Standing Committee for Economic and Commercial Cooperation of the Organization of Islamic Cooperation (COMCEC)

DEVELOPING INTELLIGENT TRANSPORTATION SYSTEMS IN OIC MEMBER COUNTRIES

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ABBREVIATIONS

AES	: The Automated Enforcement System
ANPR	: Automatic Number-Plate Recognition
ATIS	: Advanced Traveler Information Systems
ATMS	: Advanced Traffic Management Systems
APC	: Automatic Passenger Counters
APTS	: Advanced Public Transportation Systems
AVA	: Automatic Voice Announcement
AVI	: Automatic Vehicle Identification
AVLS	: Automatic Vehicle Location Systems
AwAS	: Automated Awareness Safety System
BTMS	: Bridge Traffic Management Systems
CAD	: Computer Aided Dispatch
CADS	: Computer Aided Dispatch Systems
COMCEC	: Standing Committee for Economic and Commercial
	: Cooperation of the Organization of Islamic Cooperation
CCO	: Commercial Coordination Office
CVO	: Commercial Vehicle Operation
DSS	: Decision Support Systems
EDS	: Electronic Control Systems
EMS	: Emergency Management System
ERGS	: Experimental Route Guidance System
ETCS	: Electronic Toll Collection System
EVP	: Emergency Vehicle Priority
EU	: European Union
GBA	: Great Banjul Area
GDH	: General Directorate of Highways
GDP	: Gross Domestic Product
GIS	: Geographical Information Systems
HGS	: Fast Pass System
IBCC	: International Border Crossing Clearance
ICT	: Information and Communication Technologies
IoT	: Internet of Things
ITS	: Intelligent Transportation Systems
IVHS	: Intelligent Vehicle Highway System
LDC	: Least Developed Countries
MaaS	: Mobility as a Service

MDT	:	Mobile Data Terminals
MMS	:	Maintenance Management Systems
M2M	:	Machine to Machine
NGO	:	Non-Governmental Organizations
NRA	:	National Roads Authority
OBU	:	On Board Units
OIC	:	Organization of Islamic Cooperation
OVDS	:	Oversized Vehicle Detection System
RFID	:	Radio Frequency Identification
RTMS	:	Real Time Monitoring System
SAAS	:	Suicide Attempt Alert System
SDG	:	Sustainable Development Goals
TEDES	:	Traffic Electronic Control System
TIS	:	Traveler Information Systems
TMC	:	Traffic Management Centre
TSP	:	Transit Signal Priority
TTMS	:	Tunnel Traffic Management Systems
TTMS	:	Tunnel Traffic Management Systems
TRB	:	Transportation Research Board
TWG	:	Technical Working Group
UK	:	United States
UN	:	United Kingdom
UNFCCC	:	United Nations Framework Convention on Climate Change
US	:	United States
VANET	:	Vehicular Ad-hoc Network
VES	:	Violation Enforcement System
V2V	:	Vehicle-to-Vehicle
V2I	:	Vehicle-to-Infrastructure
V2X	:	Vehicle-to-Everything
V2P	:	Vehicle-to-Pedestrian
VIP	:	Video Image Processing
VMS	:	Variable Message Signs
VSL	:	Variable Speed Limits
VTS	:	Variable Traffic Signs
WIS	:	Weather Information Systems

EXECUTIVE SUMMARY

Today, the world is more interconnected than ever. The wide web of roads, cross-cities, cross-regions and cross-borders carry people and freight to sustain local and global economies, to keep the connection active and running. The picture leaves no room for another option but a must to invest in transportation infrastructure for both developed and developing countries. In addition, a well-functioning transport system is one of the most critical infrastructures for national and regional development. The impacts of inadequate transport system are manifested particularly in terms of traffic congestion, delays, pollution, accidents, high-energy consumption, low productivity, inefficient usage of resources, community severances, and inadequate access to services. Within this perspective, **Intelligent Transport Systems (ITS)** provide solutions not only to meet people's growing mobility demands but also to enhance the quality of transportation and logistics supply chain.

ITS use **information and communication technologies (ICT)** for monitoring, measurement, analysis and control mechanisms with multi-directional data exchange between users, vehicles, infrastructure and hubs to better plan, design, operate, maintain and manage transportation systems. However, to fully realize the benefits of ITS, careful planning is essential.

A well-structured ITS necessitates a Strategic Action Plan. This Plan should involve stakeholders describing the roles and responsibilities clearly and supported by systematic ITS architecture that meets the diverse needs of all users. In addition, the adoption of internationally accepted standards is very important in ITS architecture, which determines the data security and protocols used in data exchange between equipment. Moreover, the success of such strategies relies on effective monitoring and evaluation.

With an effective monitoring and evaluation system stakeholders can determine whether ITS applications are being utilized in alignment with the defined goals and objectives and identify the reasons for any deviations. Such monitoring and evaluation systems are also valuable for decision makers, providing ideas about actions to be taken in the future.

Technological developments in ICT directly affect the field of ITS and lead to the integration of new applications. New technologies such as the Internet of Things (IoT), artificial intelligence (AI), machine learning will cause transportation modes to communicate with each other, analyze and make decisions autonomously. It is crucial to support research projects and allocate financial resources to stay in line with these developments.

Parallel with developing technology, number of mega cities and people living in cities are increasing. Urban and intercity mobility is rising as a result of migration of the population to cities from rural areas. Therefore, the formulation of new policies to enhance urban sustainability is needed. In addition to ensuring that people can benefit from transportation systems in a safe manner, minimizing negative environmental impacts such as increased carbon emissions as a result of increased vehicle use is also an important issue to be considered within the scope of sustainability. In this context, promoting alternative vehicles such as electric vehicles and public transportation will make significant contributions to sustainable mobility.

While social inclusion ensures the use of safe, comfortable, affordable and accessible transportation systems for all people in society, it also presents some important barriers in urban transportation systems. Vulnerable groups such as women, children, people with disabilities and the elderly may have limited or sometimes no access to transportation systems such as public transportation. In this case, ITS solutions, special studies and projects can solve the problem of accessibility of such groups.

ITS provide valuable solutions to meet people's growing mobility demands. However, there are considerable differences between OIC Member Countries in terms of ITS. The use of ITS applications varies according to the level of development and financial means of the countries. This situation can also be seen among OIC Member Countries. These differences between countries do not allow for the effective use of ITS systems within the OIC. This situation may also negatively affect trade among OIC Member Countries. In order to eliminate the differences between Member Countries, capacity building activities should be carried out to improve the ITS capacities of countries with more limited means, and access to low-interest loans should be provided. But the most important thing is to raise public awareness on ITS and to raise qualified manpower. Academic education programs and curricula can be organized to train the manpower in question, and practical internship programs can be created in the field.

Within the scope of this Handbook, an analysis of the current situation of ITS has been evaluated and on-site ITS applications have been observed during field visits. Furthermore, policy recommendations have been formulated to expand ITS applications in OIC countries. The actions that can be taken are also suggested in this Handbook. Each of these actions emerges as topics that need to be examined in more depth in the future.

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CHAPTER 1:

INTRODUCTION

1.1. Scope of the Study

This study focuses on in-depth analysis of Intelligent Transportation Systems (ITS) applications, through literature reviews, case studies and surveys. Policy recommendations are provided for developing ITS among OIC Member Countries., based on the analysis of these changes, best practices and reporting have been understood.

Within the scope of this study, the below are the main objectives of the Policy Guide:

- Conducting a detailed field scan on Intelligent Transportation Systems (ITS) used in Road Transport and Connected to Transportation Systems
- Examining the most current perspectives on the ITS field,
- Contributing to highway storage areas with selected samples and all other transportation options in the sample type, storing ITS and storing data,
- Collecting information on all theoretical research outside the field and to collect information about the ITS structure and applications, as well as current research techniques,
- Examining the practices used in the OIC Member Countries selected for sampling and research,
- Selecting the practices that are the subject of the sample and used among the countries that are not members of the OIC,
- Determining the best guide and contributor among the Member Countries of the group.

1.2. Research Methodology

In order to achieve the research objectives of the study, the determined methodology should be examined comprehensively and in detail. The most important and primary data collection sources, such as conducting surveys with experts, obtaining the insights of the parties, and examining newly published articles and academic studies, are examined cumulatively. Because OIC Member Countries do not show homogeneity in economic, commercial and developmental terms, it is needed to select cases that are showcase examples to the Handbook.

Therefore, three main criteria are applied in selection of case countries that represents:

- OIC Member Countries (from COMCEC List)
- The Official 3 Regional Groups of OIC Member Countries (from OIC List; African, Arab, and Asian regions):
- Different economic & socio-economic conditions:
    - o The first group includes Afghanistan, Bangladesh, Benin, Burkina Faso,

Djibouti, Chad, The Gambia, Guinea, Guinea-Bissau, Comoros, Maldives, Mali, Mauritania, Mozambique, Niger, Senegal, Sierra Leone, Somalia, Sudan, and Yemen. Defined by the United Nations (UN) as least developed countries (LDCs), these nations are remarkably challenged by poverty as their primary challenge. Industrialization is virtually non-existent, and their economies predominantly rely on the export of agricultural products.

- The second group comprises Albania, Guyana, Indonesia, Morocco, Cote d'Ivoire, Palestine, Cameroon, Kazakhstan, Kyrgyz Republic, Lebanon, Malaysia, Egypt, Uzbekistan, Pakistan, Suriname, Jordan, Tajikistan, Tunisia, and Türkiye. These countries are positioned at a middle-income level and demonstrate relatively better performance in both the industrial and service sectors compared to the first group.
- The third group includes oil-exporting countries such as Azerbaijan, Bahrain, United Arab Emirates, Brunei, Algeria, Gabon, Iran, Iraq, Qatar, Kuwait, Libya, Nigeria, Oman, Saudi Arabia, and Turkmenistan. Although the economic development levels within this group are not uniform, each country exhibits a high rate of development driven by their reliance on natural resource exports.

After the application of these criteria, following five case countries are selected for the purpose, where Malaysia and The Gambia are the countries for field visits. Table 1 shows the information about the selected case countries.

In addition to above list, desk-based study is also performed for the US, a non-OIC country, as an example to best practices for technology adoption, data management and system integration in ITS.

Table 1. Selected case country information

Research method	Case Country	OIC Member Country	Geographical Region	Economic & Socio-Economic Condition	GDP per Capita by 2022
Field visit	Malaysia	Yes	Asian	Middle Income	USD 11,972
Field visit	The Gambia	Yes	African	Need to be deve-loped	USD 825
Desk based	Türkiye	Yes	Asian	Middle Income	USD 10,629
Desk based	Iraq	Yes	Arab	Oil exporting	USD 5,937
Desk based	The US	No	N/A	High Income / Best practice	USD 76,343

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CHAPTER 2:

LITERATURE REVIEW

2.1 Applications of Intelligent Transportation Systems

ITS, as of its most general and important definition is to ensure the security of transportation networks and providing optimization to increase the efficiency of these networks within the transportation system. It is a structural program that allows internal calculation, supervision, control and the optimal use of these mechanisms.

ITS are also continuously improving field in which data, communications, computers and other ICT technologies are merged with advanced transportation approaches. Concepts such as big data, data security, open data and connected transportation technologies are more and more integrated into the ITS systems to improve and optimize effectiveness.

Worldwide used ITS applications are shown in Figure 1.

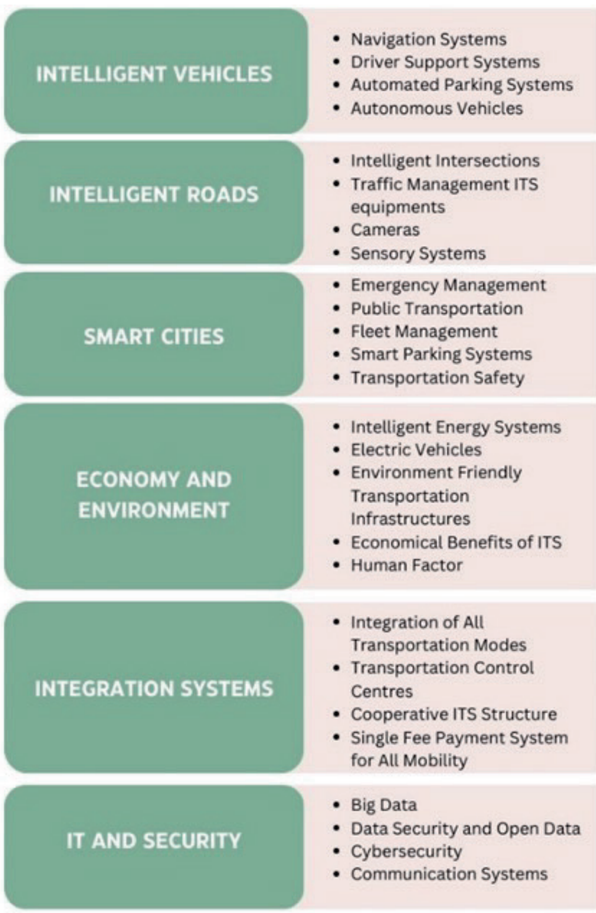

Figure 1. ITS Applications

In addition to this, ITS enable the use of many different disciplines by integrating them together. One of the most distinctive features of ITS structure is the rapid use of data from many different disciplines. Different sectors and disciplines that have ITS relationship is shown in Figure 2.

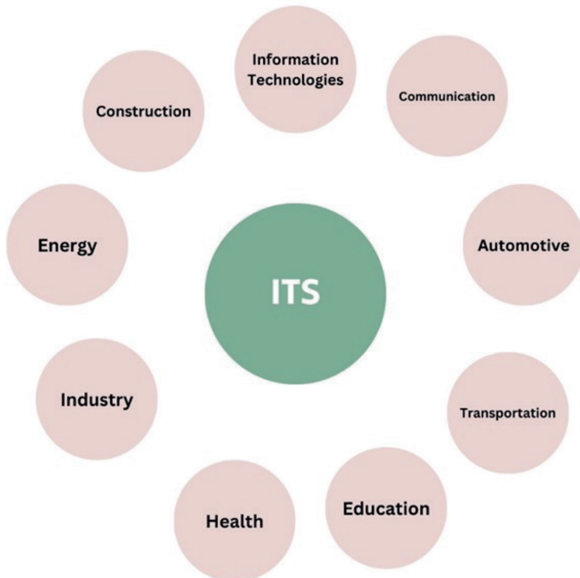

Figure 2. Sectors and disciplines which are in integration with ITS

2.2 Categories of Intelligent Transportation Systems

ITS can be categorized in many ways. From the perspective of transportation management, ITS can be categorized in four subsections. These subsections are:

- Advanced Traveler Information Systems (ATIS)
- Advanced Traffic Management Systems (ATMS)
- Advanced Public Transportation Systems (APTS)
- Emergency Management Systems (EMS)

Geographical Information Systems (GIS) enable the spatial analysis of existing data in **Advanced Traveler Information Systems (ATIS).** Route analysis, alternative route services, supplying information about different modes in routes and multimodal trips can be evaluated under this concept.

Advanced Traffic Management Systems (ATMS) have a significant role in reducing urban traffic density and time spent in traffic. ATMS provides solutions to prevent traffic congestions and accidents while working in both simulation and real time-based scenarios. These systems use analytical methods such as fuzzy logic and artificial intelligence in producing solutions to traffic problems faced.

Advanced Public Transportation Systems (APTS) harmonizes existing and emerging technologies to improve the quality of public transportation. These systems serve all stakeholders such as passengers, operators, and supervisors. Having been emerged as fee collection systems, APTS continue to develop in the forms of efficiency analyzing systems, dynamic pricing, violation detections etc.

Emergency Management Systems (EMS) involves integrated systems which work in order to intervene in many situations such as traffic accidents and fires, these systems require spatial analysis tools, therefore in these systems GIS are actively and commonly used.

2.3 Literature Review

Literature review is concentrated around four main ITS applications in roadways as mentioned in 2.2:

- Advanced Traffic Management Systems (ATMS)
- Advanced Traveler Information Systems (ATIS),
- Advanced Public Transportation Systems (APTS)
- Emergency Management Systems (EMS)

The increase in users of transportation infrastructures, the urban population, the number of private vehicles in cities, changes in the needs, demands and lifestyles of urban citizens have brought about environmental, economic and social dangers such as transportation-related traffic congestion, pollution, increased security vulnerabilities and losses in the efficiency of economic activities.

This situation deemed authorities to improve transportation management strategies and find numerous solutions to increase the efficiency of transportation activities in urban and intercity scale. In order to overcome the problems, authorities brought solutions such as establishments of transportation policies, expansion of investments and transportation infrastructures, improvements in transportation planning strategies.

Conservative solutions focused on the speed, convenience and affordability of motor vehicle travel and favored private vehicle mode related improvements. In 1960s, two-lane roads started to suffer from congestions, and it was deemed rational to expand the infrastructure by adding up more lanes to roadways. Observing that focusing solely on infrastructure expansion and capacity have not been the solution to overcoming the problems and the fact that this approach does not meet whole of the demands of the urban citizens, they have been paradigm shifts in transportation planning approaches (Litman, 2013). Instead of placing only traffic and transportation engineering-based solutions on the centre of the planning processes, authorities have diverted their focus to concepts such as smart solutions, interdisciplinary planning, sustainability and urban life quality.

Intelligent Transportation approach has been one of the useful components of transportation planning in the continuing development of the planning strategies. Assessing ITS in a conceptual point of view, it can be defined as whole of technological entities which utilize information and communication technologies in their services to present solutions to transportation problems. As there are various definitions in the literature for ITS, in 2010/40/EU Directive of EU, Intelligent Transportation Systems are defined as:

> *"Intelligent Transport Systems (ITS) are advanced applications which without embodying intelligence as such aim to provide innovative services relating to different modes of transport and traffic management and enable various users to be better informed and make safer, more coordinated and 'smarter' use of transport networks." (Directive 2010/40/EU of The European Parliament, 2010).*

In today's world, the technological developments are showing their effects in urban transportation and Intelligent Transportation. ITS concept is being structured as technological entities such as Internet of Things (IoT), sensor technologies, autonomous vehicles, cloud technology, big data, artificial intelligence, blockchain technology are used in urban and intercity transportation. Emerging transportation methods and sustainable mobility components such as Connected Cooperative and Automated Mobility, Hyperloop, Mobility as a Service (MaaS), intelligent roads lead the paradigm shift in transportation planning.

ITS on a basic level, works on the basis of data exchange between humans, vehicles and roadside infrastructure. In early 2000s Vehicular Ad-hoc Network (VANET) have been introduced to provide mobile communication through creating a wireless network in the base of vehicles. To make exchange of data and information possible, Vehicle-to-vehicle (V2V), Vehicle-to-infrastructure (V2I), Vehicle-to-everything (V2X) and Vehicle-to-pedestrian (V2P) communications are provided via communication technologies such as IoT, Wi-Fi, 5G, cloud technology and bluetooth (Ji et al., 2020). An illustration of communications that are made via VANET is shown in Figure 3 (Ehtisham et al., 2024).

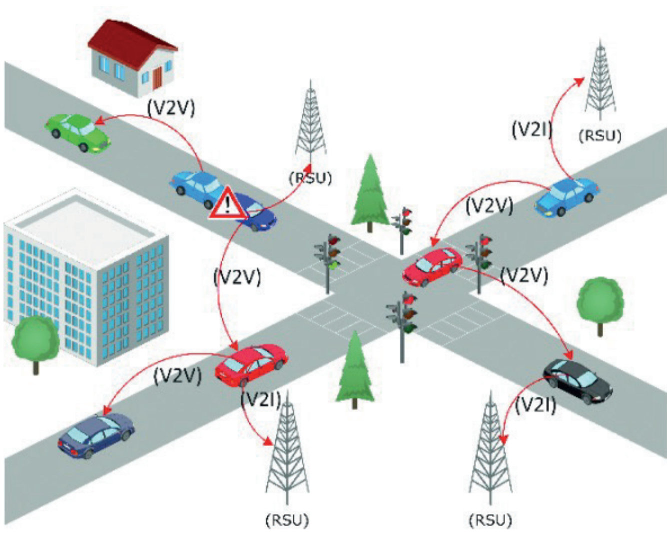

Figure 3. VANET Communications (Ehtisham et al., 2024

2.3.1. Advanced Traffic Management Systems (ATMS)

As the number of vehicles and users of the transportation infrastructure increases, existing infrastructures and management strategies have difficulty in supplying for the transportation demand, efficiency and effectiveness of the transportation management decreases. ITS provide innovational and smart solutions to enhance the traffic management strategies.

