expanded dataset of Malaysian traffic signs. The created method is insensitive to changes in lighting, rotation, translation, and viewing angle, and it has a short processing time and a low false positive rate. The system is being developed in three stages: picture preprocessing, detection, and recognition. The system demonstration, which used RGB color segmentation and form

matching before applying a support vector machine (SVM) classifier, yielded promising results in terms of accuracy (95.71%), false positive rate (0.9%), and processing time (0.43 s). To statistically analyzes recognition performance, the area under the receiver operating characteristic (ROC) curves were introduced. The proposed system's accuracy is pretty good, and its processing time is relatively short, which will be useful for identifying traffic signs, particularly on Malaysia's highways. With a reduced false positive rate, the system's stability and reliability in real-time applications will improve [32].

The samples are taken with a low-cost on-board camera (Canon SX170 IS) that is connected to a laptop in the vehicle (Figure 1). The photos were collected every two seconds on various roads and highways in Malaysia under varying weather conditions (Table 1) from 8:00 a.m. to 8:00 p.m. The camera is mounted on the dashboard's left side to collect traffic signs on the left side. This section's goal is to compile a database of traffic sign photos in many versions. The major goal of picture preprocessing in the TSDR system is to remove low-frequency background noise, normalize the intensity of individual particle images, remove reflections, and mask parts of images. The incoming image is separated into three channels: R, G, and B. Filters are applied to each channel threshold in the suggested approach to pick those portions of the image where the values of the pixels fall inside the range of our target item. For example, the threshold for channel R for traffic signs with a red backdrop is pixels with values in the range of 90–255, while the range for channels G and B is 0–70. The logical total of the three filtered channels of R, G, and B is the area of interest (ROI) [32].

Table 1 Environmental Condition for Image Acquisition

Environment	Real time
Weather	Rainy, sunny, cloudy
Capturing time	8 am–8 pm
Camera specs	24 fps
Image size	3264 × 2448
Image background	Complex; not fixed
Total number of images taken	350
Total number of signs	123
Traffic sign sizes	Different
Traffic sign condition	Faded, blurred, damaged, occluded
Traffic sign type	Stop, do not enter, do not park

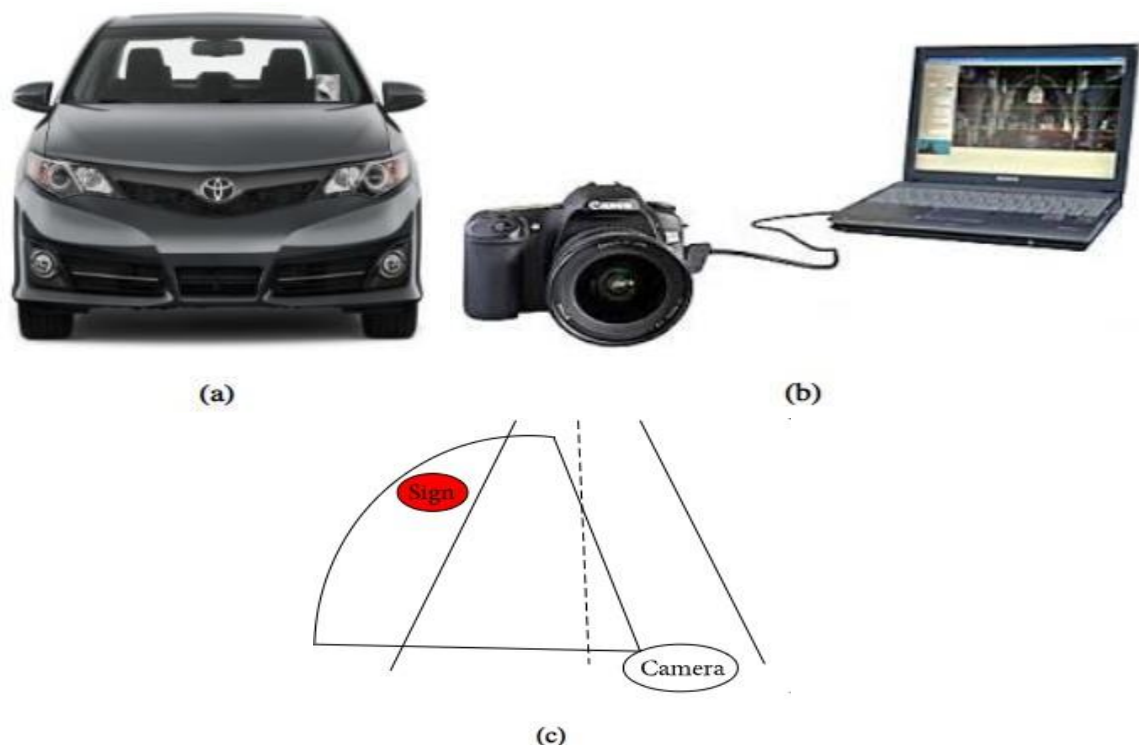


Figure 5 Sample Collections Model (a) a secondhand car with a camera mounted on the dashboard's left side, (b) Camera setup includes laptop and (c) Camera range and Sign detection on road

The concept is to use the selected object's color characteristic to speed up the process instead of using time-consuming model-based classifiers. The candidates for the traffic sign are chosen

based on shape matching after filtering and analyzing the features of the identified object. Figure 6 depicts the system's flow diagram.