ATMS, have various functions such as controlling of traffic management, congestion avoidance, travel time prediction and traffic data collection (Ravish & Swamy, 2021). In Figure 4, functions of ATMS are depicted.

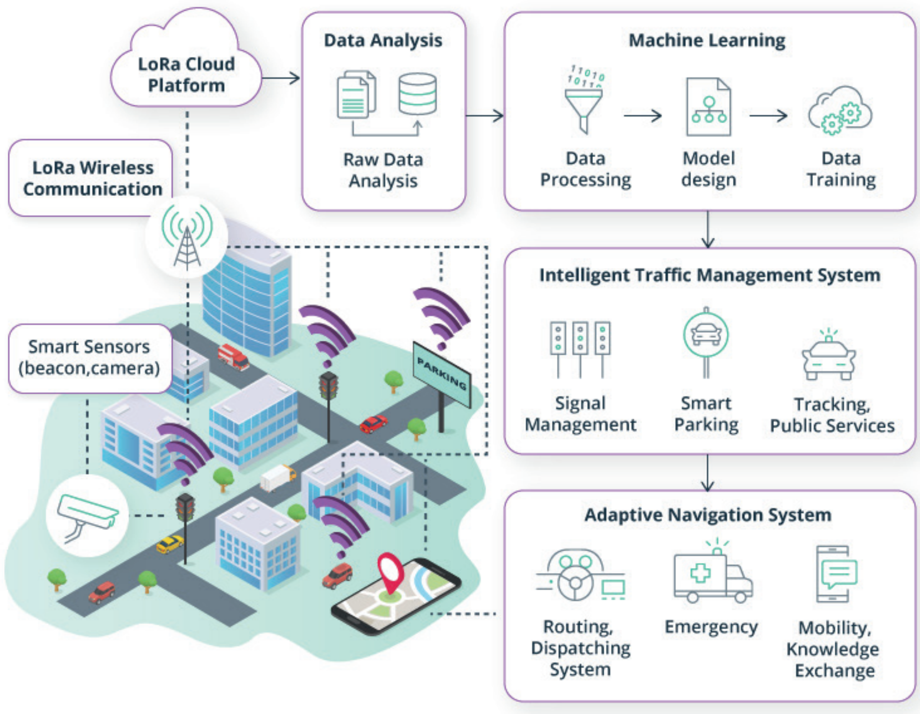

Figure 4. Advanced Traffic Management Systems Functions (Source: Intellias)

ATMS basically provide the innovative solutions to various traffic management related problems. Several components of ATMS can be listed as:

- Smart Parking Systems, which informs drivers about free parking spaces in the vicinity of the driver, presents payment and direction services
- Infrastructure monitoring services, controls the roads and traffic conditions in the city by on-road traffic cameras.
- Traffic monitoring, management and controlling systems controls the traffic signalization systems, makes informed decisions based on real time traffic data.
- Re-directing and congestion management serves drivers for avoidance of emergency

zones in where accidents or construction works are present. The system re-routes the traffic in ways which will prevent drivers to go into emergency zones by informing systems.

- Intelligent and electronic tolling systems which serves for enhancing the tolling processes and avoiding congestions at toll booths.
- Dynamic Message Signs provide information about weather, road conditions, emergency situations to drivers.
- Traffic Control Centres are monitoring centres for overseeing the functionality of the transportation systems. The aim of the centres is to take immediate measures for better managing the traffic (Olusanya et al., 2020).

Prominent and prevalent applications of ATMS around the world can be exemplified as Ramp Metering, Dynamic Route Information, Incident Management, Tapering, Peak-hour tidal flow applications, High Occupancy Lane applications. These systems and various other systems ensure the control of transportation systems and traffic in more efficient ways than conventional methods. Real time traffic management and route optimization services provide better transportation service to the users.

There are many benefits of the implementation of ATMS equipment that can be listed as:

- The implementation of these systems will provide the rate of accidents to decrease.
- Automated Traffic Control Systems, Speed Enforcement and Restriction Systems, Monitoring and Surveillance Systems, Incident Detection Systems, Incident Warning Systems, Emergency Response Systems and Weather Information Systems provide benefits for increment of safety in roadways.
- By better managing the demand, the implementation of these systems will serve for mitigation of congestions in roadways.
- Redirection of the traffic demand ensures the optimum usage of capacity in roadways.
- By navigation devices, traffic information services, route optimization services will provide many benefits such as avoiding delays, efficient parking management, capacity optimization and this will lead to the optimum usage of transportation infrastructure.
- Fuel consumption and carbon emissions will decrease, energy efficiency will increase. Fact is that, by this way intelligent management of traffic will serve for environmental protection.
- Provision of these services also serve for the comfort increase. Weather information, possible delay information, information about traffic conditions, real time traffic information, dynamic route guidance, vehicle tracking, and electronic payment systems will benefit the users in reducing transportation related discomfort.
- Various traffic management services such as integrated traffic control systems, dynamic message signs, incident detection systems, weather information systems,

monitoring systems, on board support systems ensure the increment of safety in roadways.

- Usage of these systems provide economic efficiency for operators, stakeholders, drivers and the whole system (Stanciu et al., 2012).

2.3.2. Advanced Traveler Information Systems (ATIS)

One of the most important functions of ITS is dissemination of information to users of the system. Providing of information to travelers in both real time and before the beginning of journey can be done by using ATIS.

ATIS operate on all platforms of the transportation systems such as urban arterial roads, highways and other transportation modes. It works through many communication channels. Especially with the accelerated development of communication technologies, the number of these communication channels have been increasing.

In today's world, ATIS work through the internet, smart phones, radio, mobile applications and vehicle on board systems. Various data and information types are disseminated to users through these channels. These include journey times, alternative routes, inter-modal journey opportunities. The disseminated information is beneficial for drivers and users of the system to make better travel decisions and increase the efficiency of their mobility actions.

ATIS can be categorized in three main subsections considering the time of the delivery of the information and the channel of the communication. By this method, it is reasonable to categorize ATIS in pre-trip, in vehicle and roadside traveler information systems. Information that is provided to traveler prior the journey is gathered through various channels, helps travelers to make better travel choices. In-vehicle information includes applications such route guidance, incident information, travel time information and disseminated on board technologies in the vehicle, during the journey. Route guidance technologies involves GPS-based real time data acquisition and provides the most efficient routes for travelers. Roadside information involves information systems such as Dynamic-Variable Message signs and highway advisory radio. By these channels traveler information about road and weather conditions, incident information is communicated to travelers (Highway Capacity Manual 2010).

Main aim of the ATIS is to inform the travelers about the condition of transportation network. In our day, various ATIS technologies are involved in the concept of Mobility as a Service (MaaS). Depiction of applications of ATIS and data dissemination scheme is shown in Figure 5 (Iqbal, 2017).

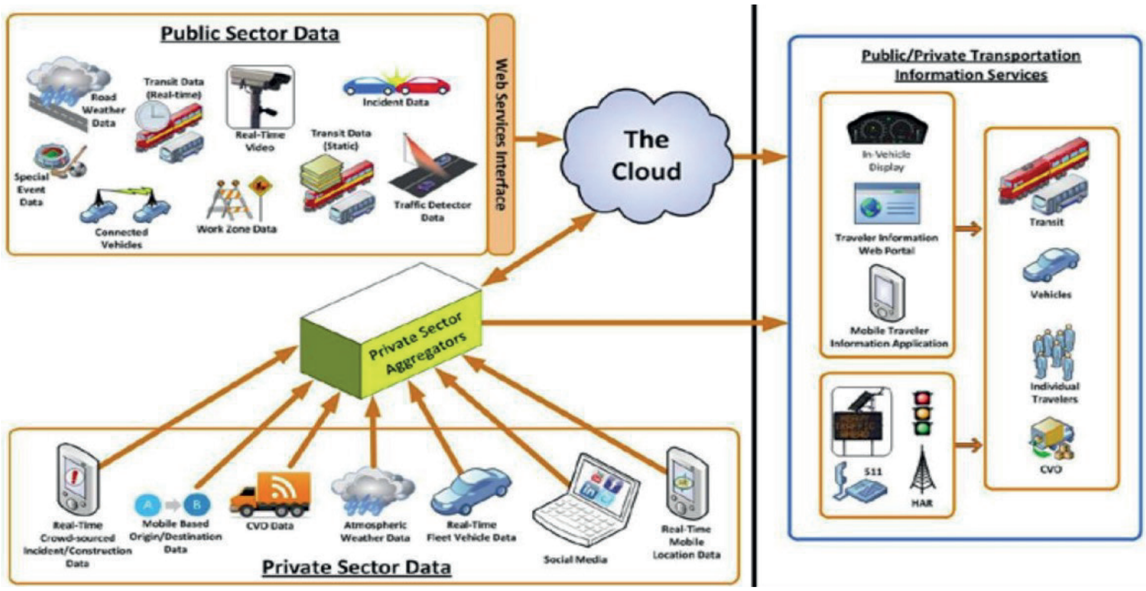

Figure 5. ATIS Applications and Data Dissemination (Iqbal, 2017)

Traveler information is disseminated through various channels with the emerging communication technologies. Social media, websites, dynamic message signs, e-mail and SMS alerts, third party applications, highway advisory radios, crowdsourcing are amongst these channels. In Figure 6, the percentages of real time traveler dissemination methods usage by the metropolitan arterial agencies of United States of America (the US) are depicted, as provided from 2020 ITS Joint Program Office Arterial Management Deployment Tracking Survey (USDOT ITS JPO, 2020a).

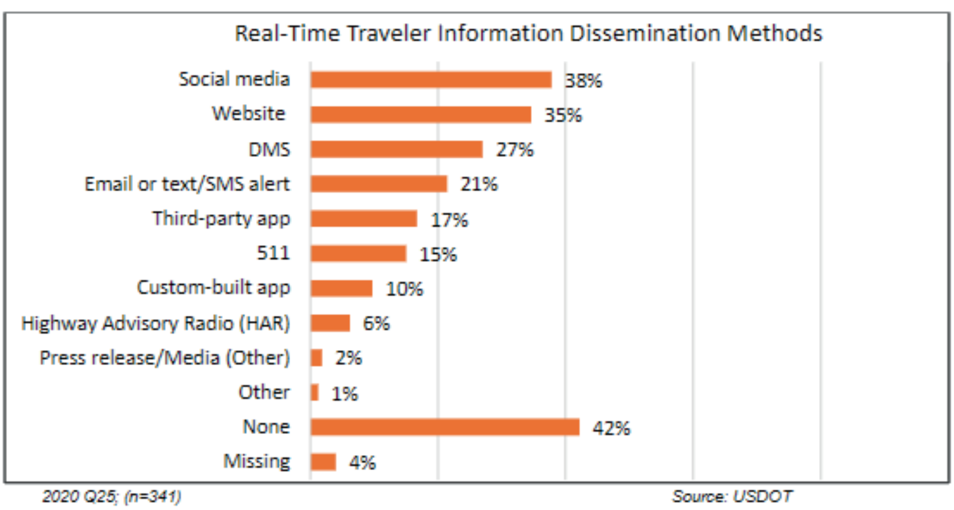

Figure 6. Real Time Traveler Information Methods Usage Percentages by Arterial Agencies in US (Source: USDOT ITS JPO)

ATIS, can be categorized or defined in many ways. Robinson et al. (2013) defined the traveler information types as,

- Determining alternative routes
- Providing support with live traffic cameras
- Offering parking facilities
- Checking public safety information,
- Inspecting road work/construction areas,
- Updating and checking security information,
- Providing orientation with special events,
- Reporting traffic incidents,
- Calculating travel times,
- Checking and reporting weather information,
- Collecting and systematically processing other information.

In order to ensure the efficiency of ATIS, there are several key points that should be taken into consideration. These key points can be listed as,

- Ensuring the diversity of the traveler information system,
- Providing information that exceeds route optimization,
- Supplying ATIS with text and voice announcement methods,
- Providing real time data in high accuracy,
- Providing diverse ATIS applications as the literature shows, (Iqbal, 2017).

2.3.3 Advanced Public Transportation Systems (APTS)

APTS has been emerged as fee collection systems at first but it continues to develop in the forms of efficiency in such as analyzing systems, dynamic pricing, and violation detections. APTS harmonizes existing and emerging technologies to serve all stakeholders such as passengers, operators and supervisors for improving the quality of public transportation.

APTS implementation and deployments increase the quality of public transportation systems and promotion of usage of public transportation modes; therefore, mitigation of congestion and decrease in environmental pollution can be possible. To make sure that APTS have the quality standards, there are various indicators that must be taken into consideration. These indicators are mainly related to:

- Safety,
- Mobility,
- Efficiency,
- Productivity,

- Energy,
- Environment,
- Customer Satisfaction.

The aim of APTS is to increase the efficiency of public transportation operations and ridership of public transport modes by ensuring the reliability of the public transportation systems (Singh & Gupta, 2015). APTS presents a variety of services such as real time information of arrival times of transit vehicles, smart cards, intelligent payment systems through smart phones or other mobile application methods, eliminating cash payment.

There is a variety of technologies that are involved in APTS. These can be listed as:

- Automatic Vehicle Location Systems (AVLS), which provide real time information of location, speed and direction of commercial vehicles to operators,
- Traveler Information Systems (TIS), which provide real time information to travelers about conditions of the network, arrival and departure times of the vehicles, journey planning services etc.
- Automatic Passenger Counters (APC), which counts boarding passengers to transit vehicles,
- Geographic Information Systems (GIS), which provides mapping, route designing and implementation services for operators,
- Decision Support Systems (DSS), which allows the operators to control the transportation network by decision making and regulation strategies (Elkosantini & Darmoul, 2013).

Traveler Information Systems (TIS) constitute a large and important part of APTS. Adler and Blue (Adler & Blue, 1998) categorized TIS into two generations. The first generation includes Variable Message Signs (VMS) and advisory radio. Second generation involves innovational and technological methods which provide travelers with various services, via two-way communication. Mobile applications, route guidance services, inter-modal journey planners, transit vehicle arrival and departure time services are the prominent services in APTS today, which are provided via TIS in public transportation systems. In Figure 7, components of APTS is shown.

On Board Units (OBU) and ITS elements on transit vehicles are another very important component of APTS. Today, there are a variety of ITS technologies that are implemented to transit vehicles such as AVL, Computer Aided Dispatch Systems (CADS), Mobile Data Terminals (MDT), Automatic Passenger Counters (APC), Maintenance Management Systems (MMS) and Transit Signal Priority (TSP).

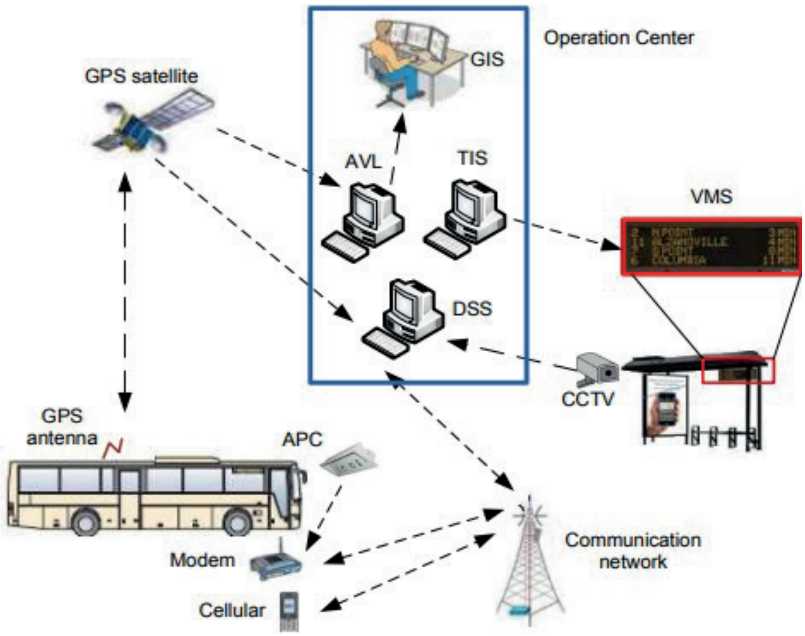

Figure 7. Advanced Public Transportation Systems (Elkosantini and Darmoul, 2013)

In 2020, Transit Management Deployment Tracking Survey of the United States Department of Transportation ITS Joint Program Office (USDOT ITS JPO) and adoption rates of these systems for transit agencies have been investigated. In Figure 8, the trend of ITS technology adoption rate of transit vehicles for transit agencies of the US metropolitan areas between 2010 and 2020 are depicted. (Intelligent Transportation Systems Deployment Tracking Survey: 2020 Transit Findings, 2020).

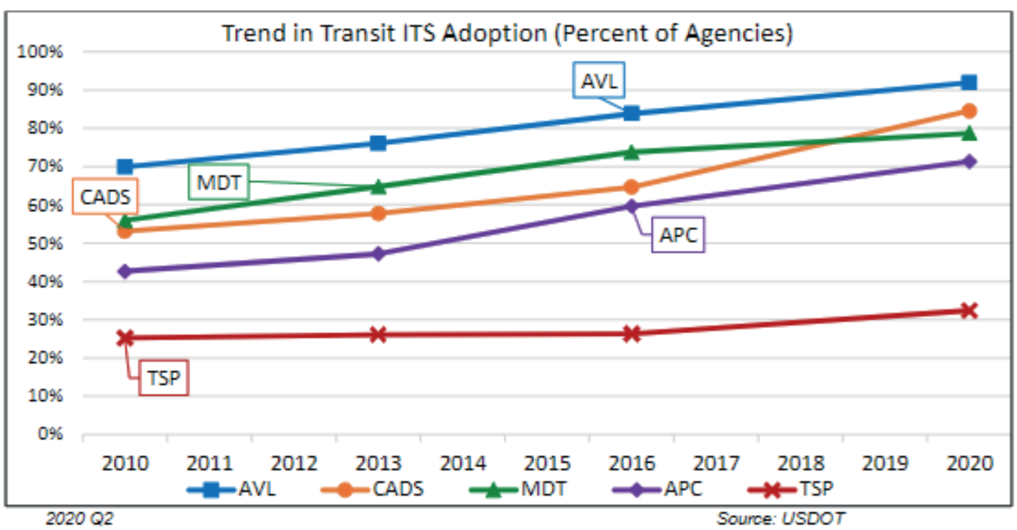

Figure 8. ITS Technology Adoption Rate Trends in the US (USDOT ITS JPO)

2.3.4 Emergency Management Systems (EMS)

Emergency Management Systems (EMS) comprises of all components of ITS which operate during emergency conditions. EMS provides in reducing the fatality rates in accidents and improving transportation safety (Singh & Gupta, 2015). EMS, being one of the most important and newly emerging components of ITS, can also be categorized under ATMS. This is since communication tools of ITS which come under VANETS play a crucial role in functioning of EMS. Singlifying the emergency contact number for enforcement, paramedics, fire department and other emergency departments are one of the most prominent, prevalent and beneficial applications that are included in EMS. This application is present several OIC Member Countries such as Malaysia and Türkiye as well as non-OIC countries like the US, which are evaluated as the best practice country in this report.