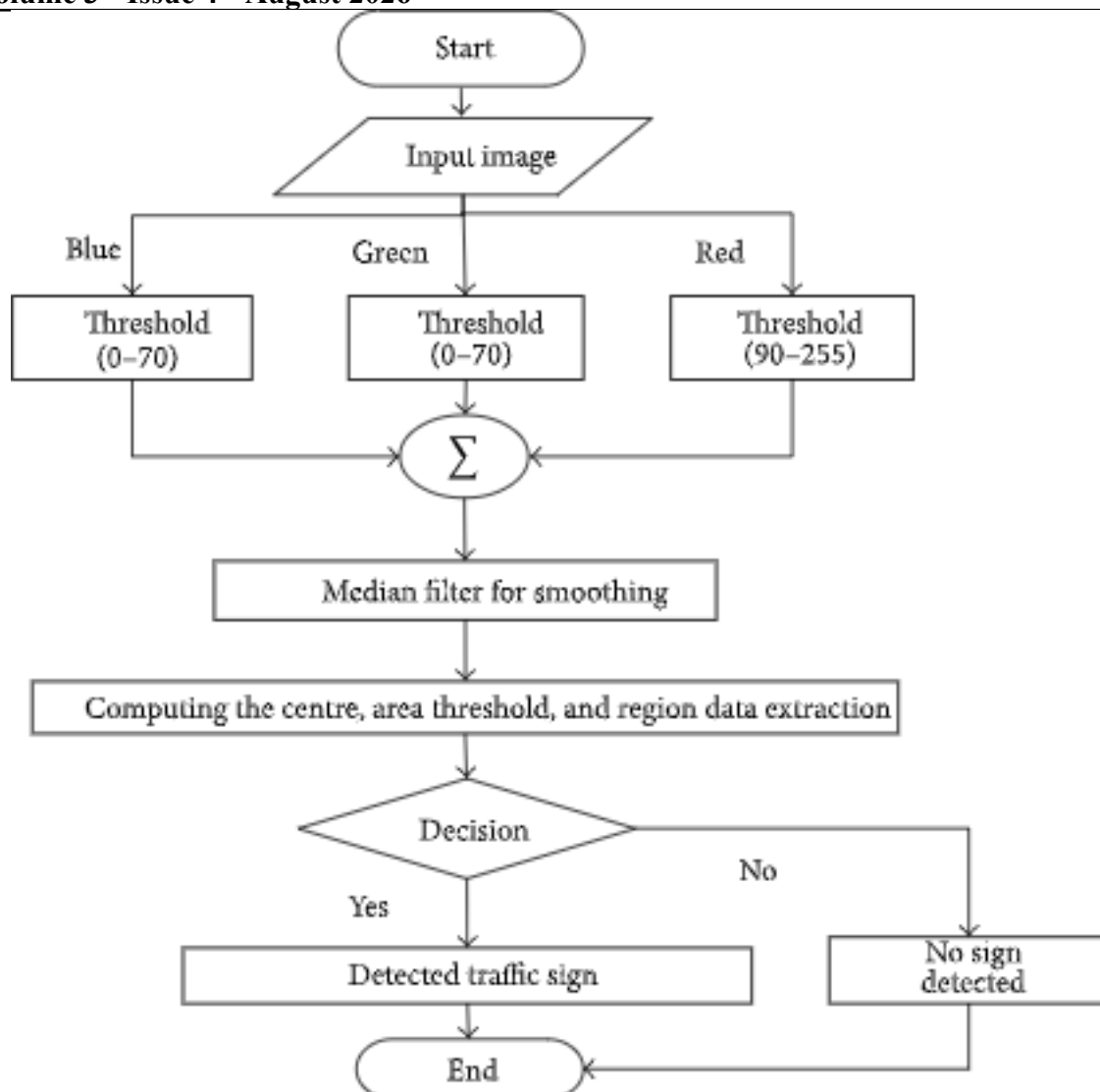


Figure 6 Block Diagram of the Overall Detection System

The distance at which the system may detect a traffic sign is determined by the area range for road signs. Objects having the same range of pixels' value outside of this range cannot be traffic signs. Important information such as the center, area, and longest breadth of each zone are determined at this level. This data is utilized to determine if each region is a traffic sign or not. SVM is then used to recognize the detected traffic sign blob pictures [32].

The created system's key shortcoming is that it is only applicable to red traffic indicators. The "warning sign" and the "prohibitory sign" both have red on them, which is the most essential color because it is the one that causes the most traffic accidents. Because color is unreliable due to many factors such as illumination,

fluctuating lighting, blurring, and fading, the suggested technique has a low detection rate. As a result, the recognition process suffers in terms of overall accuracy. The lack of photos in the Malaysian traffic sign database is another drawback. The entire processing time is 0.43 s, which is still on the high end of the spectrum. A future project could be to recognize all types of signs in Malaysia, minimize processing time, and improve the Malaysian traffic sign database. The distance at which the system may detect a traffic sign is determined by the area range for road signs. Objects having the same range of pixels' value outside of this range cannot be traffic signs. Important information such as the center, area, and longest breadth of each zone are determined at this level. This data

is utilized to determine if each region is a traffic sign or not. SVM is then used to recognize the detected traffic sign blob pictures [32].

4.6 Summary:

Based on above study we concluded that the traffic condition can be improved by data mining using various traffic signs detection processes. Sensors play one of the key role in signs detection process, perhaps the numerous sensor flaws can be mitigated by using additional sensors at the same time. As a result of the experiments, sensor fusion can be stated to be the best approach for accurate and safe detection. It has also been able to take measurements and produce data that require more research. For an actual test, the numerical value of the degree of abnormality, for example, must be determined. Furthermore, faster tests are required. We need to discover a test solution that is repeatable.

5. Optimization and Maintenance of Traffic Signs

This chapter has been made for the deterioration, decision, optimization and maintenance of traffic signs and facilities. The chapter covers the different methods of deterioration, decision based approaches, optimization and maintenance of traffic signs and facilities.

5.1 Deterioration of Traffic Signs and Facilities

Due to the rapid degradation of existing infrastructure networks and insufficient funds, U.S. Departments of Transportation (DOTs) have prioritized the repair or replacement of highway assets depending on their requirements. Many state DOTs have already developed asset management systems to monitor their inventory and conditions for bridge and pavement properties, which are high-cost but low-quantity assets [33]. Many state DOTs, on the other hand, do not have a strong statewide inventory and condition information for traffic assets because conventional methods of gathering asset information are costly and outweigh the benefits of providing such information. Sign replacement is a low-cost safety measure

that allows drivers to travel roads more safely and efficiently. Traffic authorities are expected to repair traffic signs that do not meet the minimum MUTCD retro reflectivity levels, regardless of the system used. In recent years, the most common or used method for guiding sign replacement has been expected sign life. However, the preliminary findings of this study revealed that, in addition to sign age, there are other contributing factors that could influence traffic sign retro reflectivity output that have yet to be considered in the literature.

Using the chi-square test and odds ratio, the more important damage types for sign visibility were classified by categorizing them into six groups: bending/cutting, splitting, fading, peeling, vandalism, and other forms. It was determined that there was a statistically significant difference in sign retroreflective output based on sign damage type at the conclusion of the study. The following is a recommendation for transportation authorities in terms of traffic sign replacement based on the results of this study:

➤ Since fading and cracked signs have the highest rate of retroreflective failure, these signs will need to be replaced. For regulatory and warning signs, this failure is even more important.

➤ Traffic signs that had their legends peeling off were often more likely to fail to communicate their message to drivers. However, if the sign meets the minimum requirements, agencies should focus on legend repair rather than sign replacement.

➤ Signs that have been vandalized should be tested in the field to make sure they can't be repaired. The impact of vandalism on retro reflectivity is highly dependent on the severity of the harm. Another factor that organizations should remember is that repairing vandalized signs is time consuming and can degrade sign visibility.

➤ While bent traffic signs performed well in terms of retro reflectivity, they should be examined at night to ensure sign visibility because the actual luminance of the sign under nighttime conditions may be lower than the specifications.

Under budget and other resource constraints, civil infrastructure system maintenance

preparation determines which facilities should be repaired, when and how maintenance should be performed, and what care should be used. However, the established models ignored the network infrastructure system's deterioration propagation between adjacent linked facilities. For example, a facility that receives no maintenance or fails to receive maintenance care has an impact not only on its own condition, but also on the rate of degradation of its neighbors' facilities. This highlights the importance of considering deterioration propagation while designing optimization models and determining the degree to which it can influence the best maintenance strategy. Maintenance therapies must be applied on a regular basis to avoid or postpone failures. Maintenance planning is required to maximize the distribution of resources for facility maintenance. Maintenance planning's main goal is to assist policy makers in scheduling maintenance actions and determining which facilities need to be maintained, when maintenance should be performed, and which treatments should be used. Transportation infrastructure systems are characterized by interdependence and interaction within and between different systems since they are spatially dispersed assets covering vast regions.

Researchers have created maintenance planning models that address various functional, economic, and other relationships between facilities/systems. Bernhardt and McNeil, for example, claimed that pavements are bound by geography, implying economies of scale in contracting long stretches of pavement for restoration and diseconomies of scale in terms of user disruption [34]. Gao and Zhang have pointed out that conventional optimization approaches pick road parts for maintenance that are typically spread spatially throughout the network. To take advantage of economies of scale, the authors recommended that adjacent pavement parts with identical maintenance requirements be maintained as part of a single project. Rasmekomen and Parlikad investigated how to improve industrial asset management strategies by taking into account deterioration and efficiency interactions [35].