Emergency Vehicle Priority (EVP) is an EMS technology, which is integrated with ATMS. EVP provides the priority to emergency vehicles in their route to the incident zone by adjusting the traffic signals in the route to the advantage of emergency vehicles. The system utilizes Computer Aided Dispatch (CAD), GPS and traffic information (Queensland Government Department of Transport and Main Roads.). EVP through its functions provides an emergency corridor for emergency vehicles, optimizes the route and controls the signalized intersections for the benefit of emergency vehicles. EVP systems function in steps of recognizing the emergency vehicle, collecting data of the emergency vehicle, route and emergency situation and implementing the priority case application. The data collected by the system are about the emergency vehicle are location, speed, direction, destination, route and emergency case. The system comprises of sub-systems which are acoustic, GPS, wireless communication and node-based systems (Patel et al., 2022). Working scheme of EVP is depicted in Figure 9 (Nellore&Hancke, 2016).

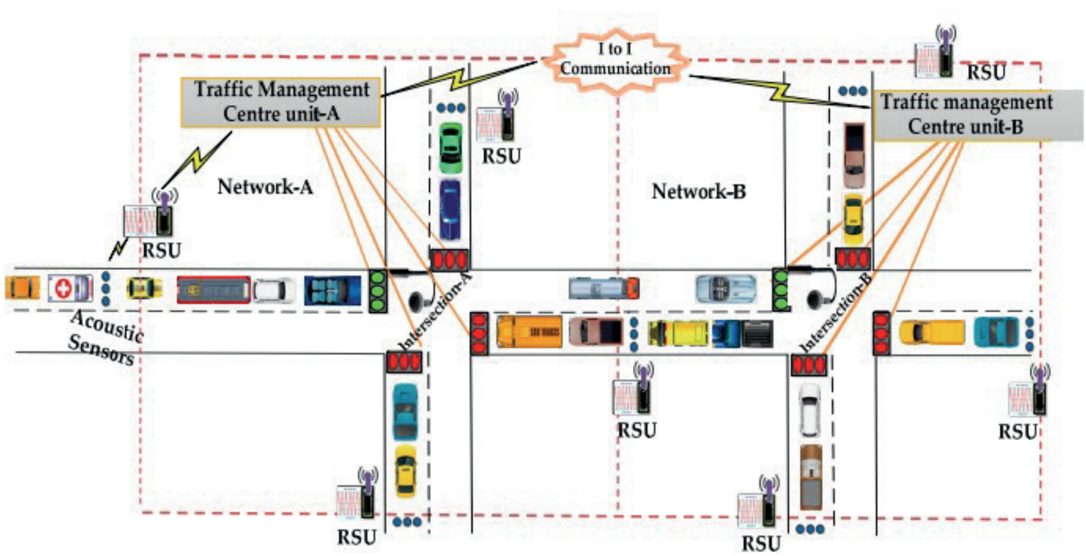

Figure 9. Emergency Vehicle Priority Function Scheme (Nellore and Hancke, 2016))

Centralized control systems is the one that EVP mechanism can be implemented. The arrival of the emergency vehicle to the signalized intersection is detected by the traffic signal controller by light, sound or radio waves. Traffic control software analyses the signal priority situation and changes the signal cycle in the intersection in the advantage of emergency vehicle. Another control system for EVP is the allowance of local signalized intersections to make decision on the signal priority of the emergency vehicle. This control mechanism takes centralized control system out of play. However, there are disadvantages to this control mechanism, which are higher implementation cost and loss of coordination efficiency in consecutive signalized intersections (Viriyasitavat&Tonguz, 2012).

CHAPTER 3:

ANALYSIS OF CURRENT CASE IN OIC MEMBER COUNTRIES

ITS are pursuing the continuous growth as a sector and numerous developed countries around the world have premier applications of ITS in their road networks, have strong legislative, political and strategical backgrounds and are heavily invested in the development of such systems. Developed countries such as the US, the UK, Japan, South Korea and Canada has excellent examples of ITS Architectures, institutional frameworks and deployment strategies. On the other hand, looking at OIC Member Countries, there are several countries, which have relatively strong institutional, legislative, strategic backgrounds, prevalent applications, investments in ITS strategies and research and development. In this section, detailed explanation is made through the desk-based research for Türkiye and Iraq. Comparative analyses are made with the US as an example for best practice country. The case of ITS in Malaysia and The Gambia has been evaluated through the field visits.

In this section, the background and current situation of ITS, institutional frameworks and applications of these case countries are explained.

3.1. Türkiye

Türkiye, as a developing country, has made significant progress in urbanization and transportation infrastructure with the advantages of its growing economy and geopolitical position. In this section, development process of Intelligent Transportation Systems (ITS) in Türkiye due to the changes in transportation related policies and transportation infrastructure is explained and planned studies for the future are summarized.

3.1.1 Background

It is believed that the roots of ITS applications date back to 1960s in the world. First applied systems were magnetic sensors and variable message systems. In 1970s and forth, technologies such as speed detection radars, automatic license plate recognition systems have emerged and developments in telecommunication systems have positively affected the development of ITS. In 2000s, violation detection systems have emerged, standardization of communication protocols were made possible. This process followed the development of active and passive safety systems in vehicles (see Figure 10).

ITS in Türkiye dates back to 1980s with the deployment of ITS equipment in intercity highways having started to take place. As there have been several applications earlier, prevalent applications have emerged in 1980s in traffic management and toll collection systems. In 2000s, in parallel with technological developments worldwide, ITS have made significant progress both in technologies used and in prevalence of usage of the system which is shown in Figure 11.

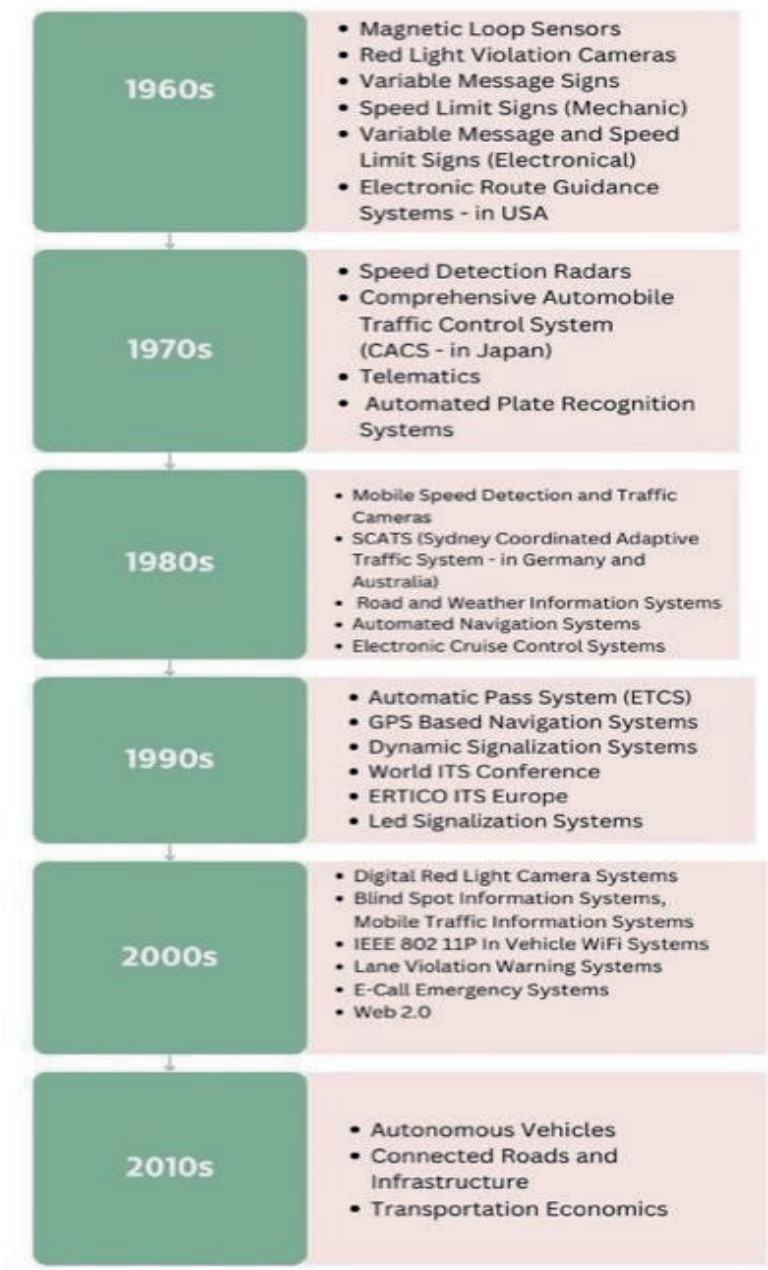

Figure 10. Historical Development of ITS

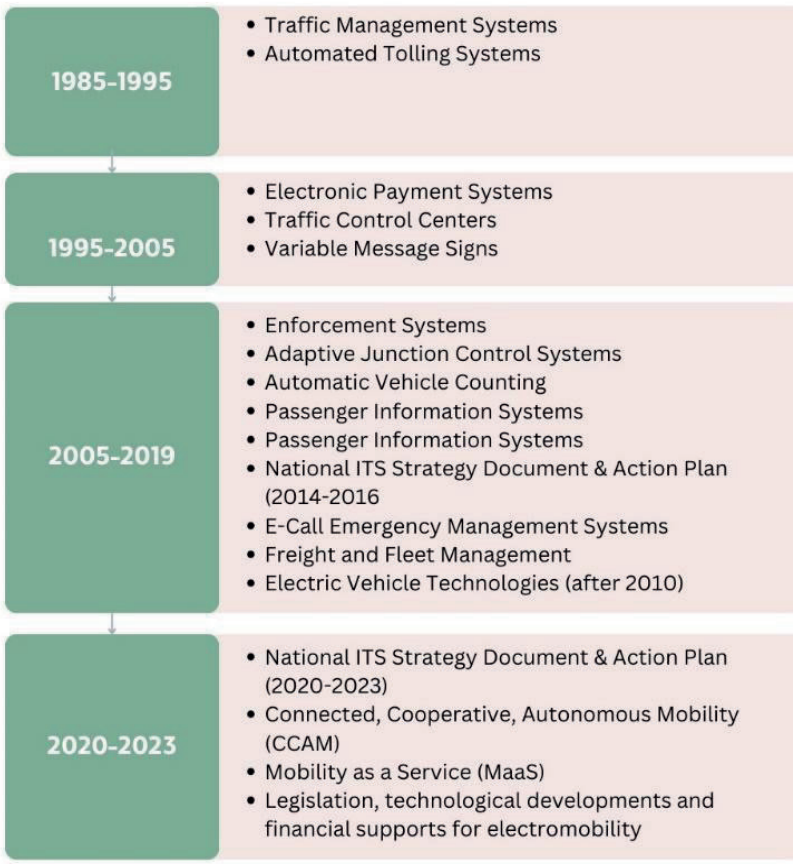

Figure 11. Development of ITS in Türkiye

Türkiye has shown significant growth over the 100-year period. During the same period, transportation infrastructure also showed significant growth and development. For example, especially in the last 20 years, road networks have increased from 18,300 km to 70,000 km, the number of ports and piers has increased to 180, and the number of airports has increased to 62. Mobility in air transportation increased six times, in railway transportation four times, and in road transportation, the number of passenger-km increased two times. In the same period, the number of licensed motor vehicles increased from 8*106 to 28*106.

It is possible to evaluate transportation policy of Türkiye in three separate periods. First period starts from the foundation of Republic of Türkiye, 1923, until the end of the Second World War, 1945-1950, in which period railway transportation investments have been dominant. The second period witnessed the domination of investments in road transportation between 1950 and 2000.

The third period refers to the period after 2000s in which railway transportation investments have been the priority, multimodal transport and cooperation with private sector have gained significant importation.

In order to manage the accelerated growth in development of transportation infrastructures and mobility, in 2022 Türkiye has prepared the Transport and Logistics Master Plan with the target year of 2053 and prepared the investment plans depending on strategies and goals for 30-year period with an environmentally friendly and sustainability-based approach. Within the context of planning studies, it has been foreseen that in the year 2053 population will reach 113*106 and annual nominal economic growth will be around 3.5-4.0%. Based on specified developments, investment programs aiming to balance the modal share in transportation and their expected outcomes are given in Figure 12 and Figure 13.

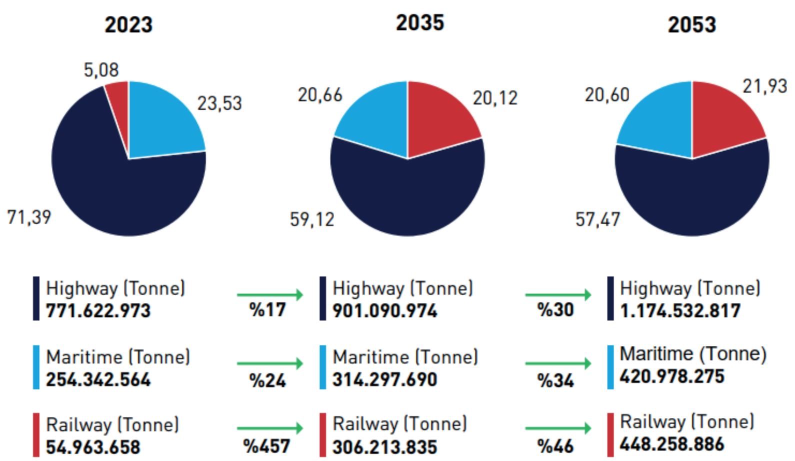

Figure 12. Expected Modal Share in Freight Transport

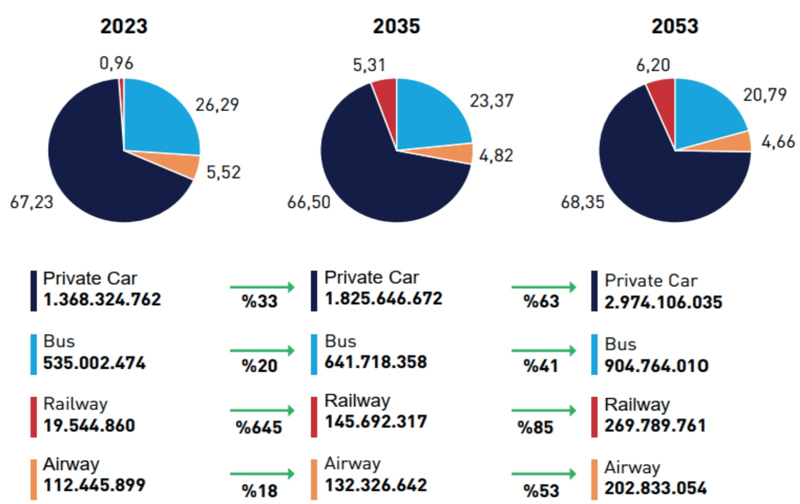

Figure 13. Expected Modal Share in Passenger Transport

In passenger transportation, it is expected that the modal share of road transportation will be kept below 70%. It will be reduced below 60% in freight transportation. Emerging technologies to gain prevalence in transportation systems have a significant importance for these goals to be reached. To ensure the usage of transportation infrastructure efficiently, ITS strategy planning will be made in accordance with safety, environmental impacts and integration principles.

3.1.2 ITS Applications in Türkiye

Following the immense acceleration in growth of communication technologies in 21st century, increasing ITS applications and equipment deployments in transportation infrastructures has been achieved throughout Türkiye. With the preparation of 2014-2016 and 2020-2023 Intelligent Transportation Systems Strategic Action Plans, Türkiye has determined its national goals for reaching quality standards and ensuring the prevalence of ITS applications. In this section, ITS applications in Turkey have been evaluated in eight subsections.

Advanced Traffic Management Systems (ATMS)

City Security Management System (Kent Güvenlik Yönetim Sistemi -KGYS) is a monitoring system that was established by Turkish Police Organization, General Directorate of Security. (General Directorate of Security).

System encapsulates vehicle tracking system, mobile vehicle inquiry system and automatic number plate recognition system. Electronic Detection Systems (EDS) is a system that is applied to urban roads as a continuation of the Traffic Electronic Control System (TEDES) and contributes significantly to ensuring traffic safety in urban areas. EDS detects traffic violations through image processing and sensors, such as average speed, red light, emergency lane parking, pedestrian crossing, scan offset, yellow box, wrong road, tramline, wrong turn, instantaneous speed and indicator violations. All enforcement systems within the scope of EDS work on the same application via cloud technology. Traffic violations are recorded and reported with EDS (ISBAK, Electronic Detection Systems). Figure 14 and Figure 15 show the EDS parking violation detection and the widespread use of EDS throughout Türkiye, respectively.

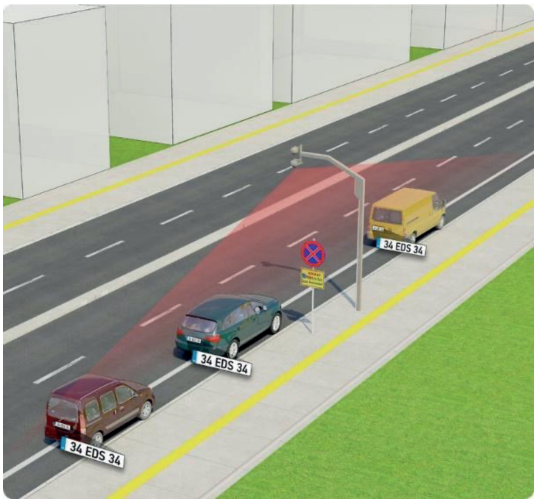

Figure 14. Parking Violation Detection via EDS (Source: İSBAK)

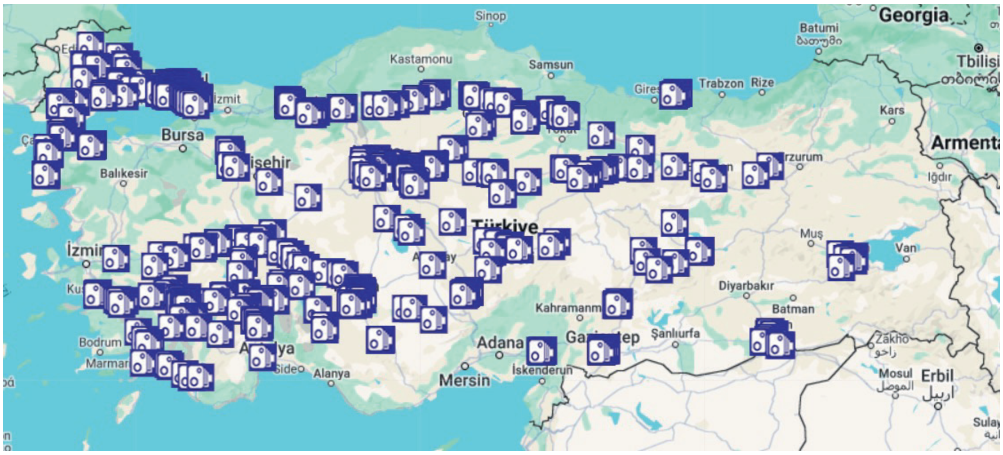

Figure 15. Points of deployed EDS in Turkey
(Source: General Directorate of Security of Türkiye

In highways, which are in the road network of General Directorate of Highways (GDH), speed violations are detected by radar and laser-based violation systems. Also, laser-based speed measurement devices, magnetic loops and air pressure tubes are used for vehicle counting and spot speed studies in highways. In highways, by utilizing electronic toll collection systems as checkpoints, average speed detection is conducted as well.

Variable Message signs, throughout highways in Türkiye, are used in order to warn drivers about speed violations, lane adjustments, weather conditions, aiming to increase traffic safety. With image processing and radars integrated into these systems, license plates are identified, and drivers are warned about speed violations.

In Türkiye, monitoring and controlling of traffic signals are commonly conducted by municipalities. On the intersections which are in road network of GDH, traffic signals are managed by signalization management centres of Highway Regional Directorates. By these management centres, remote access to traffic signals is ensured in order to modify the signal programs.

Electronic Toll Collection Systems (ETCS)

In Türkiye, the highways within the scope of the GDH highway network, the Istanbul and Çanakkale Bridges and the Osmangazi Bridge between Izmit and Yalova provinces are subject to electronic toll collection. Electronic fare collection is used by HGS (Fast Pass System), which works with the Radio Frequency Identification (RFID) system.

In Türkiye, vehicle classification systems categorize vehicles in 6 classes. 1st class is vehicles with 2 axles which axles are seperated less than 3.2 m away, 2nd class is vehicles with 2 axles which axles are seperated more than 3.2 m away, 3rd class is vehicles with 3 axles, 4th class is vehicles with 4 and 5 axles, 5th class is vehicles with 6 and more axles and 6th class is motorcycles. (North Aegean Motorway. (n.d.). Vehicle Classifications. Retrieved September 6, 2024, from https://www.kuzeyegeotoyolu.com/arac-siniflari) In Figure 16, electronic toll collection gate of Osmangazi Bridge is depicted.

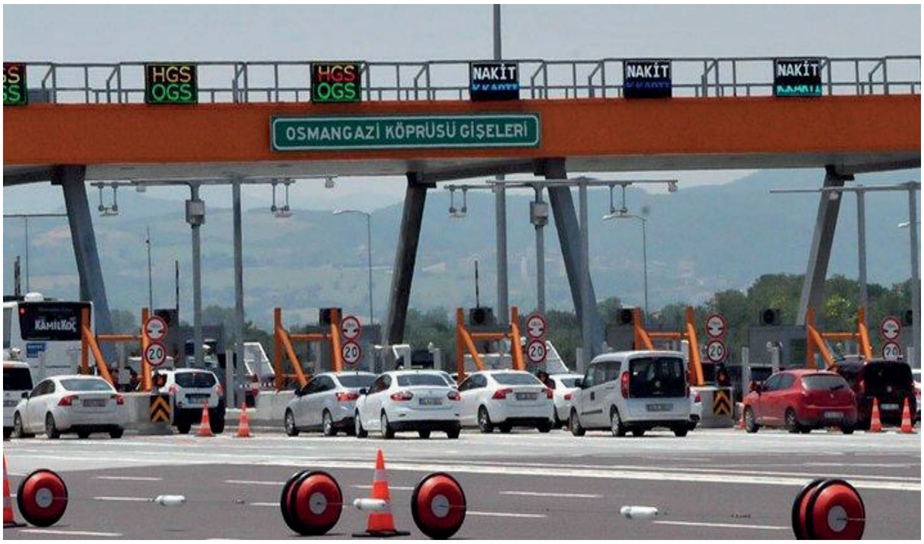

Figure 16. ETCS gate in Osmangazi Bridge

Advanced Traveler Information Systems (ATIS)

Various traveler information systems in Türkiye have been established by the Ministry of Transport and Infrastructure, GDH and municipalities. Authorities provide traveler information via Variable Message Signs (VMS), web sites and mobile applications. GDH provides information of road conditions, closed roads, route analysis services and traffic conditions via its website and mobile application. Traveler information is also provided by 159 Call Line of GDH. One other traveler information system application is announcement broadcasting via FM Radio transmitters. This system provides real time information of traffic accidents, road works, traffic conditions and road conditions to the travelers. In Figure 17, route analysis application of GDH is shown.

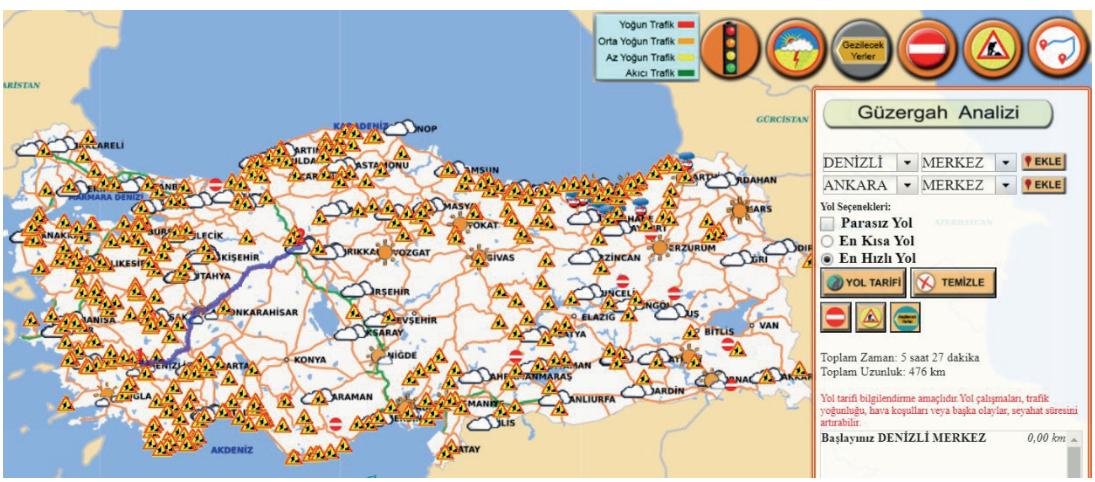

Figure 17. Route Analysis Application GDH (Source : GDH)

Advanced Public Transportation System (APTS)

Metropolitan Municipalities in Türkiye provide passenger support to public transportation users through mobile applications. Several metropolitan systems provide standalone mobile applications and passenger services such as Google Maps and Moovit. Through these mobile applications, tariff service analysis, delays, arrival times, intermodal route planning service, locations of public transportation vehicles, and bus stops information are provided to public transportation companies. IETT, Public Transport Operation Agency of Istanbul Metropolitan Municipality, provides information about locations of Istanbul Kart (smart card of IETT) deposit locations, ISPARK (parking lot agency of Istanbul Metropolitan Municipality) parking lot locations in addition to features listed above through its mobile application. In Figure 18, route planning service of IETT is shown.

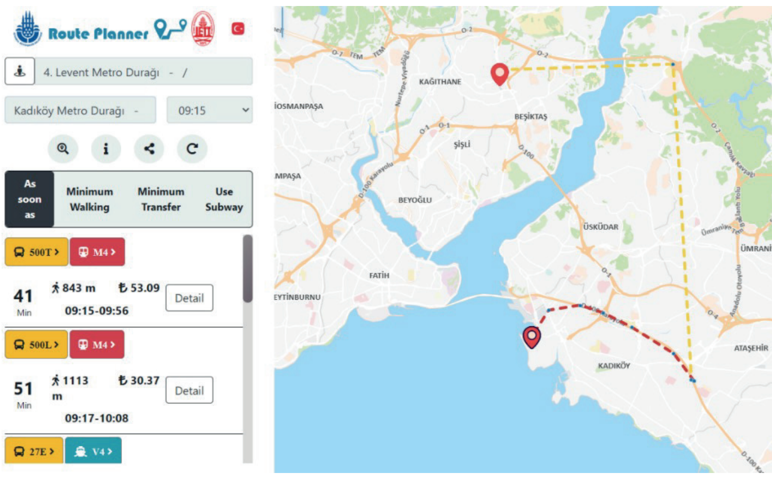

Figure 18. Route Planner of IETT (Source: IETT)

IETT provides 55 thousand trips per day with 6495 transit vehicles (IETT). Bus Fleet of IETT is managed and monitored 24/7 by Bus Fleet Management Centre in İkitelli İstanbul. From this centre, real time management of the bus fleet, operational changes, real time data production to information channels is assured. IETT İkitelli Fleet Management Centre is depicted in Figure 19.

Figure 19. Fleet Management Centre of IETT

Emergency Management System (EMS)

Türkiye, in cooperation with the Minister of Interior and the Dutch Government, has carried out studies to unify the emergency call number as "112" since 2003, within the scope of MATRA Projects. As of 2020, the emergency call number in 81 provinces of Turkey has been unified to 112.

On the other hand, Türkiye also participated in the second phase of the HeERO Project, which aims to develop an integrated and mathematical in-vehicle emergency call system. Emergency calls from these systems are to be made by vehicle occupants manually or automatically by sensors in case of accidents. The system provides data of location and magnitude of damage that were received by the vehicle. The project aims to speed up the emergency response time (Minister of Interior). The scheme of operation of HeERO e-call systems is shown in Figure 20.

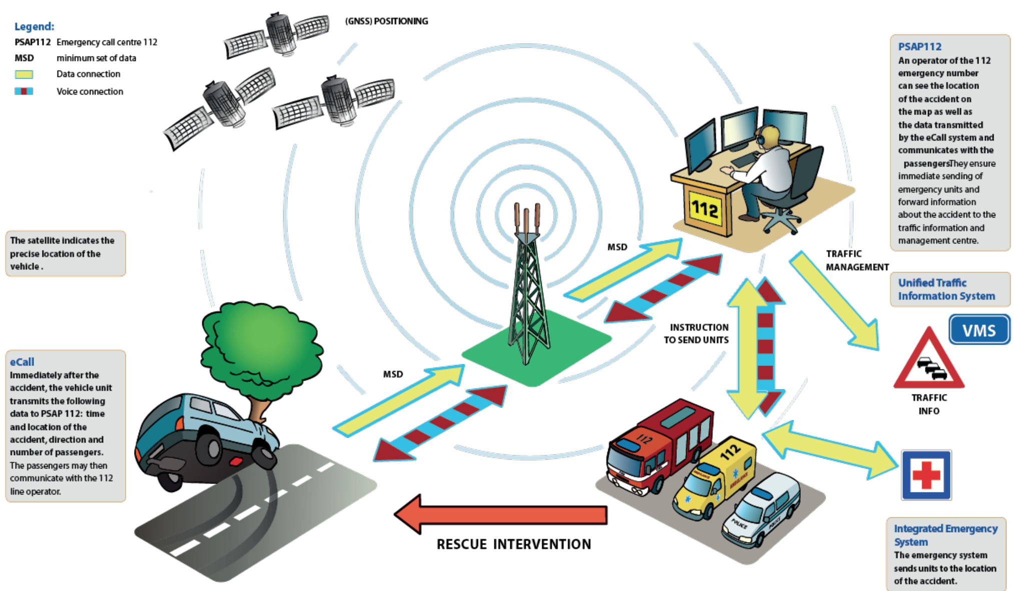

Figure 20. E-call System Operation Scheme (Source: HeERO Pilot)

Tunnel Traffic Management Systems (TTMS) and Bridge Traffic Management Systems (BTMS)

In tunnels, traffic management systems are working in integration with many other systems such as lighting, power supply, gabarite detection, public announcement, fire detection, ventilation, energy systems, EDS, signalization and incident detection. Traffic data, speed, travel time, traffic density, queue length and progress are measured at ISBAK's (Istanbul Bilişim ve Smart Şehir Teknolojileri A.Ş.) Tunnel Management Centres. Alarm situations arise in detection of stationary crossings, traffic congestion, passengers in the tunnel, queue times exceeding maximum levels, journeys arriving under speed limits and standing, crossings going in the wrong direction, debris on the road due to incidents (Turkish Road Association).

Tidal flow is implemented on the Istanbul Strait Bridges in order to manage oncoming traffic flow more efficiently during peak hours. Since most of the business centres in Istanbul are located on the European Side, the peak travel hours for home-to-business in Asia-Europe direction are much higher in the morning. Since there are more trips from work to home during evening rush hours, the direction of the dominant flow changes towards Europe-Asia. In order to ensure the quality of traffic management during the morning rush hours, traffic safety cones were aligned on the Asia-Europe direction of the bridges and additional lanes were added. The same practice is also applied to the Europe-Asia direction during evening peak hours (The Economic and Social Commission for Asia and the Pacific).

Commercial Vehicle Operation (CVO)

In Türkiye, GSM operators are actively involved in fleet management systems with Machine to Machine (M2M) applications that they integrate into their special SIM cards. M2M technology provides monitoring and management of fleets as well as communication between fleet vehicles. Fleet management systems provide the vehicle location data and special data taken from sensors integrated into vehicles and transmits these data to fleet management centres.

İSBAK provides fleet management data with the İSMOBİL mobile application. This system, which provides vehicle grouping and real-time vehicle tracking, has sensors that detect emergency situations such as unauthorized intervention and power outage. Vehicle location, speed and other data are transmitted to the centre via the VTA900 vehicle-tracking device (ISBAK). User interface of ISBAK Fleet Management Software is depicted in Figure 21.

Figure 21. User Interface of ISBAK Fleet Management Software (Source: ISBAK)

Weather Information Systems (WIS)

Weather Information Systems undertakes the task of evaluating data such as location, road condition, rain, snow, icing and humidity together with road surface temperature sensors and transmitting it to road users through event detection sensors and cameras. These systems are mainly used at common points where accidents occur, at tunnel entrances and exits, and at points where extreme weather conditions are expected throughout the year (The Economic and Social Commission for Asia and the Pacific, n.d.).

Other Major ITS Projects in Türkiye

In Türkiye, ITS applications on highways are becoming widespread in four systems: Traffic Management Systems, Traveler Information Systems, Electronic Toll Collection Systems and Tunnel Control Systems. In this section, examples of recent applications of such systems on highways and in various provinces of Türkiye are explained.

Northern Marmara Highway is a 462 km long, 8-lane (4+4) high-standard highway, connecting the Asian and European continents. The highway passes through the 15 July Martyrs Bridge via the Yavuz Sultan Selim Bridge. Northern Marmara Motorway is equipped with various systems such as Variable Message Signs (VMS), Variable Traffic Signs (VTS), CCTV cameras, Meteorological Stations, Traffic Count Sensors, Fog Warning System and Optical Gauge System. There are 94 VMS signs, 2026 CCTV cameras, 171 VTS signs and 3589 ITS equipment along with other systems across the highway (Northern Marmara Highway Sustainability Report, 2022).

Ankara-Niğde Highway, which opened to traffic in 2020, is a 330 km long, 8-lane (4+4) wide highway. The highway is equipped with a 1300 km long Fiber optic communication network, incident detection cameras, toll booth cameras, video wall monitoring screens, variable message signs, traffic measurement sensors, meteorology stations, fog warning systems, field management units and mobile radio systems. . There are a total of 2640 ITS equipment along the highway. There are also many ATS buildings and facilities along the highway, such as Main Control Centre (MCC), Traffic Control Centre (TCC), Unit Control Centre (UCC) and Toll Stations (Ankara Niğde Highway Intelligent Transportation Systems).

Traffic Management Centres were first established on the highways of GDH’s highway network in the provinces of Ankara, Istanbul, Izmir and Mersin. In these centres, general management of road traffic is carried out, including road and weather conditions, information systems, vehicle sensors and CCTV cameras. However, the establishment of these centres is more common in other provinces of Türkiye such as Kahramanmaraş, Gaziantep and Kocaeli.

In Kahramanmaraş, traffic monitoring is ensured via 300 cameras in 96 points. Also, various monitoring cameras are in communication with Kahramanmaraş Traffic Management Centre and are used in traffic management studies. In case of emergence or need of intervention VMS systems are used to inform road users. Signalization Systems are also remotely controlled from this centre (Ministry of Transportation and Infrastructure). In Figure 22, Traffic Management Centre of Kahramanmaraş is shown.

Figure 22. Kahramanmaraş Traffic Management Centre
(Source: Ministry of Transportation and Infrastructure)

Traffic Management Centre of Gaziantep was established in 2015. From this centre management of public transport modes and signalization systems are conducted. In total, 350 signalized intersections are remotely controlled (Ministry of Transportation and Infrastructure). Gaziantep Traffic Management Centre is depicted in Figure 23.

Figure 23. Gaziantep Traffic Management Centre
(Source: Ministry of Transportation and Infrastructure)

Kocaeli Traffic Management Centre were established in 2020. The centre works in integration with other units of authorities of municipality in order to provide traffic safety. Centre operation monitors the flow of transit vehicles. 235 provincial adaptive signalized intersections are managed from this Centre (Ministry of Transportation and Infrastructure). VMS systems are also remotely controlled from the Kocaeli Traffic Management Centre. Kocaeli Traffic Management Centre is shown in Figure 24.

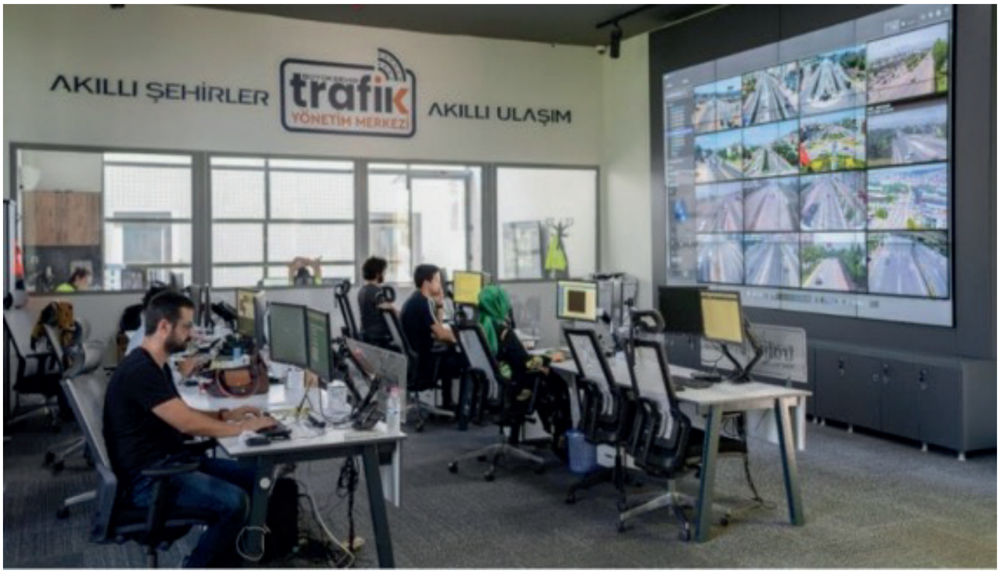

Figure 24. Kocaeli Traffic Management Centre
(Source: Ministry of Transportation and Infrastructure)

All 301 buses and trams in the public transportation system in Kocaeli are equipped with in-car, visual and audio passenger information systems. 2050 transit buses are equipped with an audio passenger information system. Traveler information is also available through Kocaeli Municipality's mobile application. The application provides information such as bus arrival, smart card deposit points, route planning services, real-time transit vehicle location, travel time and online smart card deposit services.

In Gaziantep, visual traveler information systems are equipped in various public transport stations. In transit vehicles audible and visual traveler information systems are provided. Mobile application of the Metropolitan Municipality provides, route planning services, real time transit vehicle location, smart card deposit points information and bus arrival time information. In 2018 Variable Message Sign systems have started to be deployed in Gaziantep (Ministry of Transport and Infrastructure).

3.1 Iraq

3.2.1 Background

Iraq is the sixth largest oil exporting country in the world and third largest oil exporting country in the Middle East after Saudi Arabia and United Arab Emirates. Iraq's crude oil export value exceeded $99 Billion in 2023 (World's Top Exports).

Despite the worldwide influence of Iraq's oil export on transportation investments and operations, the investment and regulation efforts related to transportation policies and infrastructure development have been very scarce nationwide. The National Development Plan 2018-2022 estimated that the damage to transportation infrastructure has been reached to $2.8 Billion. Damage to roadways is estimated as $523,1 Million and damages to bridges are estimated at $1,2 Billion. Around 2,300 km of roadways, (of which 57 km of primary roads), 118 km of secondary roads, and 207 km of tertiary roads are estimated as damaged as a consequence of war on terrorism (KAPITA, 2022).

The Ministry of Transportation in Iraq administers the aviation, land, and maritime sectors. In Figure 25, organizational structure of transportation in Iraq and the relationship between transport authorities is shown. (KAPITA, 2022).