Despite the findings of the studies described

above, the propagation of degradation from one facility to adjacent facilities has not been taken into account in infrastructure management maintenance planning. Previous studies have discovered that infrastructure degradation normally spreads to nearby facilities. In other words, a facility that receives no maintenance or fails to receive maintenance care has an impact not only on its own condition, but also on the rate of degradation of its neighbors' facilities. Pavement cracks, for example, normally start out as hairline or very narrow cracks. When water reaches the underlying layers of the pavement through cracks, it can cause pumping, swelling, and migration of finer materials, causing the crack to expand. Secondary or several cracks will grow parallel to the initial crack if it is not properly sealed and preserved. Furthermore, the crack edges will deteriorate the adjacent pavement facilities by raveling and eroding them. Another example is that when stress corrosion cracks appear in pipes, the likelihood of a pipe break increases, potentially resulting in a whipping pipe that can destroy adjacent piping and its attached wall. We built a new mixed integer linear programming model to solve this problem as a result of these details. The developed model determines the best maintenance strategy while taking deterioration propagation into account.

5.2 Maintenance Decision of Traffic Signs and Facilities

Complex systems theory can be used to quantify the inherent complexity of decision-making in transportation infrastructure systems.

- Many agents or decision-makers functioning in parallel with dispersed control,
- the presence of many organizational levels,
- the ability of agents to adapt based on decisions made at higher levels, and
- the use of internal models to predict the future are all characteristics of complex systems.

We investigate the behavior of the pavement condition, as well as user and agency costs, under various situations using a simulated pavement network, and relate this behavior to the features of a complex system. To better manage these assets, infrastructure

management systems must acknowledge the inherent complexity of these systems [34].

5.3 Optimization and Maintenance of Traffic Signs

Transportation infrastructure management is the method of deciding how to allocate money for the upkeep of the infrastructure that makes up transportation systems. The aim of these decisions is to ensure that the systems can perform the functions for which they were designed and installed, while taking into account resource constraints and service level requirements. In this sense, management decisions balance user costs, such as travel time, fuel usage, vehicle depreciation and repairs, with agency costs, such as expenditures for resource and staff supply, supplies, and so on. The pace at which user costs accrue rises as facilities deteriorate. As a result, organization expenses are incurred to boost the situation

and thereby reverse the deterioration's results. Current maintenance optimization models compromise important functional characteristics in favors of computational tractability/simplicity, which is the primary inspiration for the work presented here. Models for multifacility transportation systems, in particular, are typically formulated as constrained Markov Decision Processes (MDPs) with the notion of "randomized policies" and solved as linear programmes (Golabi et al., 1982; Golabi and Shepard, 1997; Murakami and Turnquist, 1997; Smilowitz and Madanat, 2000). Individual facilities are not defined in this framework, and they are believed to be homogeneous. As a consequence, for all facilities in a given state, optimal policies define the same set (probability distribution) of maintenance behavior.



Figure 7 Signs used in Highway for various information

Traffic signs are important highway components because they convey the laws, notices, directions, and other highway agency details

that drivers need to navigate roads and streets safely and efficiently. Signs that are well-maintained are vital because they assist drivers

in making informed decisions. This guide is intended to assist local agency maintenance staff in ensuring that their signs are kept in good working order to fulfil this requirement. For each sheeting form, ASTM has developed new sheeting requirements for minimum retro reflectivity values, known as the "coefficient of retro reflection" (RA). RA is a metric unit of candelas per lux per square meter and is expressed in candelas per lux per square metre. The specification specifies an initial RA value for a specified entrance angle and observation angle

common angles within a RA-measuring instrument that are related to roadway/vehicle geometries. Minimum RAs for different sheeting styles used for permanent rigid signs

in the colors white, black, fluorescent yellow, green, and red at the common angle readings of -4-degree entrance angle and 0.2-degree observation angle.

Table 1 shows the purchase of newly acquired sign sheeting. When exposed to the sun and weather, the colors fade and the retroreflective qualities of the sign sheeting deteriorate to the point that the sign is no longer readable at a distance required by the driver, both day and night. Most traffic signs must meet minimum sustained retro reflectivity standards, according to the 2009 MUTCD. Table 2 shows the values for some of the most common types of permanent signs found on local, non-freeway roads. White to red contrast ratio shall be at least 3:1.

Table 1 Minimum Coefficient of Retro reflectivity (RA) for several types of new sheeting used for rigid signs Source: ASTM Standard Specification D4956-09.

Sheeting Type	Coefficient of Retroreflectivity for 0.2 deg Observation and -4 deg Entrance Angles				
	White	Yellow	Flourescent Yellow	Green	Red
I	70	50	N/A	9	14
II	140	100	N/A	30	30
III	250	170	N/A	45	45
IV	360	270	220	50	65
VIII	700	525	420	70	105
IX	380	285	230	38	76
XI	580	435	350	58	87

Table 2 Minimum Maintained Retro Reflectivity Levels for Specified Signs (Source: Modified from MUTCD, 2009)

SIGN CLASS	SIGN COLOR	BEADED SHEETING I	BEADED SHEETING II, III	PRISMATIC SHEETING III, IV, VIII, IX, XI
Guide	White on Green: White (Ground Mount Only)	Do Not Use	= 120	= 120
Guide	White on Green: Green (Ground Mount Only)	= 7	= 15	= 15
Warning	Yellow: = 48 in. or Bold Symbol	Do Not Use	= 50	= 50
Warning	Yellow: < 48 in.	Do Not Use	= 75	= 75
Regulatory	White on Red*: White	= 35	= 35	= 35
Regulatory	White on Red*: Red	= 7	= 7	= 7
Regulatory	Black on White: White	= 50	= 50	= 50

Since it does not provide the retro reflectance level provided by the driver, Type I sheeting material should not be used for warning signs or the white legend on green background guide signs, according to the values in Table 2. Higher-level sheeting forms can produce a brighter sign and have a longer service life in general, resulting in a cost savings.

In several countries, traffic congestion is one of the most serious issues. Congestion wastes a significant portion of national income due to fuel costs and traffic-related environmental and socioeconomic issues. It's a commuter's dream: the road is congested, but green lights appear on time, traffic moves smoothly, and lane changes are few. Tailgating is an uncommon occurrence. It could sound like a miracle, but it may simply be another success story resulting from traffic signal management, which is one of the most cost-effective ways to keep traffic flowing smoothly and make streets safer (Public roads 2002). Many issues arise as a result of traffic congestion, including air pollution, noise pollution, economic issues, and sluggish vehicle movement. After the first computerized traffic signal system was implemented in the early 1960s, transportation authorities have gradually installed more adaptive traffic signal systems. Travel time, travel speed, vehicle stops,

delays, fuel consumption, and pollution are all advantages of signal lights that have been recorded in areas.

Many countries are seeing rapid increases in the number of vehicles using their roads, especially in densely populated urban areas. Transportation has a strong effect on economic growth, and vice versa. Most congested cities in third-world countries and many industrialized cities in North America did not design their road networks effectively in the early stages, making re-planning and reconstruction extremely difficult. Because of the loss of valuable commercial buildings near highways, these countries and cities face numerous challenges when widening their roads. The only practical alternative in the short and medium term could be to use existing road networks with modern technologies. The most cost-effective approach is to construct roundabouts at intersections. Roundabouts, on the other hand, are only ideal for low-traffic-flow densities. Traffic signal lights are another inexpensive and reliable solution. Signal lights can effectively accommodate relatively high densities of traffic flow, but traffic movement efficiency is dependent on signal light timing. Vehicles approach the intersection from various directions. A junction is a point where

vehicles from several roads intersects. Signal lights are used to reduce traffic congestion at intersections and enable traffic to flow as smoothly as possible. Signal light timing is the most important element in ensuring a smooth traffic flow. The timing of signal lights is determined by the demand for vehicles in each direction as well as the demand for each turn. The traffic flow is calculated manually using the average value of each path flow.