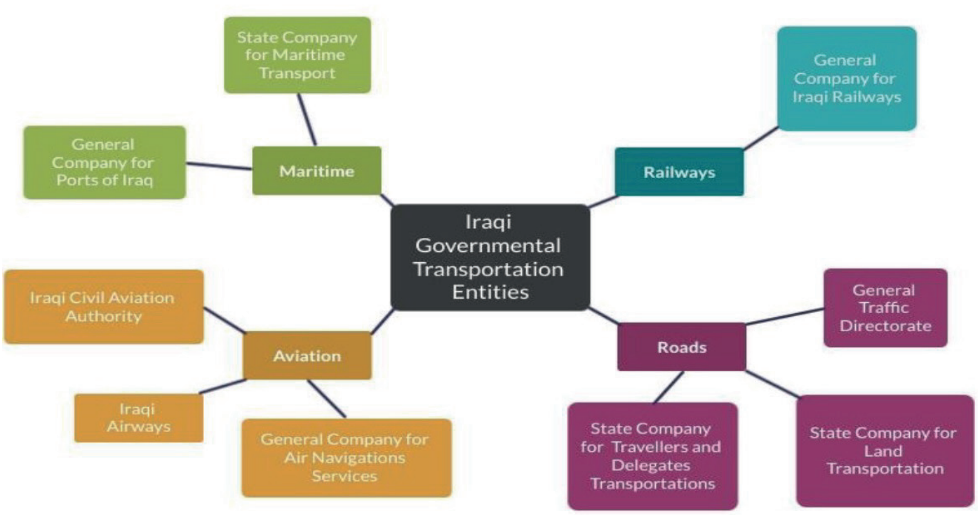

Figure 25. Organizational structure of transportation in Iraq and the relationship between transport authorities (Source KAPİTA 2022)

One of the modes of transportation in Iraq is rail lines. It has historical rootes which goes back to 1902, where the Ottoman empire agreed with the Germans to build the Iraqi railways for traveling between Baghdad and Al-Dujail in Salah Al-Din governorate. In 1920, the railways have been extended to Babil, Nineveh, Sharqat, Salah Al-Din by the British administrated Mesopotamian

Railways. In 1936 Mesopotamian Railways have been sold to Iraq and later named to Iraqi Republic Railways (IRR) in 1953. Furthermore, international connections have been established to Syria and Türkiye both connected with the Nineveh railway lines, with the first train reaching Haydarpaşa in Turkiye in 1940 (KAPITA, 2022). By 2020, total length of Iraqi Railways have been 2,893 kms and annual ridership was recorded as 77 thousand passengers. According to the latest investment map of 2018 to 2022, and the following 2020/2021 investment map, the General Company for Iraqi Railways announced 10 projects ready for investment including Baghdad Metro, which consists of two lines with a total length of 46 kms, it has 47 stations, two locomotive garages on both lines, and three power transferring stations. The other metro project is planned for Basra, contains 5 main lines with 35 main and branch lines (KAPITA, 2022).

The other important transport mode is road transportation in Iraq. It is managed by the Ministry of Transport through the State Company for Land Transport and the State Company for Travelers and Delegates Transportation. The State Company for Land Transport is responsible for managing the movement of goods and cargo entering and exiting the country via trucks, particularly through the northern border with Türkiye. The State Company lends its services to Ministries of Health, Trade, Electricity, Agriculture, and Industry. The State Company for Travelers and Delegates Transportation is responsible for the transportation of officials and visitors in and outside Iraq. They have a fleet of buses, taxis and minibuses for various uses, like the airport taxi and minibus responsible for the transportation of travelers to and from the Baghdad international airport.

Total length of roadways in Iraq has reached to 58,592 kms in 2018 (Logistics Cluster, 2021). Iraq has two main highways, Iraq Expressway 1 and Iraq Expressway 2. Iraq Expressway 1 connects Iraq-Jordan border to Basra and reaches 1200 kms in length. Iraq Expressway 2 lies between Iraq-Türkiye border and Baghdad. It links to Expressway 4 in Erbil. Roadways in Iraq is well structured, so they cover most of the cities and rural areas (KAPITA, 2022). In Figure 26, roadways of Iraq is shown.

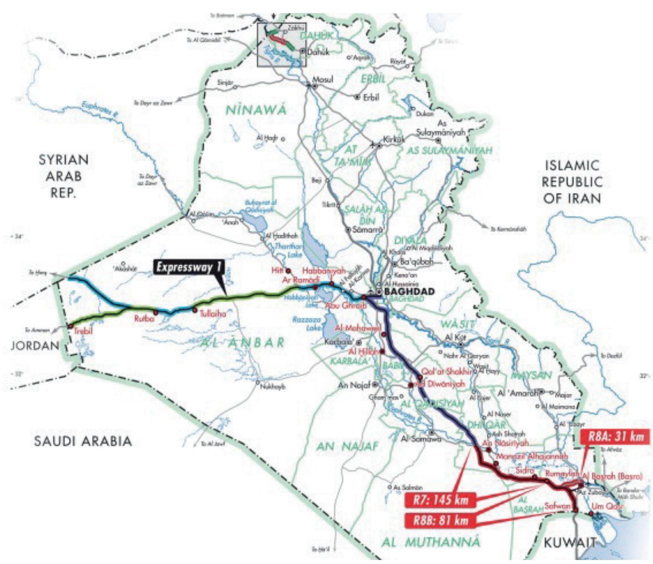

Figure 26. Roadways of Iraq (Source: COSIT, Iraqi Ministry of Planning)

Trading routes have a significant role in dictating the establishment of transportation infrastructures in Iraq. Crop transportation in Iraq is a very important component of economic activities. Therefore, several routes have been established for crop transportation in Babil, Salah Al-Din, Anbar, Nineveh and Diyala (KAPITA, 2022). In Figure 27, roadway lengths in Iraqi cities are depicted.

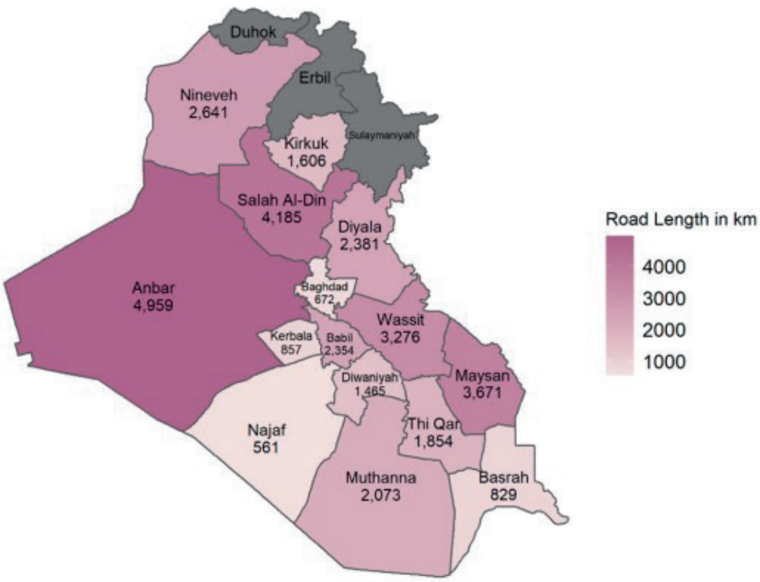

Figure 27. Roadway Lengths in Iraqi Cities in 2020
(Source: COSIT, Iraqi Ministry of Planning)

It's observed that many cars have entered the country without proper paperwork and documentation. Therefore, the number of private vehicles has increased in the major cities of Iraq. The number of registered private vehicles were 1,5 million in 2003, this number has reached 5,5 million in 2015 and 7 million in 2020 (KAPITA, 2022). Change in number of private vehicles is depicted in Figure 28.

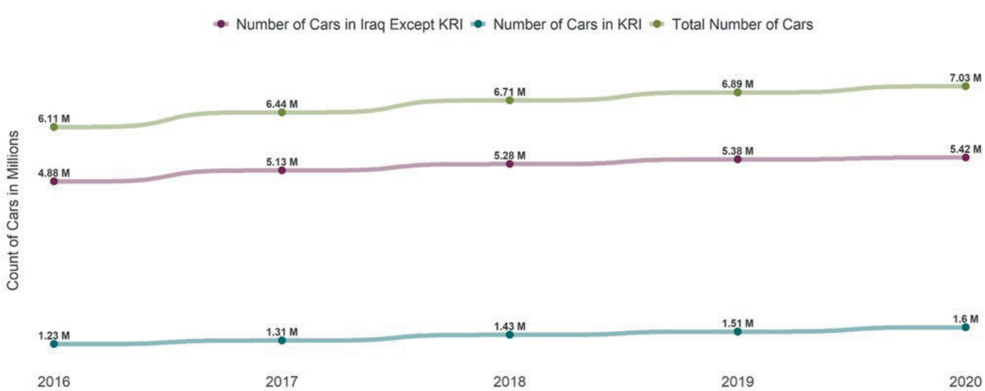

Figure 28. Number of Private Vehicles in Iraq Throughout the Years
(Source: COSIT, Iraqi Ministry of Planning)

As a result of the increase in the number of vehicles, arterial roads in the major cities in Iraq and intercity roads suffer from severe traffic congestion and traffic safety vulnerabilities (Al Jameel & Abdabas, 2017; Jumaah et al., 2019). Non-upgraded google maps data and lack of investments in cargo transportation are the other issues related with road transportation in Iraq.

There are also initiatives on improving the road transportation in Iraq. There have been several bridge construction projects in the recent years such as Al-Khalse Bridge, Al-Yabany Bridge and Al-Jihad Bridge. Addition to the bus fleet in Karbala, reactivation of Baghdad-Mosul mailing system are examples to those initiatives. Additionally, there are planned projects which are expected to be established in near future. These are:

- Establishment of tramway lines in Erbil, Sulaimaniyah and Duhok
- Rehabilitation of Baghdad-Basra Highwayy,
- Rehabilitation of Baghdad-Mosul-Rabeea-Feshkhaboor highway.
- Rehabilitation of Baghdad-Baquba-Iranian border highway.
- Construction of a highway between Baghdad and Kirkuk
- Rehabilitation of Bismaya-Baghdad-Muhamed Al Qasim highway and implementing several bridges throughout the highway (KAPITA, 2022).

Although rehabilitation of transport infrastructure is one of Iraq's top priorities, the transportation sector has comperatively small share of the National Development Plan (NDP) for the years 2013 to 2017. Only 9.5% of investment has been allocated to the communication and transportation sector. Other main problems of the road transportation in Iraq are the lack of regulations for transportation sector, weak traffic safety and congestion in major cities. Only a third of all damaged roads are under the responsibility of the Ministry of Transport (MoT), the rest fall under the responsibility of the local city administration. Nearly 4 billion USD is estimated to be needed for recovery of damaged transportation modes. (KAPITA, 2022).

3.2.2 ITS Applications in Iraq

Road transportation in Iraq is managed by the State Company for Travellers and Delegates Transportation and the State Company for Land Transport. The State Company for Travellers and Delegates Transportation oversees the transportation needs of officials and visitors. The State Company for Land Transport, being established in 1970, is responsible for movement of goods and cargos.

In addition to the increase in private vehicle numbers over the last 20 years, dependence of private vehicle transportation in Iraq is another important issue. In Baghdad's public transportation systems, only 667 buses operate. Annual public transportation ridership in Baghdad is estimated as 19 million. Countrywide, the amount of bus fleet has been 1,934 buses in 2018 but only certain amount of the buses has been able to operate. In addition, the amount of total and working trucks of the General Company for Land Transport have been decreasing (KAPITA, 2022). Total working amount in bus and truck fleet is shown in Figure 29.

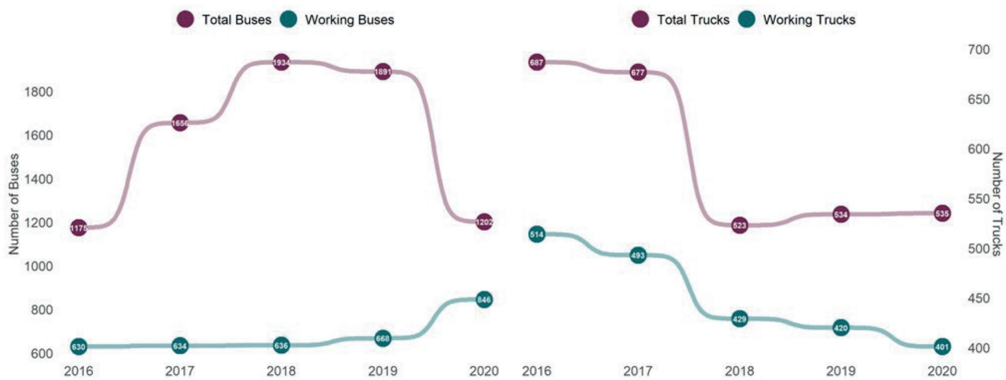

Figure 29. Total and Working Amount in Bus and Truck Fleet of Iraq (Source: COSIT, Iraqi Ministry of Planning)

The stated irregularity of public transportation in Iraq created the need for other means of public transportation. As a result, public transportation operators such as paratransits, songthaews and rickshaws have been emerged. Paratransits are minibuses, which carry up to 14 passengers on spesific routes. Songthaews, which operate in small distances are the pick-up trucks which are transformed with addition of benches, and they are carrying 8 to 10 passengers. Rickshaws (Figure 30) are small, three-wheeled vehicles which carry one or two passengers. While rides on paratransits and songthaews cost 500 to 1000 Iraqi Dinar per ride, rickshaw ride fees depend on the distance of the destination (KAPITA, 2022).

Figure 30. Public Transportation by Rickshaw in Iraq (Source: Anadolu Agency)

Dependence on private vehicle transportation and lack of investments in public transportation cause traffic congestion in Iraq's major cities. The traffic congestion has negatively effects on the environment as CO2 emissions in Iraq are rising continuously, reaching 4.9 metric tons in 2019, alongside increased levels of air pollution, reaching 62 µg/m3 on the PM2.5 scale, indicating un-safe air quality (KAPITA, 2022). In addition to the stated public transportation operations, there are several ride hailing businesses in Iraq. Companies such as Careem, Baly, Obr, Taxi Al-Mumayaz, City Taxi, Lady Go, Taxi Baghdad and Bolt are operating in Baghdad. In Figure 31, traffic condition and congestions in Baghdad in 2:00 PM in a working day is depicted.

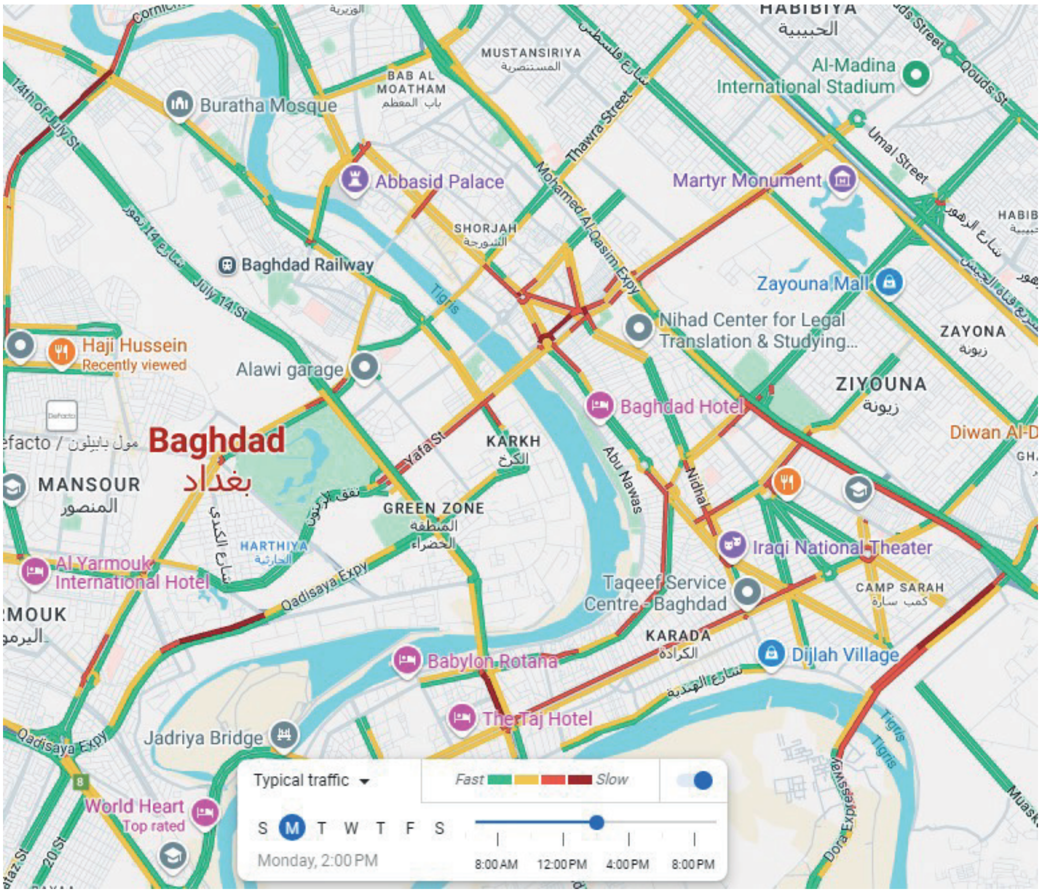

Figure 31. Traffic Condition in Main Arterial Roads of Baghdad in 2.00 PM
(Source: Google Maps)

Although, instruments like Google maps could be used to avoid traffic congestion and plan route optimization, some maps have not been updated since 2008, and majority of public and private places have not been added to Google maps services in Iraq due to security reasons (KAPITA, 2022)

In terms of ITS, there has been several applications in major cities of Iraq. In 2022, the Traffic Signals in Baghdad have been reactivated following 19-year suspension with the initiative of the government. With this initiative, also traffic enforcement officers and army personnel have been appointed to intersections where traffic signals do not work. Activated traffic signals in the city of Baghdad is shown in Figure 32.

Figure 32. Traffic Signal in Baghdad (Source: Anadolu Agency)

In 2023, CCTV cameras and speed radars were deployed in Baghdad. With installed traffic monitoring system speed, seatbelt and red-light violations have been aimed to detect (Iraqi News). Installation of monitoring equipment is depicted in Figure 33.

Figure 33. Installation of Monitoring Equipment in Baghdad (Source: Iraqi News)

On 12 March 2024, General Traffic Directorate (GTD) started to enforce fine applications through surveillance systems (Shafaq News).

On the other hand, despite the lack of initiatives in Iraq, the academic literature presents several applications of ITS to improve the efficiency and sustainability of transportation systems in Iraq

(Abdulwahab et al., 2018; Al-Bistenchy & Szpytko, 2018; Al-Shebillawy et al., 2021; Al Jameel & Abdabas, 2017; Alrawi, 2017; Jumaah et al., 2019; Mahdi & Ibrahim, 2023; Zbar, 2023).

Several scholars have presented ideas in their academic studies, which bring ITS solutions to transportation problems in Iraq. Abdulwahab et al. (2018) presented an institutional framework recommendation for the development of ITS in Iraq in their study. The key elements for institutional framework have been selected as Transport System Levels, Transport System Management, Dimensions of Governance in the Transport Sector, Levels of Governance and Decision Making in the Transport Sector, Scopes of Decision Making in the Transport Sector , Policy Makers, Elements of Decision-Making Process, System Financing and System Management. Recommended institutional framework is depicted in Figure 34.

Figure 34. Institutional Framework Recommendation for Iraq (Abdulwahab et. al. 2018)

Al-Bistenchy and Szpytko (2018) have stated the road safety and pollution hazards in Iraq and emphasized the importance of Traffic Information Systems and their potential benefits for Iraq.