Simulating a road network using either inferred potential values or real traffic flow data is possible. In an assumed scenario, the consumer will simulate the worst and most likely scenarios based on current or potential traffic demand. The simulation model isn't limited to applying the average traffic demand to a specific approach. It uses real-time traffic demands to calculate timing and allows the user to specify the cycle time and cycle testing time. The tool assumes the initial green time for each direction is the same. However, after the first few cycles, it starts to change the timing according to vehicle demands. Following that, the vehicles (entities) in the simulation will be shifted according to the new timing. Throughout the simulation, the same protocol will be followed, and the user will specify the total simulation time span. The optimum green times for each direction of a junction are the simulation's outputs. Green time will be measured based on real time intervals during the day. It will assist the user in observing changes in signal light timing over the course of the day. Any time period can be simulated, and the same time period can be simulated an unlimited number of times. This benefit in simulation improves the accuracy of the analysis.

5.4 Maintenance of Traffic Facilities

As we progress through the twenty-first century, the need of maintenance is becoming increasingly apparent. The focus of transportation projects is changing from capital investment to maintenance and operation now that the Interstate highway system is substantially complete. Maintenance is viewed as critical by senior executives, legislators, and the general public in order to maintain the nation's multibillion-dollar highway investment

while also ensuring a safe and efficient transportation system. In the near future, funding for additional roadways on the size of the Interstate program is unlikely to be given. The issue for maintenance managers is to get the most out of the current system, which will remain critical for the foreseeable future.

As we progress through the twenty-first century, the nature of maintenance is changing rapidly, and the rate of change will continue to accelerate. The first 60 years of highway maintenance saw little change save for gradual improvements in equipment and materials. Technology began to advance in the mid-1970s, and it continues to do so at a breakneck pace. The changes are affecting corporate attitudes as well as the organization's underlying cultural values. Change has been helpful in general. Maintenance companies are more professional, productive, and deliver better quality and consistency of service than they have ever been. As a result, highways are safer and upkeep is more cost-effective.

We can't predict how maintenance will change in 20 years. We can only learn from the past and be aware of current patterns if we look back. The only certainty is that maintenance will be much different. While the political climate is shifting toward smaller government, vehicle and truck traffic levels are increasing on an outdated highway system. The maintenance community will need to foresee and prepare for the future in order to be successful stewards of the customers' tax funds. The following strategic initiatives are expected to be implemented:

- Citizens and politicians should be more conscious of the necessity of maintenance in protecting our assets while ensuring a safe and efficient transportation system.
- Promote a culture of continuous improvement within the maintenance community, with the belief that technology, business methods, and management techniques should evolve on a regular basis for the benefit of consumers.
- Examine the prospect of the government and industry working together to develop new products or techniques, with either or both providing technical expertise and funding.
- Accelerate technical research in

maintenance methods, equipment, materials, diagnostic procedures, and asset performance in order to take advantage of technology and capacity and apply the most efficient maintenance practices feasible.

➤ Investigate the utilization of private contractors and partnerships with local governments to provide the resources needed to improve overall transportation services for customers.

➤ Work toward national standards for professionalism and competency to improve maintenance professionals' education, training, remuneration, and recognition in order to create the trained workforce that will be required in the twenty-first century.

Corrective, preventive, risk-based, and condition-based maintenance are the four types of maintenance philosophies that can be defined.

Following the discovery of an anomaly, maintenance is performed with the goal of restoring normal operating conditions. This strategy is predicated on the conviction that the costs of downtime and repair in the event of a malfunction are less than the cost of a maintenance program. Until catastrophic faults occur, this technique may be cost-effective.

Maintenance performed at set intervals or according to predetermined criteria with the goal of lowering the risk of failure or degradation of the equipment's functioning. Maintenance cycles are scheduled in accordance with the necessity to remove the item from service. The number of operational errors is reduced.

Standard preventative maintenance is carried out by integrating analysis, measurement, and periodic test activities. The acquired data is analyzed in the context of the equipment's environmental, operational, and process conditions. The goal is to assess the asset's condition and

risk, as well as to develop an adequate maintenance plan. Every piece of equipment that has anomalous values is reconditioned or replaced. This way, the plant's usable life can be extended while maintaining high levels of dependability, safety, and efficiency throughout time.

Maintenance that is based on the monitoring

of equipment performance and the control of the remedial actions that are conducted as a result. The real-time detection of significant working device characteristics and their automatic comparison with average values and performance provide a continuous assessment of the real-time equipment status. When certain signs indicate that the equipment is deteriorating and the likelihood of failure is increasing, maintenance is performed. In the long run, this method provides for a significant reduction in maintenance costs, lowering the occurrence of serious problems and maximizing the management of available economic resources.

5.5 Summary

The laws, notices, directions, and other highway agency details that drivers need to navigate roads and streets safely and effectively are all communicated through traffic signs. Well-maintained signs are essential because they aid drivers in making informed judgments. This guide is designed to help local agency maintenance employees ensure that their signs are kept in excellent working order in order to meet this obligation.

6. Frame work design for GIS based Signs and facilities asset management system

This chapter includes how the GIS Database is used to evaluate the condition of traffic based on existing traffic inventories. The data collection of traffic signs through GIS is discussed and a road segment from Babu-Sabu interchange to Careem block is considered as the study site.

6.1 Intelligent Traffic System (ITS)

The system, as an important component of ITS, has features including traditional electronic map capabilities, basic traffic information maintenance and query, and data sharing with other transportation systems.

The Intelligent Traffic System (ITS) is a software that unifies control, administration, and decision-making. It is based on geographic information systems (GIS). It is intended for use in a modernized traffic command center. It strengthens the relationship between road, vehicle, driver, and traffic supervisor by

utilizing advanced information process technology, navigation technology, wireless communication technology, automatic control technology, image analysis technology, and computer network technology, resulting in an omnidirectional real-time, accurate, and effective traffic management system[1x]. However, ITSs are currently limited in terms of data sharing, and data processing integration is difficult to implement.

The use of GIS functionality for graphic depiction of the road network, as well as visualization and spatial analysis of emissions caused by road traffic, is quite beneficial. Most GIS technologies, in addition to visualization, allow interactive graphics, which we employed in the emission inventory programme to provide selective display (and edit) of road segment attributes[36].

6.2 Aim of GIS System

The basic information database for traffic management is a GIS-based fundamental traffic management system. It contains both static and dynamic information, such as road network, road width, classification, road name, and primary location, as well as traffic organisation, traffic jams, black spots, and police deployment. This method is intended for basic traffic police officers who need to be able to grasp as much information as possible. The system's key functional objectives are listed below.

Basic traffic police officers may gather and manage violation and traffic accident data on a single platform, which will satisfy the needs of law enforcement officers dealing with traffic infractions and accidents. Realize jurisdiction over vehicles or drivers, and establish a mechanism for updating and maintaining vehicle and driver information, as well as traffic safety information from units in the jurisdiction area, so that basic-level police officers can quickly gain a comprehensive understanding of the current traffic safety situation [37]. Realize computerized account management for the work of the battalion and officers of basic-level police officers. Realize an associative query of vehicle, driver, and violation information, as well as accidents. In addition, an integrated query system for traffic

management data was established.