Al-Shebillawy et al. (2021) diagnosed the transportation related problems in Najaf as it proposed a series of ITS applications to increase the sustainability of transportation in the city with traffic congestion, insufficient parking, long emergency response time, high levels of pollution and traffic accidents and proposed a set of ITS applications to increase the sustainability of transportation in the city. Implementation of surveillance cameras, remote sensing devices, electronic counters, weigh in motion equipment and radars are suggested for data collection. In addition to that, structuring a telecommunication network, traveler information systems (Al Jameel & Abdabas, 2017) and new public transportation routes for the city of Najaf which provides solutions for the requirements of the citizens are recommended. Public transportation routes, major trip generator and distributor locations are also represented by GIS in the study.

Alrawi (2017) developed a model, which represents the traffic volume by speed, traffic density and free flow speed using the data collected in Jadriya Intersection in Baghdad. Emission rates of particulate matters have been derived with this model and positive impacts in reducing the emissions by implementation of ITS in this intersection in future projections have been shown in the study. Jumaah et al. (2019) represented the emission levels of pollutant particulate matters via several models and shown the estimated reduced emission levels in an intersection in Baghdad with the potential implementation of ITS. Zbar (2023) shown the improvement in level of service with the implementation of ITS in four intersections in Baghdad in their study.

3.2 Malaysia

3.3.1 Background

Malaysia is a middle-income country and have a continuing development path in all aspects of industry. Malaysia is one of the OIC Member Countries, which can be presented as a good example for the study since ITS applications have reached significant level in certain regions of the country.

Especially in highways around Klang Valley, there are various ITS applications such as Electronic Toll Collection Systems, Variable Message Signs and monitoring devices. Malaysia developed its National ITS System Architecture in 2007 and have a promising future. There are several documents and strategic plans that have been released over the years, which are ITS Strategic Plan in 1999, ITS Master Plan in 2004, ITS System Architecture in 2007 and 2019-2023 Malaysian ITS Blueprint in 2019.

The need for development of the ITS system architecture in Malaysia has been stated with certain motives in ITS Master Plan of Malaysia in 2004 for the first time. In the master plan, it has been stated that the aim of the ITS architecture is to promote the interoperability, identify the standards and promote the compatibility of systems. With this motive, ITS System Architecture has been established in 2007. With the establishment of ITS Architecture of Malaysia, it had been aimed to provide a framework of deployment strategies of the interconnected subsystems, achieve compatibility among ITS elements in the process of deployment and development of the whole transportation system and ensure unified standards.

Currently, there are 11 published ITS standards in the name of Malaysian Standards (MS), where ITS standards are mostly adopted from ISO/TC 204. The definitive scheme of ITS System Architecture of Malaysia is shown in Figure 35.

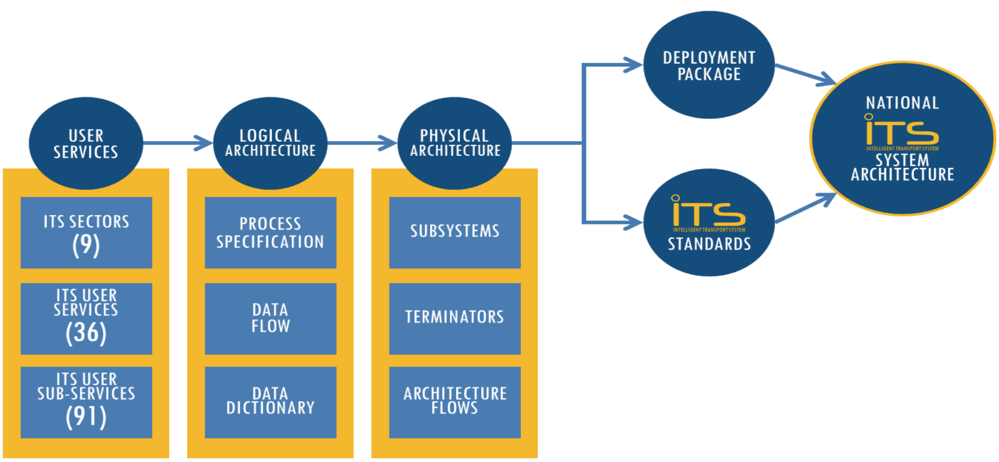

Figure 35. ITS System Architecture of Malaysia (Malaysian ITS Blueprint (2019-2023)

Malaysia ITS Architecture consists of two sub-architectural layers: Logical Architecture and Physical Architecture. Logical architecture represents the complete set of process specifications, data flow diagrams, and data dictionary entries and is the embodiment of functional layer of the user services. Logical architecture defines the boundaries of the system. Logical architecture does not contain the physical processes and physical entities. Data flow diagrams are the graphical illustration of the processes which are seen in user interfaces. Process Specifications are defined as the transformation of the data that that is imported to the logical architecture or exported from the logical architecture. Data dictionary entries provide the textual description of the data flow and lower-level data elements which serve to the data flow (Development of ITS System Architecture for Malaysia, 2007). Descriptive scheme of the logical architecture is depicted in Figure 36.

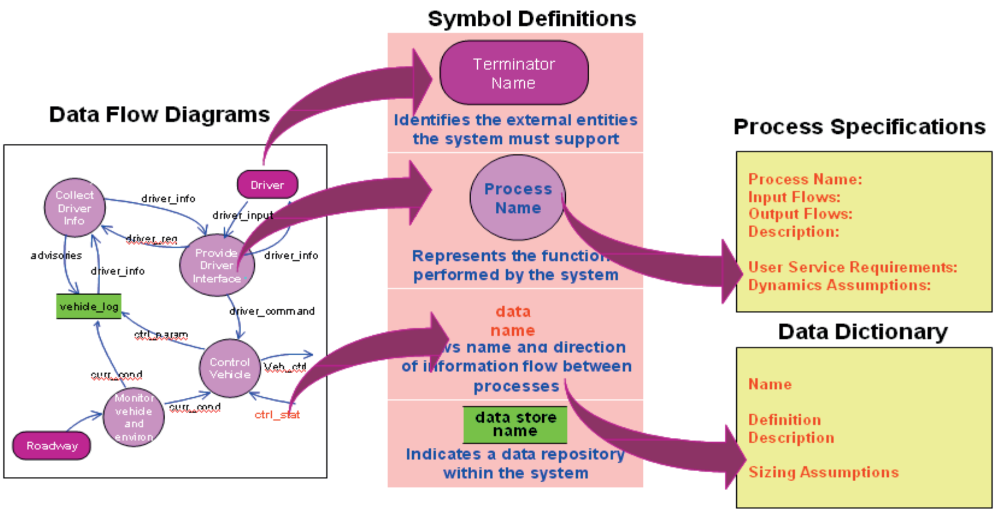

Figure 36. Logical Architecture (Development of ITS System Architecture for Malaysia, 2007)

Physical Architecture represents the physical entities and subsystems, which the processes defined in Logical Architecture. The communication channels are included to Physical Architecture. (Malaysian ITS Blueprint (2019-2023), 2019). The Physical Architecture comprises of four components, which are subsystems, terminators, physical architecture flows and physical architecture interconnection. Terminators define the boundaries of the physical architecture, which consists of people, systems and environment. The data flows that are transferred from the logical architecture are grouped in physical architecture. These grouped data flows are assigned to the subsystems in the physical architecture. The architecture flows between subsystems and terminators are defined as physical architecture interconnection. The collection of these interconnections is the communications layer of the architecture (Development of ITS System Architecture for Malaysia, 2007). The scheme of Physical Architecture is depicted in Figure 37. The subsystems of the physical architecture are centres, roadsides, vehicles and the travelers. The subsystem in detail is shown in Figure 38.

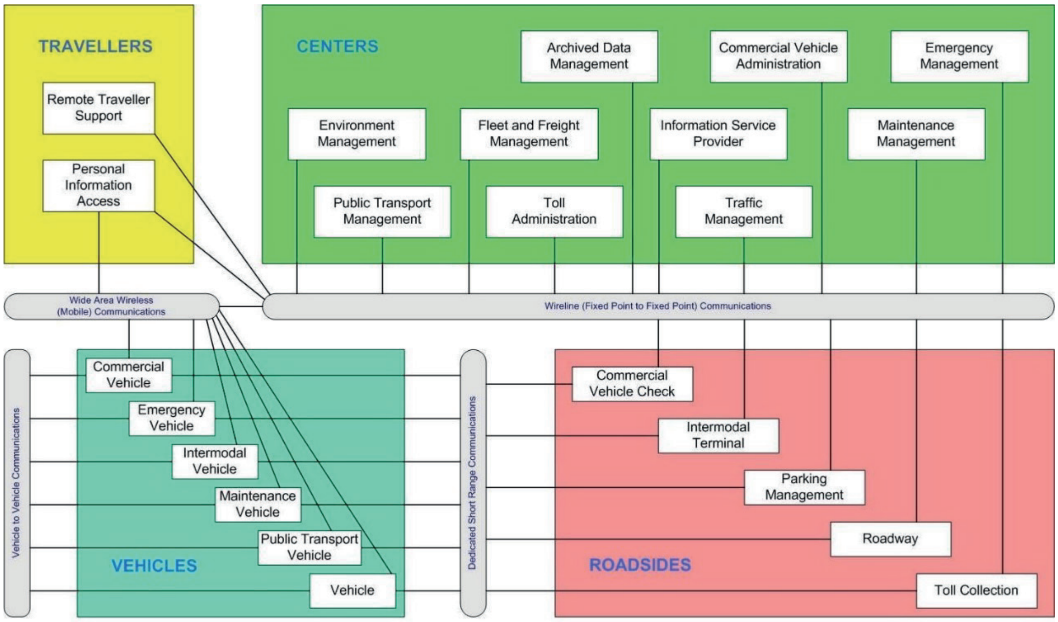

Figure 37. Physical Architecture
(Development of ITS System Architecture for Malaysia, 2007)

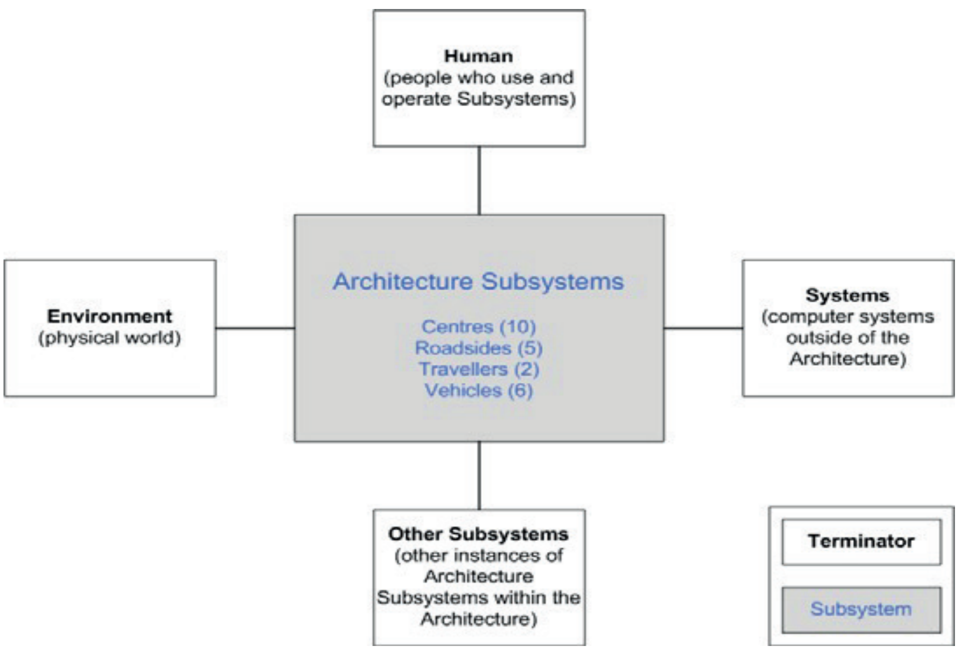

Figure 38. Scheme of Physical Architecture
(Development of ITS System Architecture for Malaysia, 2007)

Deployment Packages are the real-world solutions according to the needs of the users, operators, engineers and overall, the stakeholders of the system. They are defined after the establishment of logical and physical architecture. To exemplify, in Malaysia, the Disaster Management Deployment package includes;

- Emergency Response Management,
- Emergency Vehicle Routing,
- Personal Security and Mayday Support,
- Disaster Command and Control,
- Disaster Information Dissemination (Malaysian ITS Blueprint (2019-2023), 2019).

With the definition deployment packages, the ITS standards have also been developed for ITS deployment in Malaysia. The aim of the ITS standards development is to ensure the synergy and compatibility of the systems in functionality level. This assures the interoperability between ITS systems for the system operators. In the development process of the ITS standards, various Standards Development Organizations took active part such as Intelligent Transportation System (ITS) Protocol (NTCIP), Institute of Electrical and Electronics Engineers (IEEE), Institute of Transportation Engineers (ITE), American Society for Testing and Materials (ASTM), International Society of Automotive Engineers (SAE) and APTA. In Malaysia, it has been proposed to establish a committee of stakeholders to ensure the development of Standards for the benefit of ITS, under the leadership of the Ministry of Investment, Trade and Industry (MITI). Other stakeholders are the Ministry of Public Works (MOW), Ministry of Transport (MOT), Communications and Multimedia Commission Malaysia (MCM) and Prasarana Malaysia Berhad (Prasarana), a state-owned public transport company with multi-modal utilities assets. Stakeholders in transportation systems are shown in Figure 39.

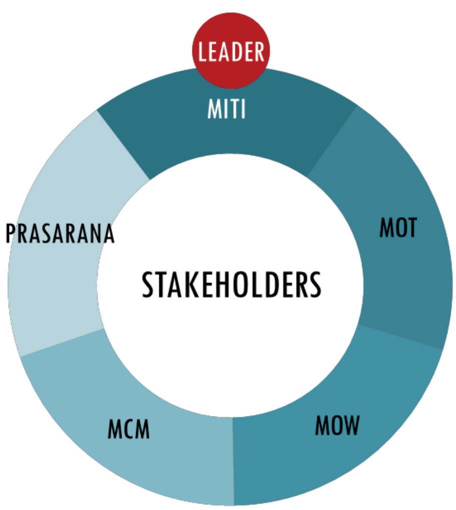

Figure 39. Stakeholders of Standard Development Process (Malaysian ITS Blueprint (2019-2023), 2019)

3.3.2 ITS Applications in Malaysia

stated in Malaysian ITS Blueprint 2019-2023, ITS in Malaysia are grouped in nine sectors, which are shown in Figure 40.

Figure 40. ITS Sectors in Malaysia (Malaysian ITS Blueprint (2019-2023), 2019)

There are various ITS which operate under these sectors that integrate with users of the system on the basis of data exchange. Development and upgrading of such systems are made possible by the transaction of data amongst the users as well. A committee of stakeholders have been established which consists of the Malaysian Administrative Modernization and Management Planning Unit (MAMPU), MOT, MOW and MITI. This committee is formed to ensure the progress in implementation of ITS and put forward common understanding between agencies in terms of data security, data sharing and various data related issues. The committee is led by MITI, as depicted in Figure 41.

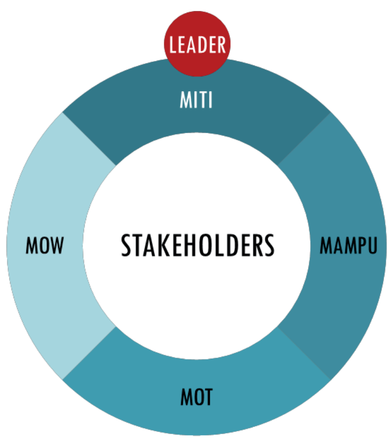

Figure 41. System and Data Stakeholders Committee (Malaysian ITS Blueprint (2019-2023), 2019)

Advanced Traffic Management Systems (ATMS)

There are various examples of ATMS applications in the road networks of Malaysia. According to ITS Blueprint of Malaysia, one of the strategic pillars have been stated as "Congestion-Free Infrastructure". With the purpose of ensuring a congestion-free infrastructure, two main focuses are determined as establishment of ensuring Multi-Lane-Fast-Flow (MLFF) in Traffic Management Centres (TMC) and road networks. MLFF is intended to be provided with ITS elements such as Electronic Toll Collection (ETC) and Radio Frequency Identification (RFID), and Automated Number Plate Recognition (ANPR). Congestion Free Infrastructure scheme is shown in Figure 42.

National Intelligent Transportation Management Centre (NITMC), as one of the most important stages, have been taken for ensuring the congestion free infrastructure. The establishment of these centres serves for safety, disaster management, traffic and transportation management purposes. In these services, various ITS technologies such as Video Image Processing (VIP), Bluetooth and Wi-Fi Tracking systems are used for the purposes of collecting real time data for traffic monitoring, incident detection and other related traffic data. The data that is collected are used for facilitating the traffic management.

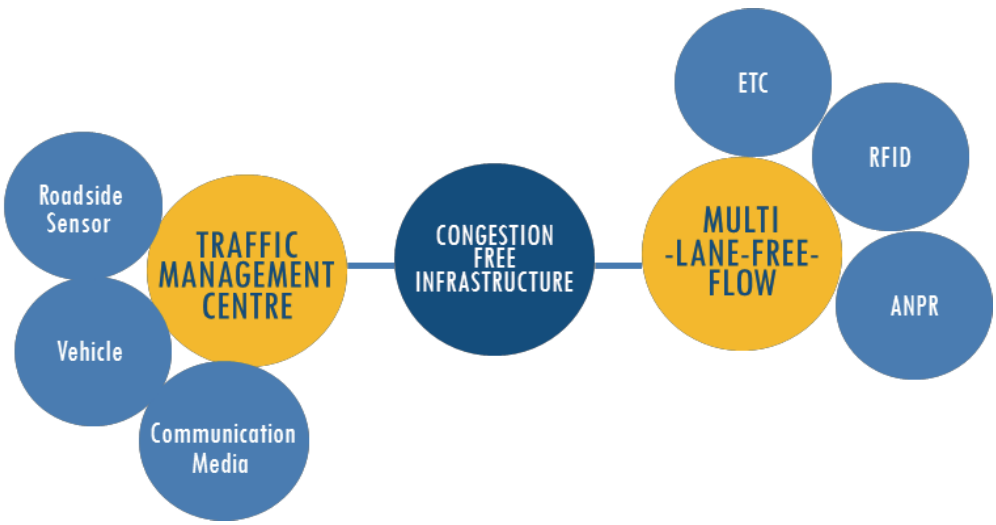

Figure 42. Congestion Free Infrastructure (Malaysian ITS Blueprint (2019-2023), 2019)

There are traffic management centres which are established in urban arterial and highway road networks of Malaysia. Integrated Traffic Information System (ITIS) must be also mentioned, to define the ATMS in Malaysia. ITIS, beginning operation in 2005 in Klang Valley, comprises of two components, which are Advanced Traffic Management System (ATMS) and Advanced Traveler Information System (ATIS).

ATMS works under the body of Integrated Transport Information System (ITIS). ATMS utilize CCTVs, Automatic Detection System (AID) and Automatic Vehicle Location System (AVL) for transferring the data to Traffic Management Centre (TMC). TMC serves for managing the transportation operations (UniMAP Library Digital Repository). Kuala Lumpur Control and Command Centre (KLCCC) oversees the traffic control and management through 5000 installed CCTVs. In Figure 43, AID Camera incident detection application is shown.

Figure 43. AID Application in Malaysia
(UniMAP Library Digital Repository)

Highway operators also have installed TMCs in Malaysia. One of the Traffic Management Centre of Kuala Lumpur City Hall and Malaysian Highway Authority National Traffic Management Centre is depicted in Figure 44 and Figure 45, respectively.