6.2 Road intersections data base and safety evaluation using GIS

The data of intersection is collected and incorporated into computer model. The GIS based data used by computer model to evaluate the safety of existing traffic condition of intersection. These models based on prevail data determined the existing traffic safety problems. The model system provides various solution to that problems and counter it. These models are also helpful in finding the benefit-cost ratio. With the help of GIS data we can improve the efficiency of Traffic and also manage the existing inventories of road like Traffic signs, signals etc. the geometrical design of road section at various region can also be designed based on existing GIS database. On highway 30%-50% of road accidents occur at or near intersection [38] so GIS is great opportunity to improve the efficiency of intersections and thus reduce the road accidents.

6.2.1 Problem diagnosis and countermeasure regarding Safety:

The diagnosis is done to find the existing safety problems and to expose the existing hidden problems. Safety problems initially recognized all possible safety problems based on the casual analysis of road accidents field survey and through expert suggestion. Engineering forms are used to rank the different safety problems and diagnosis model is prepared based on the sequence of rank data [39].

6.2.2 System database composition:

Visual basic programming is used to built the GIS safety management system. The control ADO, SQL, True DBGrid Pro7.0, and ListView are used to group GIS-MapObjects, Active X controls, and database operations. The GIS database (graphical information system) is one of the system databases data which is used for intersection information database (data and criteria for intersections), and system inner database (user data; various model and report data). Map operation, information inquiry, safety level-of-service display, report (countermeasure) production,

and model parameter setting are the system's core modules. Figure 4 depicts the logic

framework.

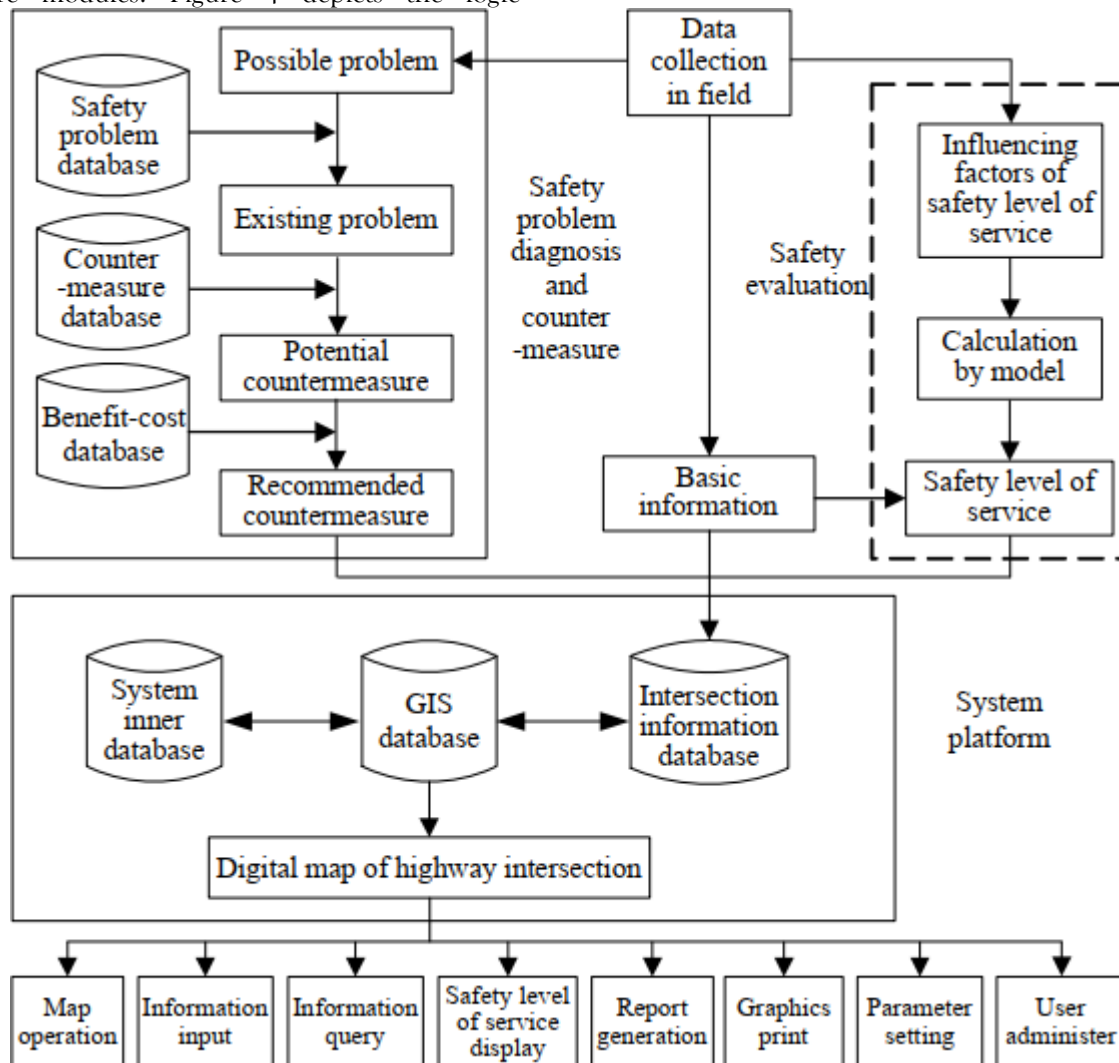


Figure 8 Safety management framework

6.3 Data collected and Geographic information:

Based on a 1/5000 map of Huzhou, we digitised intersections and road segments information to a MapInfo table file, and finished updating the map, adding layers, and encoding geographic information in MapInfo. Figure 1 depicts the system's layers. There are three layers to this digital map: a base layer, an information layer, and a detailed layer. A spatial attribute database stores information about the digital map's attributes. The user can use logic to query the characteristics, and the requested item will appear on the MapInfo map.

The Lahore Ring Road is a 53-mile-long (85-kilometer-long) ring road in Lahore, Pakistan.

It connects to the M-2 and M-11 motorways, as well as the N5 National Highway.

Lahore is encircled by a ring road. Babu Sabu to Saggian Interchange, Lahore, Niaz Chowk is the route. From there, it runs to Mehmood Booti via GT Road, Canal Bank Road, Harbanspura Interchange, Barki Road, Abdullah Gul Interchange, Allama Iqbal International Airport, Ghazi Road, DHA Phase V & VII, Sui Gas Society, Ferozpur Road, Hudaira Drain (South) to Halloki, Bahria Town to Niaz Biag.

The data is collected from Babu Sabu interchange to Kareem block on the Main service road. In GIS software Google earth images are taken as a Raster Data. The layers as a vector data is used to show and locate traffic

signs on the road and also layers is used to show road alignment. Figure 3 shows the traffic signs

around Baba sabu interchange.

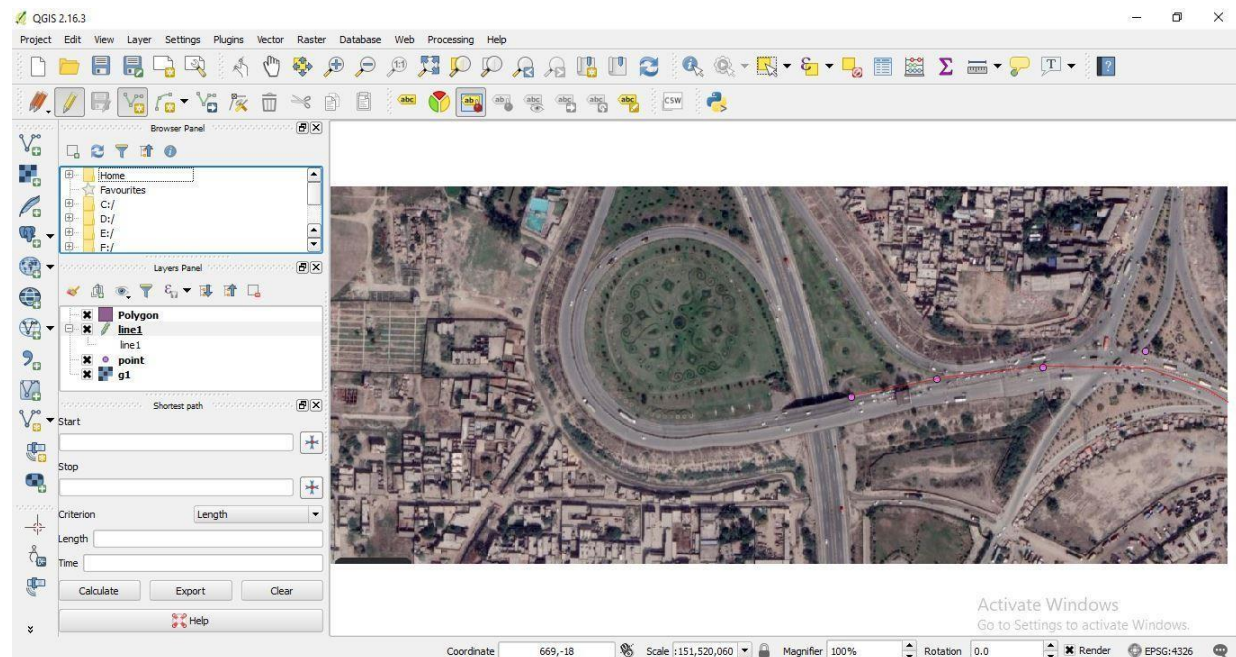


Figure 9 Babu Sabu interchange Traffic Signs

Georeferencing is done in GIS software to locate the traffic signs. The coordinates of traffic signs are then easily taken from the attribute table of Traffic Signs layer in GIS. Figure 12 and 13 shows the georeferencing steps and location of traffic signs.