Figure 44. Traffic Management Centre of Kuala Lumpur City Hall
(Source: ITS Asia – Pacific)

Figure 45. Malaysian Highway Authority National Traffic Management Centre (Source: ITS Asia-Pacific)

In addition to above mentioned applications, Variable Message System (VMS) is served for the road users. VMS shows real-time and informative message to road users as they can plan their journey more efficiently. Road users can avoid traffic jams by using the VMS to display information about accidents, roadblocks, and alternate routes. In Figure 46, a VMS application from Malaysia is shown.

Figure 46. VMS Applicatioon in Malaysian (Source: Malasian ITS Blueprint (2019-2023),2019)

Another ITS application in Malaysia is the Automated Enforcement System (AES), which came into operation in 2012. AES operates on federal roads, highways and expressways in Malaysia. System includes cameras for speed and red-light violations. Speed camera application in Malaysia is shown in Figure 47.

Figure 47. Speed Camera Application in Malaysia

Electronic Payment Systems

The Electronic Toll Collection (ETC) systems in Malaysia are implemented nationwide in the road networks. The aim of the systems is to reduce congestion in tool booths and traffic hazards that comes forward with congestion. The improvement of these systems will serve for ensuring the Multi Lane Free Flow (MLFF) purposes. Currently, Smart Tag Lanes and Touch n Go Lanes are still in usage, but it is aimed to realize the transition to RFID and ANPR passage in all toll collection booths in Malaysia. The transitional passage to RFID and ANPR technologies in all highways and all vehicle classes. Deployment of the MLFF is aimed to be completed by 2025 (Paultan). Transition phases to MLFF is depicted in Figure 48.

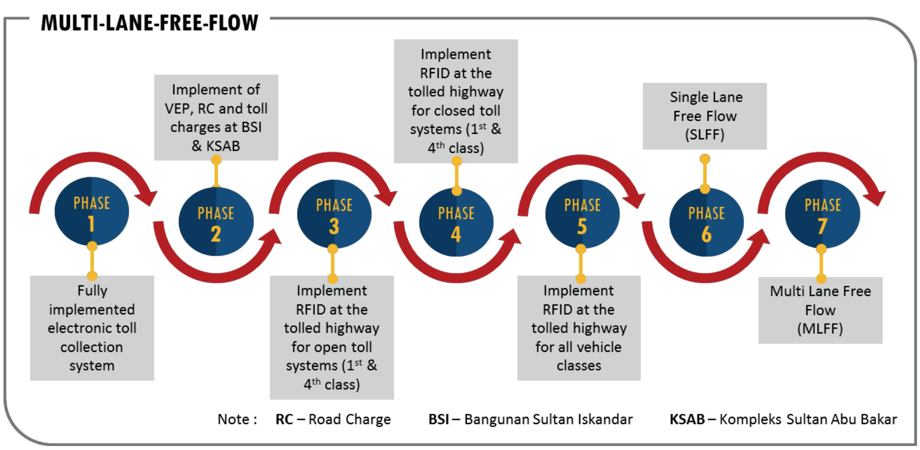

Figure 48. MLFF Transition Phases (Malaysian ITS Blueprint (2019-2023), 2019)

The Electronic Toll Collection systems via RFID are in usage in several highways in the Klang Valley in Malaysia (Malaysian ITS Blueprint (2019-2023), 2019). An ETC application from Malaysia is shown in Figure 49.

Figure 49. ETC Application in Malaysia

Advanced Traveler Information Systems

Traveler Information is provided through various systems in Malaysia, and one of the primary services is the Variable Message Signs (VMS). VMS, although categorized under ATMS, are used in order to inform drivers. In Figure 50, VMS which informs the drivers about speed violation enforcement is depicted.

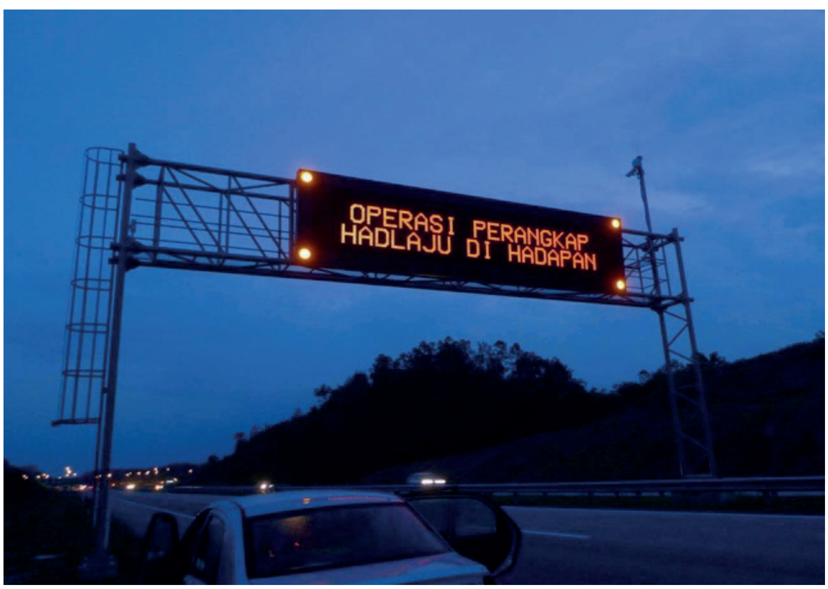

Figure 50. VMS Application in Malaysia (Source: Intertraffic)

Advanced Traveler Information System (ATIS) is a component of ITIS and delivers real time traffic information to drivers about various traffic conditions. The data is delivered to the drivers via VMS, radio stations, internet and ITIS Call Centre (UniMAP Library Digital Repository). PLUS, Mobile Application is developed by PLUS highway which provide information about Toll Fare, Traffic update via CCTV, Travel Time Advisory (TTA) and nearby R&R Facilities.

Advanced Public Transportation Systems

Traveler information for public transportation in Malaysia is disseminated via mobile applications and websites. Psarana Malaysia Berhad is a government owned public transportation company and is the operator of public transportation services in the country. As an example, Public Transportation Operations Rapid KL, Rapid Penang and Rapid Kuantan which operates in Klang Valley, Penang and Kuantan cities respectively, provide information to passengers via PULSE mobile application and web journey planner of the agency. Passengers are able to plan their journey and choose travel modes with the application and web journey planner. Intermodal journey planning service is also provided by the journey planner (MyRapid). User interface of the journey planner is depicted in Figure 51.

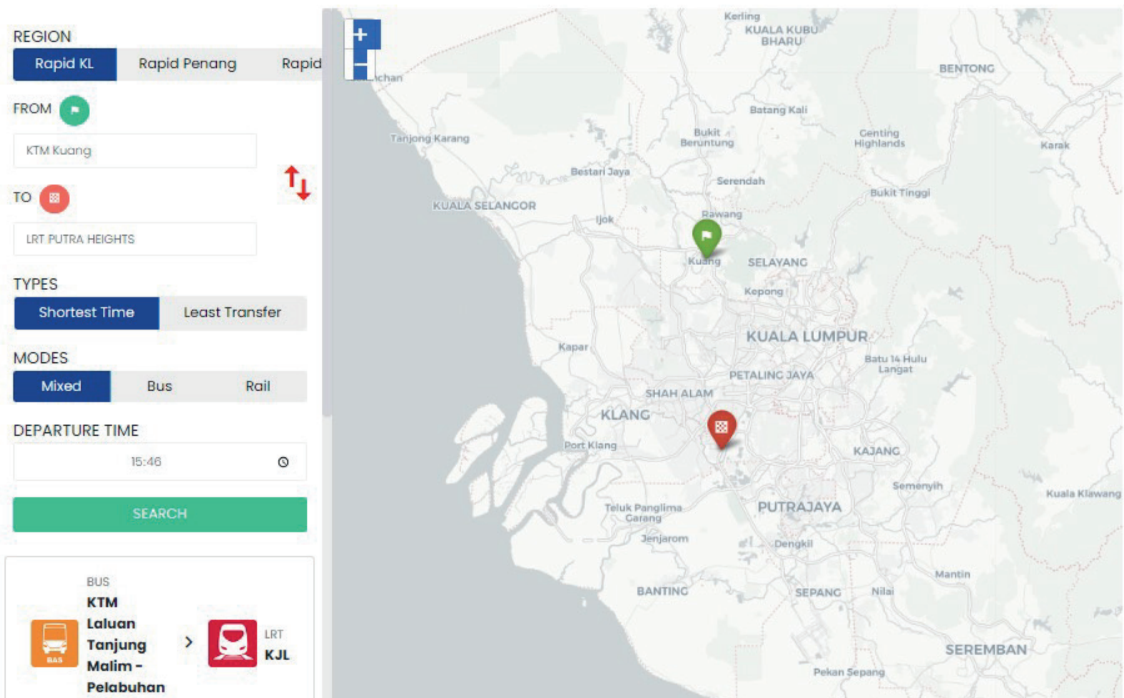

Figure 51. User Interface of The Journey Planner

Emergency Management Systems

Emergency Management Systems are one of the three focus areas of Safety Systems in Malaysia, which are Automated Enforcement Systems, Weigh in Motion Systems and Emergency Management Systems. In Malaysia, the singlified Emergency Call number is 999, which is controlled through MERS 999 Call Centre. The MERS 999 Call Centre coordinates agencies such as Ministry of Health, The Royal Malaysian Police (RMP), Fire and Rescue Department of Malaysia (BOMBA), Malaysian Maritime Enforcement Agency (MMEA) and Malaysia Civil Defense Force (APM).

Automated Awareness Safety System (AwAS) is the automated enforcement system for speed violations. The system is implemented by the Malaysian government and works through deployed sensors throughout highways. The aim of the system is to reduce the fatality of possible accidents. The system's components are fixed red light, fixed speed and mobile speed cameras (Malaysian Institute of Road Safety Research, 2016).

Real Time Monitoring System (RTMS) is an early warning system that warns relevant parties in case of rainfall threshold while preparing the related parties for early preparation for accidents. Suicide Attempt Alert System (SAAS) is an AI supported system that detects suicide attempts in Penang Bridge and notifies Traffic Monitoring Centre. SOS buttons in PLUS mobile application enables travelers to get immediate help from TMC.

Tunnel Traffic Management Systems (TTMS) and Bridge Traffic Management Systems (BTMS)

Tunnel traffic is managed by highway operations TMCs in Malaysia. There are several TTMS applications in Malaysia. In Menora Tunnel, Oversized Vehicle Detection System (OVDS) is used to detect the height and weight violations of vehicles. SMART Tunnel application applied in highway tunnels of Malaysia is equipped with 212 units of CCTVs. It includes Automatic Detection systems and SMART helpline which helps motorists in emergency cases.

Examples to BTMS in Malaysia can be given as CCTV deployment in Penang Bridge and the second Penang Bridge.

Commercial Vehicle Operation (CVO)

Commercial Vehicle Operation (CVO) consists of three focus areas in Malaysia, which are logistic and fleet Management, ports connectivity and International Border Crossing Clearance (IBCC). Technical Working Group (TWG), led by MOT, is developing National Freight Data and Ports Connectivity initiatives to realize the objectives of Malaysian ITS Blueprint 2019-2023.

Weather Information Systems (WIS)

Weather information provided by Malaysian Meteorological Department (MetMalaysia) is integrated with the National Disaster Command Centre (NDCC), which governs the disaster management in Malaysia. Additionally, weather related disaster early warning systems gather information from:

- Bilik Gerakan Bencana (BigBen) or Disaster War Room under Public Work Department for landslide risks.
- Department of Irrigation and Drainage for flood risks
- MetMalaysia for tsunami risks.

3.3.3 Insights from site visit to Malaysia

Site visit for Malaysia is realized between 25-27 June 2024. Meeting agenda is coordinated by Ministry of Transport Malaysia (MOT). During the site visit, a questionnaire (Annex 2) is requested to be answered. In line with the question set, a special meeting with Ministry of Works, Ministry of Housing and Local Government, Malaysia Institute of Road Safety Research (MIROS) is organized by Ministry of Transportation. The Centre for Transportation of the University of Malaya was also visited.

3.3 The Gambia

3.4.1 Background

The Gambia is classified as a Least Developed Country (LDC) with a Gross National Income per Capita of $750 (United Nations Department of Economic and Social Affairs). The Gambia's national transportation system comprises of three modes as maritime and river, air and road transport.

Banjul, the capital of The Gambia,is located in the end of The Gambia River and the port of Banjul serves as a trading center of the West Africa. The port of Banjul (see Figure 52) is an important asset for the countries in the hinterland of The Gambia; Senegal, Guinea, Guinea Bissau and Mali. Gambia Ports Authority (GPA) oversees the construction, maintenance and operation of the port. The trading activity from the port consists of the 80% of the international trade of The Gambia (African Development Bank Group).

Figure 52. Port of Banjul (Source: African Development Bank Group)

In 2021, 253,503 tonnes of goods have been exported from the port of Banjul and 2,400,240 tonnes of goods have been unloaded to the port. Port of Banjul serves as a primary center for passenger transport as well. In 2022, 1,830,957 passengers have been recorded as the number of passangres travelled from the Port of Banjul. Annual number of passengers and freight volumes of the Port of Banjul is shown in Figure 53 and Figure 54.

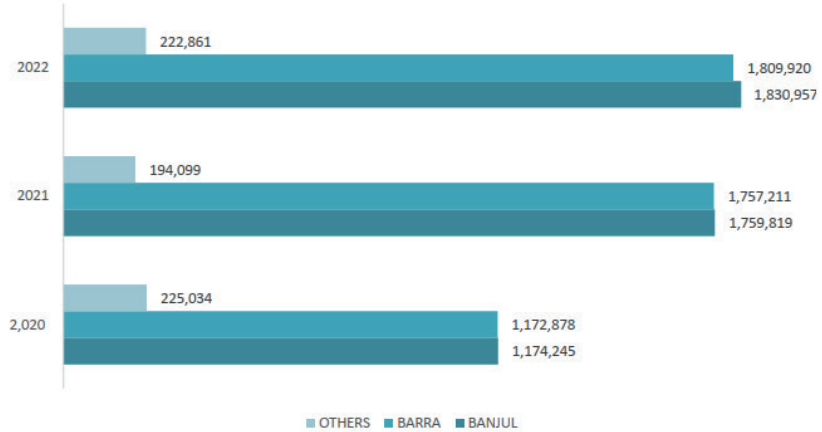

Figure 53. Annual Passenger Mobility of the ports of Banjul and Barra (Source: Gambia Bureau of Statistics)

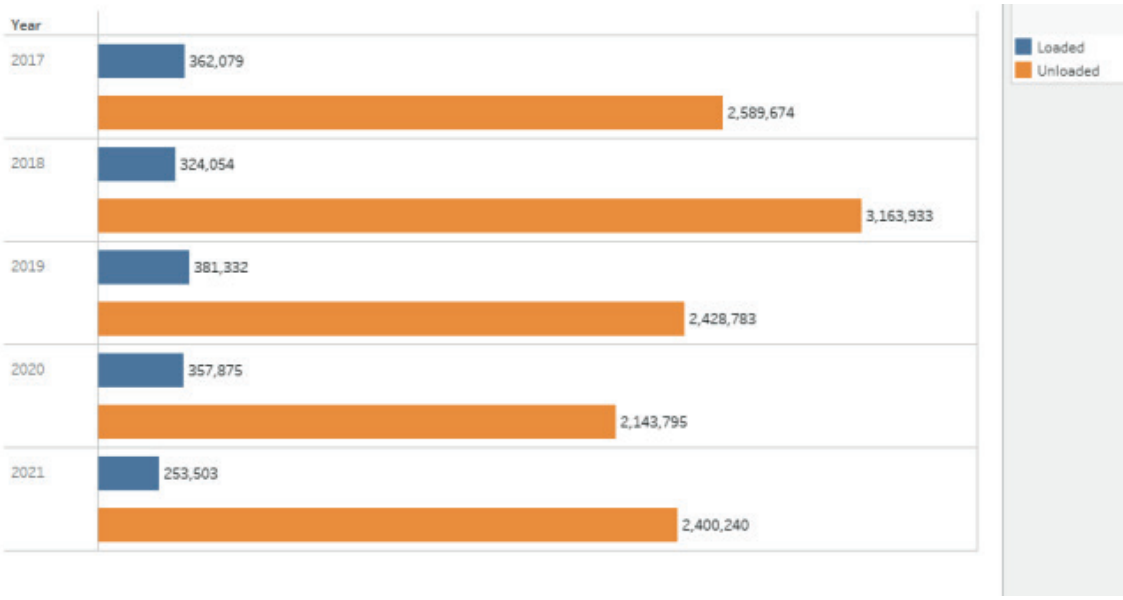

Figure 54. Annual Freight Volume of the Port of Banjul (Source: Gambia Bureau of Statistics)

Air transportation is another transportation mode in The Gambia. Air transportation plays a significant role in means of supplying the international connectivity and tourism industry. The Gambia Civil Aviation Authority (GCAA) have been established in 1991 to operate the Banjul International Airport (BIA), manage and regulate civil aviation and be responsible for compatibility with International Civil Aviation Organization (ICAO) standards (African Development Bank Group).

Banjul International Airport (BIA) (Figure 55) has a single 3,600 metres long runway. Annual passenger capacity of the airport is one million passengers (African Development Bank Group, n.d.). Between 1997 and 2017, a total of $50,73 Million have been invested in several projects for infrastructure development. These projects are;

- New terminal construction (completed in 1997)
- Access road construction with street lighting, inner perimeter fence, generators and technology investment in aviation (completed in 2005)
- Resurfacing of the runway and upgrading airfield ground lighting system (completed in 2007)
- Apron expansion, taxi way construction and rescue and firefighting facilities upgrade (completed in 2009)

Figure 55. Banjul International Airport
(Source: Gambia Civil Aviation Authority)

BIA is an important center for both passenger and freight transportation in The Gambia. After the COVID-19 pandemic these numbers have shown significant increase for the first time. In 2022, 180,473 passengers have disembarked from BIA and 176,392 passenger have embarked to BIA. In 2022, 647,59 tonnes of freight have been unloaded in BIA and 793,85 tonnes of freight have been loaded to the aircrafts in BIA. Record number of freight import to the BIA in the recent years have been recorded as 1,050 million tonnes in 2019. In Figure 56 and Figure 57, annual passenger and freight transportation statistics is depicted.