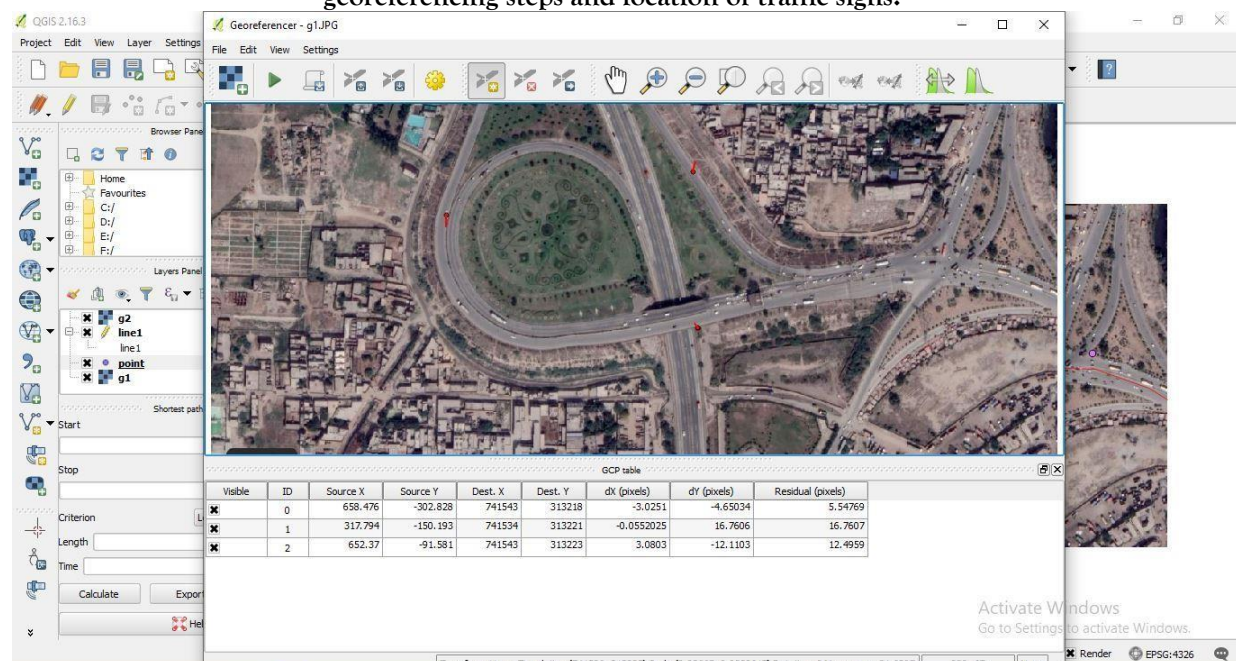


Figure 10 GIS Geo-referencing

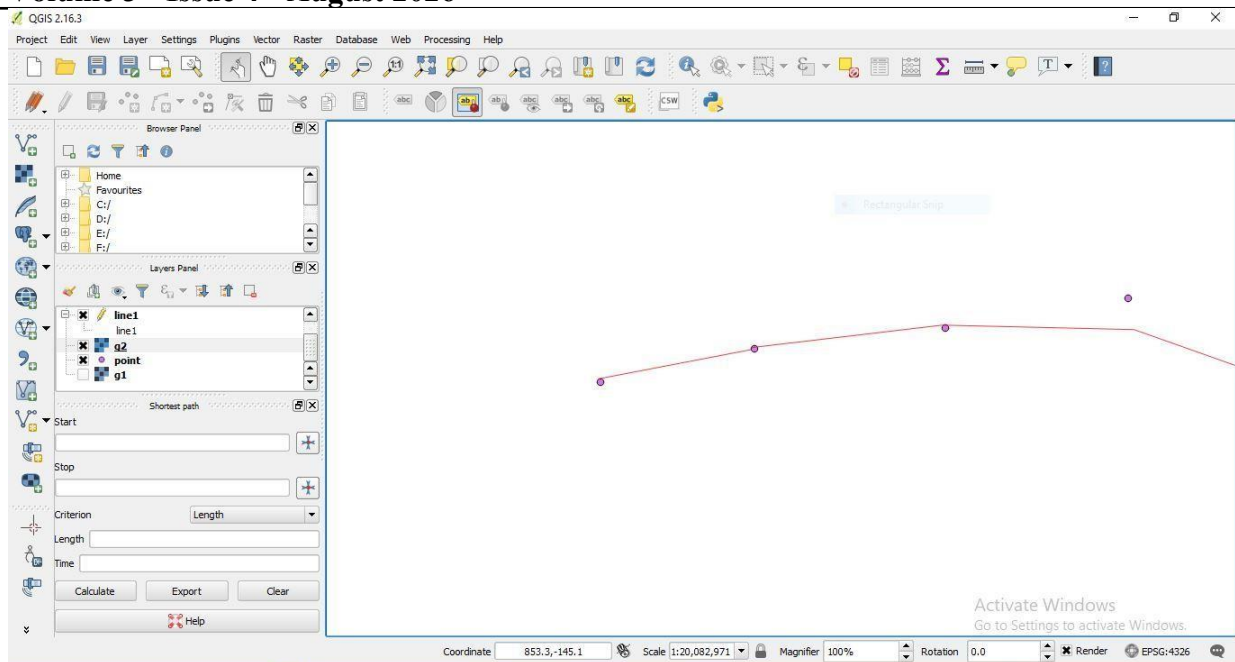


Figure 11 Traffic Sign Locations

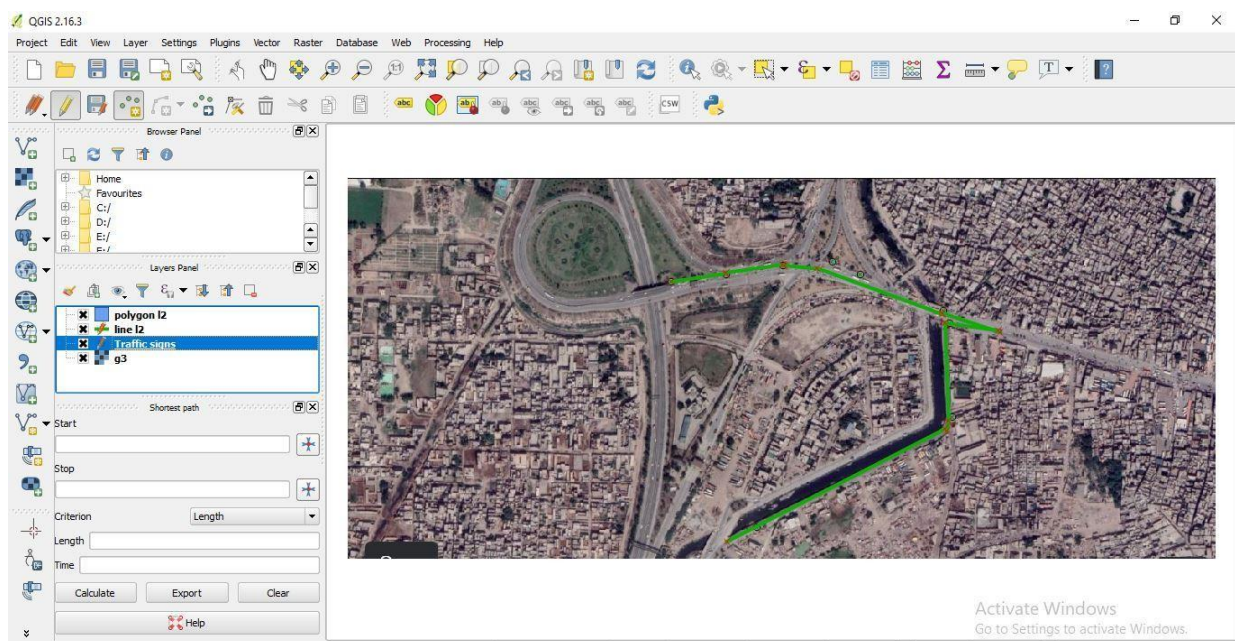


Figure 12 Main service Road Segment 1

The Attribute table in Figure No. 07 gives the information on traffic signs.

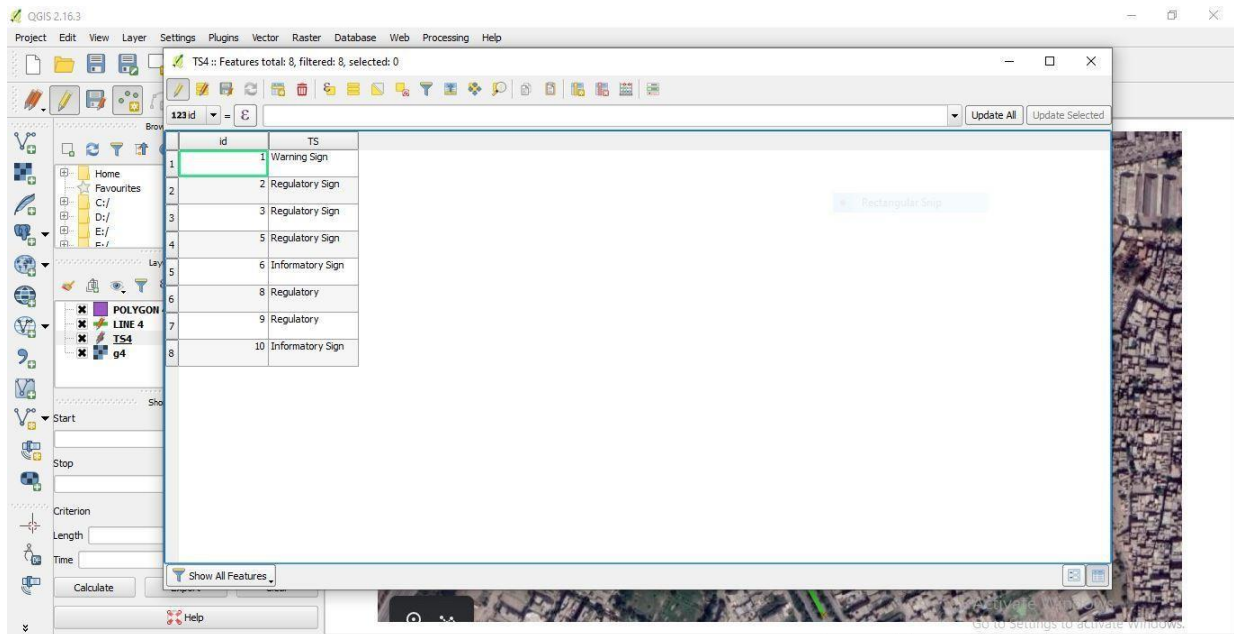


Figure 13Attribute Table

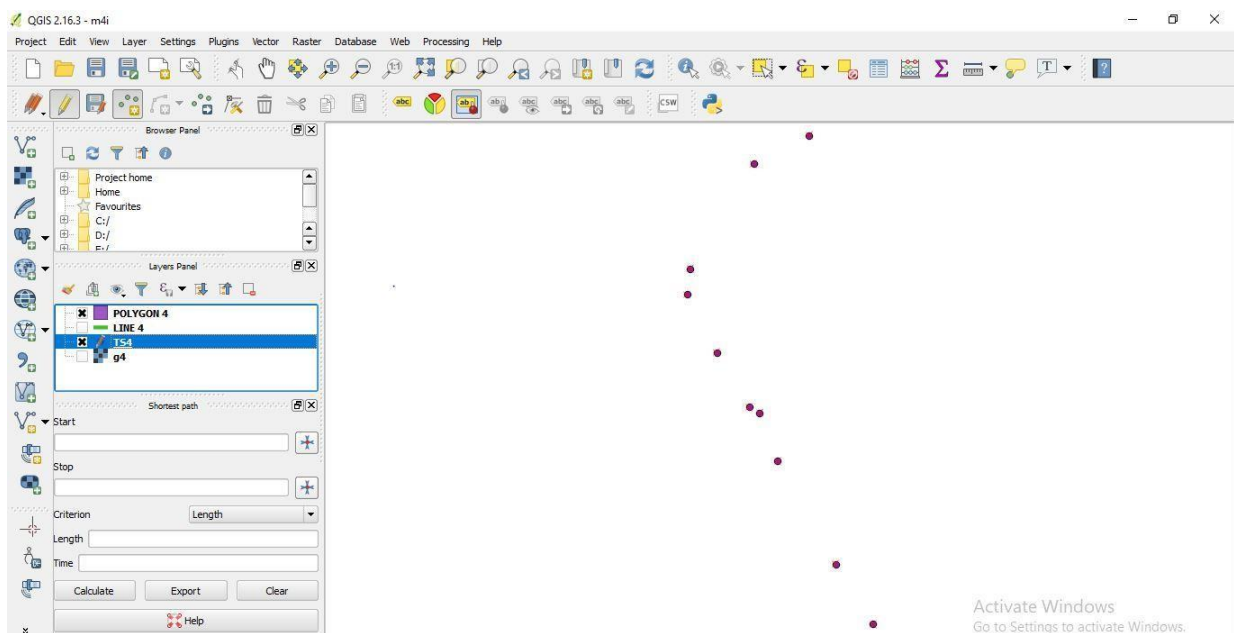


Figure 14 Traffic Signs

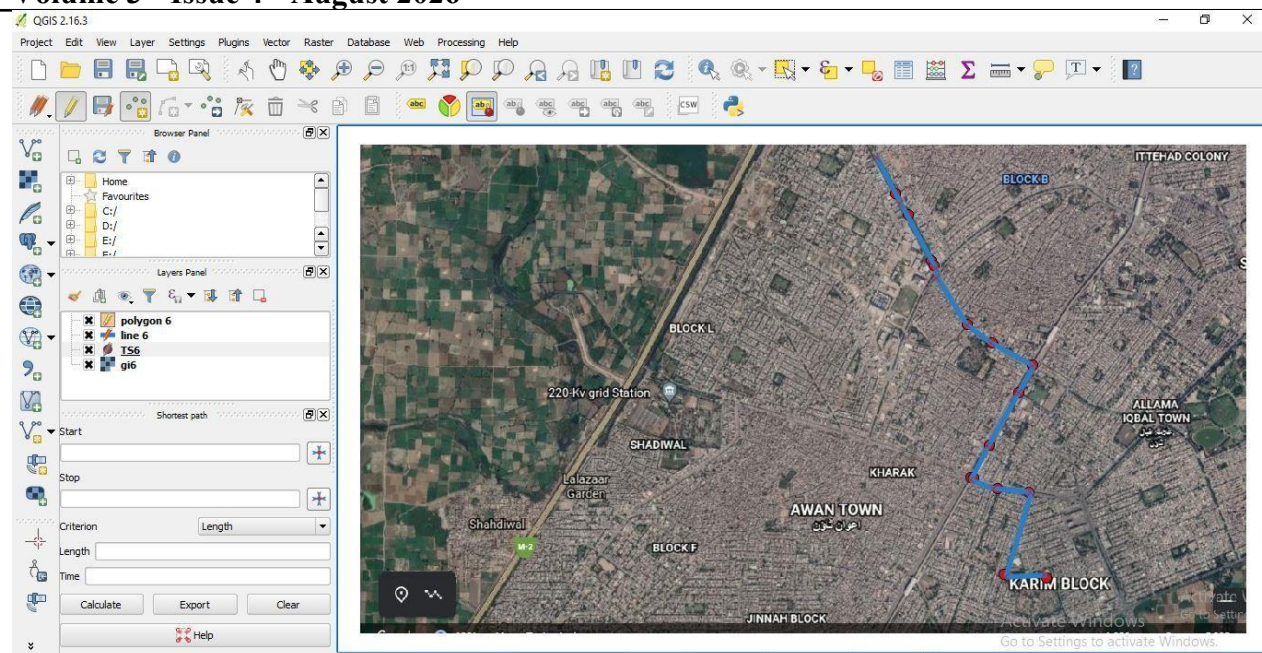


Figure 15 Traffic signs on Main service road segment 2

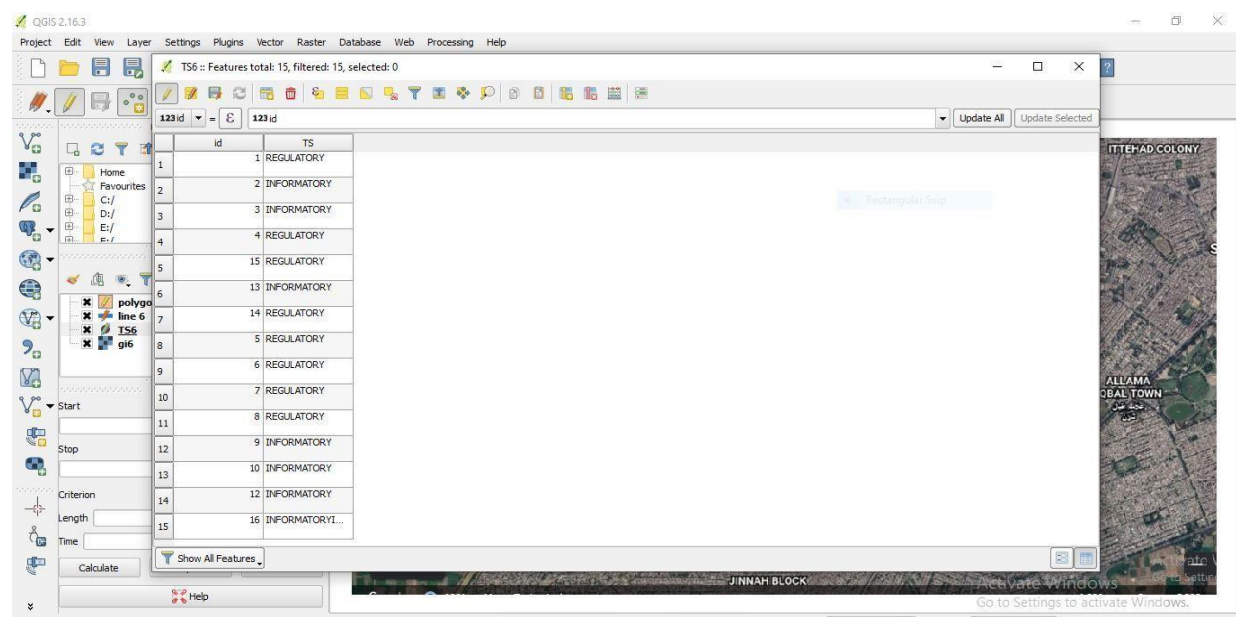


Figure 16 Traffic signs information

7. Conclusions and Recommendation

Conclusions

- The purpose of this study is to look at how traffic signs are managed as assets. On local and state roadways, it is possible to reduce sign asset expenses while maintaining a high degree of safety. GIS software can be very helpful tool to create database of traffic signs and facilities. Databases created based on GIS is more precise and efficient than simulation and other

methods discuss above. Data of traffic signs can be easily accessed though GIS and exact location of each facility can be determined

- These findings are compared to the Traffic Signs Specifications, which are nearly identical to AASHTO Specifications.
- Some signs are not put in appropriate locations, resulting in a reduction in safety.
- It is possible to make a cost estimate.
- It is simple to identify the need for fresh

inventory signs and their positioning.

- It is possible to coordinate signs, which is vital for safety and to minimize confusion.
- Using GIS database can help in data simulation which helps in improving the efficiency of existing traffic analysis and counter the safety problems.
- Accident reduction can be achieved if coordinated and well managed traffic signs are installed.

Recommendations

To analyze traffic safety management for intersections, it is recommended that Visual Basic programming language and the GIS base model idea of safety level-of-service should be employed. The results of the above study show how rapidly intersection safety may be assessed, current safety issues identified, countermeasures and enhancing the highway department's efficiency personnel thus recommendations is made.

Because safety level-of-service is a new approach of evaluating safety, more research is needed, particularly to correlate the evaluation results with the traffic accident method. Furthermore, the computer modules' graphical user interface may benefit from further refining and optimization.

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