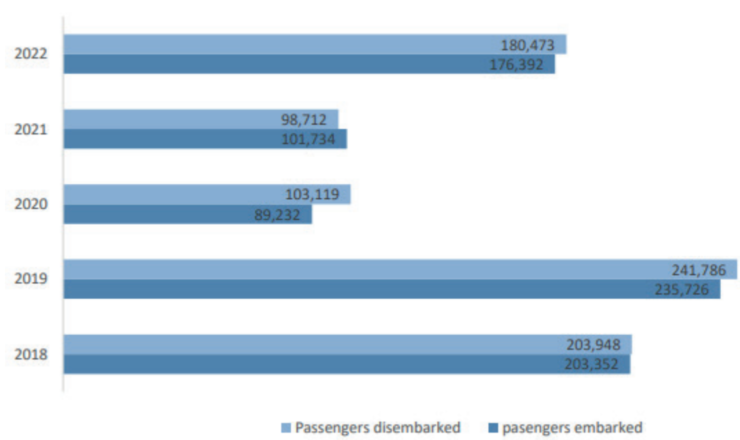

Figure 56. Annual Passengers Disembarked from and Embarked to BIA Over the Years

(Source: The Gambia Bureau of Statistics)

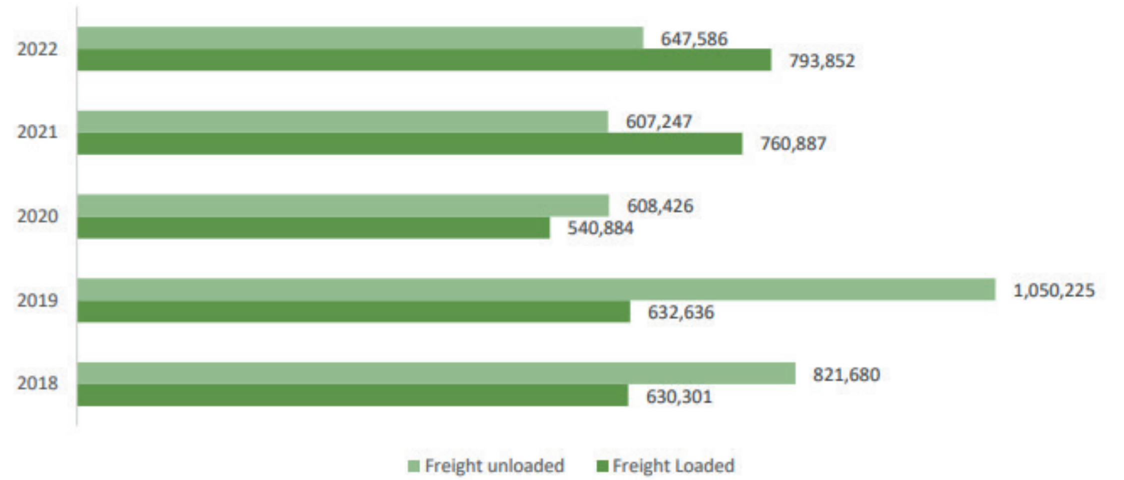

Figure 57. Annual Freights in Kg Unloaded from and Loaded to Aircrafts in BIA Over the Years (Source: The Gambia Bureau of Statistics)

Road transportation is the third transportation mode in The Gambia. The country's road network is estimated as 3,920 kms long. 818.5 kms of this network is classified as primary roads, inter-urban trunk roads. Secondary roads make up of 359 kms while urban roads, mainly within the capital region Greater Banjul Area (GBA), make up of 187 kms of the road network. 2,556 kms of the road network are rural feeder and gravel/earth surface (The Gambia National Transport Policy 2018-2027). Road network of The Gambia is depicted in Figure 58.

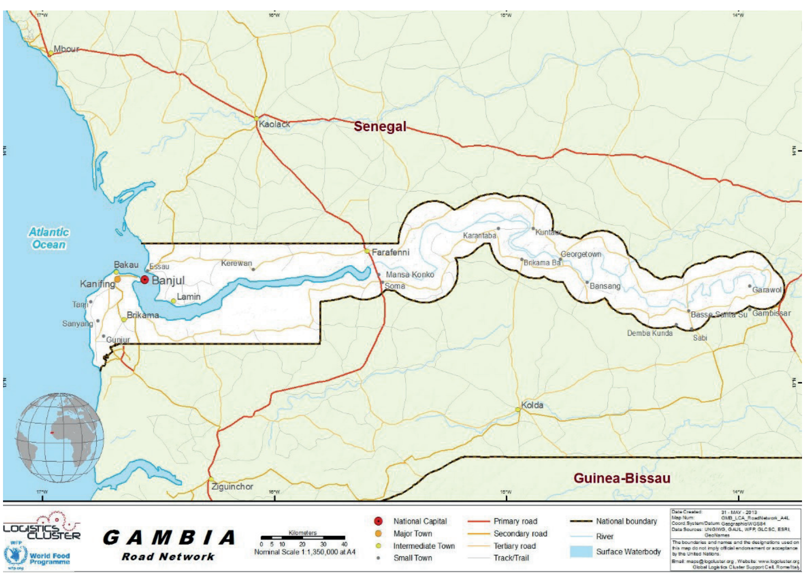

Figure 58. Road Network of The Gambia (Source: Logistics Cluster)

As the result of rapid urbanization in The Gambia, traffic congestion especially in Banjul port area is becoming a real problem. During tourist season, November to April, the number of people and movement of these people are increasing, resulting the overcapacity usage of three modes of transportation in The Gambia. There are also issues regarding institutional hierarchy and regulation in urban transport services on arterial, collector and side roads. (The Gambia National Transport Policy 2018-2027). Increasing rate of motorization as well as the lack of regulations and transport policies causes the weak road safety, vulnerabilities and increased congestion. In addition to that, there is a lack of electronic database and necessary reporting systems (data collection, collation, analysis, surveillance) for monitoring fatalities and serious injuries. For example, latest official data about fatalities and injuries are announced for the year of 2016 (The Gambia National Transport Policy 2018-2027). On the other hand, there are initiatives for developing strategies for road safety. These strategies and goals are reported in The Gambian Road Safety Strategy 2030. According to this report, estimated and target rates for fatality and injury rates for 2017 and beyond, are reported. These figures are shown in Table 2.

Table 2 . The target fatality and serious injury rates for 2030
(Source: The Gambian Road Safety Strategy 2030)

	Fatalitics	Serious Injuries	FSI Combined
2008-2012	89	290	379
2013-2016	130	290	379
Change	+46%	+52%	+51%
2017-2020(+62.5%)	211	729	93
2017-2020(+50%)	195	663	858
2017-2020(+37%)	179	608	787
2030	<100	<330	<430

As mentioned above, road safety is one of the major issues in transportation systems in The Gambia. Lack of human resources and institutional capacity, inadequacy of the legal framework, insufficient funding, and lack of initiatives in data management strategies causes the problems related with safety in roads. Therefore, The Gambian Road Safety Committee has been established to coordinate the delivery of road safety on behalf of the Government of Gambia, to provide a coordinated line of advice to the Minister of Transport Works and to provide governance to the implementation of programmes for road safety issues. The road safety governance structure is shown clearly in Figure 59 , which is stated in The Gambian Road Safety Strategy 2030 .

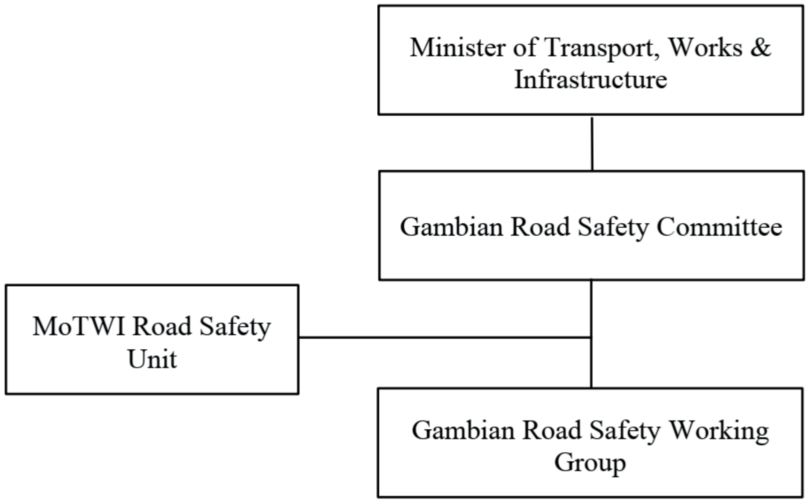

Figure 59. Road Safety Governance Structure
(Source : The Gambian Road Safety Strategy 2030)

Poverty is another problem in The Gambia. The rural areas contain about 64% of the total poor in the country. This fact accelerates the migration from rural areas to urban areas where transportation infrastructure is inadequate. Increasing population in urban areas and lack of ITS infrastructure such as CCTVs, leads to insufficient traffic safety. One of the major reasons for limited infrastructure is inadequate financial sources.

3.4.2 ITS Applications in The Gambia

In The Gambia, the responsible agencies of road transportation are Ministry of Transport, Works and Infrastructure (MOTWI), National Roads Authority (NRA) and Gambia Public Transport Corporation (GPTC). The responsibility areas of MOTWI are the formulation of the policies and regulation of the roads, construction works and management of the operation of the passenger and freight terminals. GPTC is responsible for public transportation operations. Remaining activities related with road transport are coordinated within NRA. (African Development Bank Group). Main objective of the authorities in The Gambia are to increase the road capacity, promote the quality of infrastructure, improve maintenance of the road network and increase road safety. Ministry of Transportation, Works and Infrastructure released 1998-2006 and 2018-2027 National Transport Policy and 2020-2030 Gambian Road Safety Strategy documents in attempt to strengthen the strategical background for reaching these goals.

Public Transportation consists of two different entities as formal and informal public transportation in The Gambia. Formal public transportation operations in The Gambia are owned by the Gambia Transport Services Company (GTSC). Buses of the GTSC serve for long distance trips, school bus service and interstate trips between the capital city of The Gambia, Banjul, Dakar and Bissau (Gambia National Transport Policy 2018-2027). Buses of the GTSC is shown in Figure 60.

Figure 60. GTSC Buses (Source : GTSC),

On the other hand, informal public transportation in urban areas has been emerged as a necessity due to financial problems faced by GTSC. GTSC does not operate in shorter distance trips as such trips are so costly and not profitable. Instead, individually owned modified vehicles called "Gele gele" are used as informal public transportation for shorter distances (Gambia National Transport Policy 2018-2027). This mean of public transportation is depicted in Figure 61.

Figure 61. GTSC Buses (Source : GTSC),

In The Gambia, the applications of ITS are limited and does not exceed few applications such as amounts of traffic signalization and traffic cameras. A signalization application from Kairaba Avenue, Banjul in The Gambia is shown in Figure 62.

Figure 62. Traffic Signalization in The Gambia

Although the current applications are inadequate, there are attempts to develop strategies for implementation of intelligent transportation systems applications in the road networks of The Gambia. There is an ambition of officials to improve the current situation. For example, "Improving Human and Institutional Capacity for the Development of an Institutional Framework for Intelligent Transportation System (ITS) in The Gambia" Project executed by Ministry of Transport of The Gambia, Works and Infrastructure is in motion. The project aims to design a plan to develop an institutional and strategic framework to create smart, efficient and environmentally sustainable urban transport system in The Gambia. The project includes a field visit to Qatar in order to benefit from Qatar's better practices in ITS activities and benefit from one-on-one experience sharing. It is aimed that a blueprint is to be developed for The Gambia's institutional and strategic framework for implementation of ITS in urban transportation systems of The Gambia, with the information gathered from Qatar field visit.

Similar projects must be carried out in order to provide a background for implementation of ITS in The Gambia's road networks.

The Gambia has basic needs and necessities to improve urban and intercity transportation systems. First of all, institutions that will play role in ITS should be determined and organized. Regulatory framework must be planned, and a Strategic Action Plan for ITS should be prepared. In order to keep and increase the skilled manpower that will take responsibility in ITS area, special education programs, trainings and seminars should be organized with developed OIC Member Countries.

Infrastructural investments must be planned and executed according to this Action Plan. The road network needs to be expanded, capacities should be increased and maintenance work in the transportation infrastructures need to be promoted. Therefore, capacity building projects can be implemented in The Gambia. In order to achieve the funding for development of the infrastructure, grants, credits with low interest rates can be implemented.

3.4.3 Insights from site visit to The Gambia

During the site visit, a questionnaire (Annex 2) is requested to be answered by different stakeholders related to ITS including the Ministry of Transport, Works and Infrastructure, Ministry of Trade (also acts as the COMCEC National Office), The National Roads Authority, The Gambia Police Force, Kanifing Municipal Council, Banjul City Council and the Bertil Harding Highway.

During the visits the principal personnel related with ITS were present at the face-to-face meetings where brief information was given about the projects and planned developments for ITS in The Gambia were evaluated.

3.4 The United States of America

3.5.1 Background

The United States of America (the US) having started their nationwide initiatives in early 1900s, are one of the pioneers in the matter of ITS in the world. With the continuous improvement of communications technologies worldwide, developed and developing countries have made significant progress in terms of deployment of the ITS equipment in their highway networks. The US, on the other hand, is one of the prominent countries because of the strength of the country in terms of legislative and political background, investment in research and development, ITS architecture and standards. In this section, the status of the US on ITS is summarized by explaining the history of ITS in the US, defining the ITS Architecture and Standards of the US and giving examples to ITS applications in the highway network of the US nationwide. The section aims to explain the motives of the US being a best practice country on ITS by detailing the given subsections.

The first application of ITS in the US started with three color traffic signalization applications in 1914. Following to better manage the increasing automobile usage in the country, National Research Council Highway Research Board was founded in 1920. The name of the institution was changed as Transportation Research Board (TRB) in 1974. Purpose of the institution have been providing data related to highways until it had started conducting research studies after the 1950s. In 1960s, this institution has conducted studies related to multimodal transportation and navigation technologies.

Between 1960-1970, the Experimental Route Guidance System (ERGS) Project has been carried out by Bureau of Public Roads (now the Federal Highway Administration), which provides communication between infrastructure and vehicles. The system was tested in the Washington, D.C. However, due to high infrastructure costs, the project has been never fully adopted.

In 1966, the US Department of Transportation (USDOT) was founded to manage solving the problems related to transportation systems and infrastructure countrywide. In 1967, seatbelts in vehicles, standardized bumper heights, airbags and standardized brake systems became mandatory.

In 1970s, traffic signalization control systems and map matching algorithms have been developed. In the same year, National Highway Traffic Safety Administration (NHTSA) has been founded to ensure highway safety. In 1971, using map matching algorithms, Automatic Route Control Systems (ARCS) have been developed, and loop detectors have emerged. Loop detectors have been utilized to detect traffic density to better manage the green phase times in intersections.

In 1980s, the focus of the transportation policies shifted to safety and environmental concerns. With the decrease in purchasing cost of technology and advancements in technology in the 1980s, new technologies which are utilized to improve traffic management have emerged. Microprocessors, computers, sensors and GPS have been the emerging technologies in this decade. The concept of Intelligent Vehicle Highway System (IVHS) has also emerged in the 1980s. The term represents the group of information, communication and control technologies, which provides the bridge between infrastructure and vehicles and helps improving transportation safety and efficiency. In 1983, Fuel-Efficient Traffic Signal Management (FETSIM) program have been established in California with the purpose of retiming the traffic signals in order to improve traffic operations and reducing fuel consumption and emissions. During 11 years of active period of the program, 12,245 signals in 160 cities have been retimed. In 1984, Automated Traffic Surveillance and Control System have been installed in Los Angeles, which was an integrated system of CCTV cameras, vehicle detectors and coordinated signal timing.

In 1990s, a significant growth has been occurred in technological improvements, especially with the invention of World Wide Web. To ensure the integrated systems of technological devices used in highway networks to work systematically, a need for ITS Architecture to be developed have occurred. With this purpose, ITS Architecture of the US has been developed in 1993. The US Department of Transportation (US DOT) has established Intelligent Transportation Systems Joint Program Office (ITS JPO) in 1994. ITS JPO has been conducting ITS deployment tracking surveys since 1999, in every 2 to 3 years to monitor and evaluate the ITS deployment status in highways, arterial roads and of public transportation agencies in the US.

In 2000s, the most prominent growth has been achieved in the growth of communication technologies. The number of cellular subscribers and Wi-Fi networks have multiplied immensely. Another technology that has occurred and became prevalent is the cloud technology. The improvement of the cloud technology has been beneficial in collecting the large datasets and performing the analyses. With the development of these technologies, the need to provide data for operations and transportation infrastructure users have gained importance. For this reason, the investment on sensors and cameras have been primary focus. The opportunity to collect and share information of the end users have increased in this decade.

In 2010s, the use of probe vehicles equipped with geographic location and mapping systems have gained popularity. In this decade, the focus of ITS applications has been in two main areas: automated vehicle purposes and connected vehicle purposes. The use of Vehicle-to-vehicle (V2V), Vehicle-to-infrastructure (V2I) and Vehicle-to-other modes such as cyclers, pedestrians (V2X) technologies emerged in this decade, which provides data transfer of location and information between these entities. ITS America Annual Report has been published in 2010-2011. In that report, it is stated that 511 systems are applied in 38 states, which covers 70% of the population, and highway and arterial road coverage by Traffic Management Centres have reached thousands of miles. The developments at the legislation end have also continued in this decade. In 2012, to increase the performance of highways and support the prevalence of emerging technologies, MAP-21 was signed into law. With MAP-21, the idea of development of ITS strategic action plans of 2015-2019 and 2017-2021 have been decided, and 2020-2025 ITS strategic action plan have been foreseen.

In 2020, 2020-2025 ITS JPO Strategic Plan have been released. To accelerate the deployment of ITS equipment, strategic goals have been determined. In 2022, V2X Wireless Communications Summit have been held with the purpose of supporting the development of V2X wireless communication technologies (USDOT Intelligent Transportation Systems Joint Program Office, 2023).

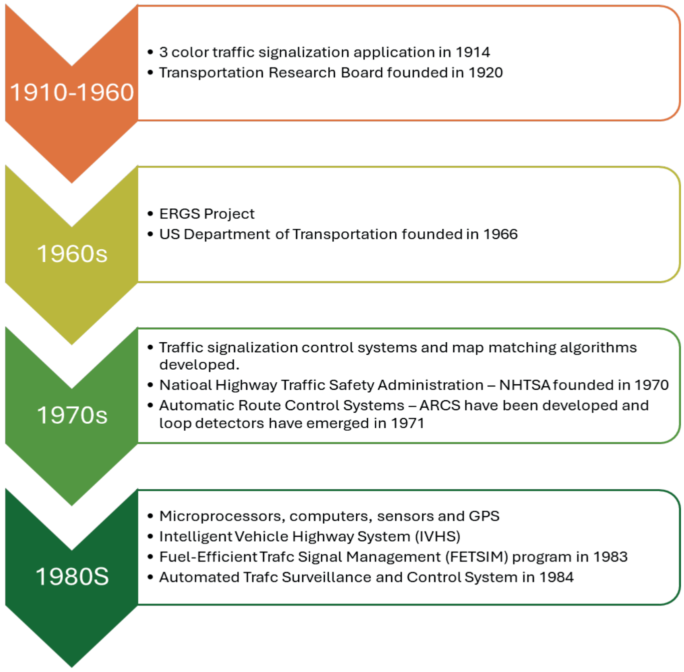

Figure 63. A History of ITS in USA 1910s-1980s

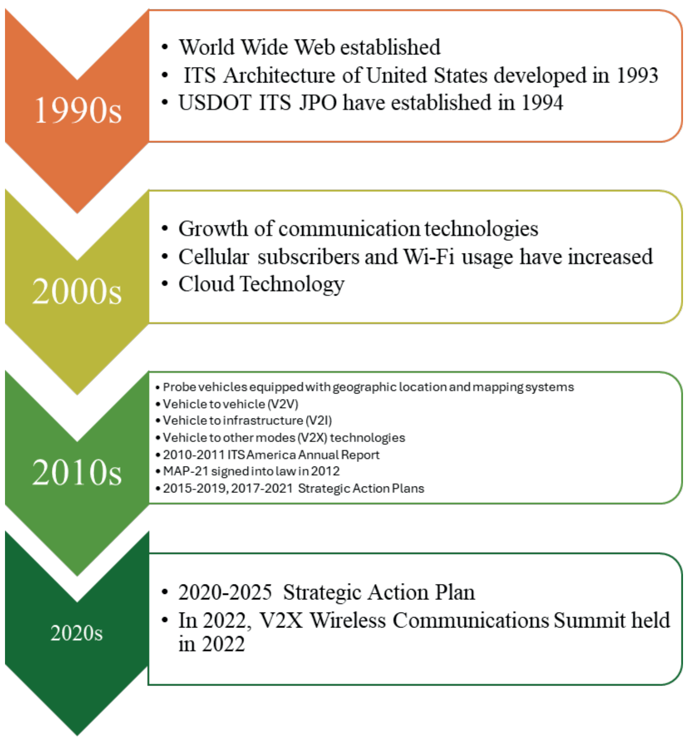

Figure 64. History of ITS in USA 1910s-1980s

The continuous development of ITS Architecture, which is the detailed structure that ensures meeting the needs of system users and the flexibility which allows the inclusion of multi-disciplinary design approach and emerging technologies in the US, is shown in Figure 65.

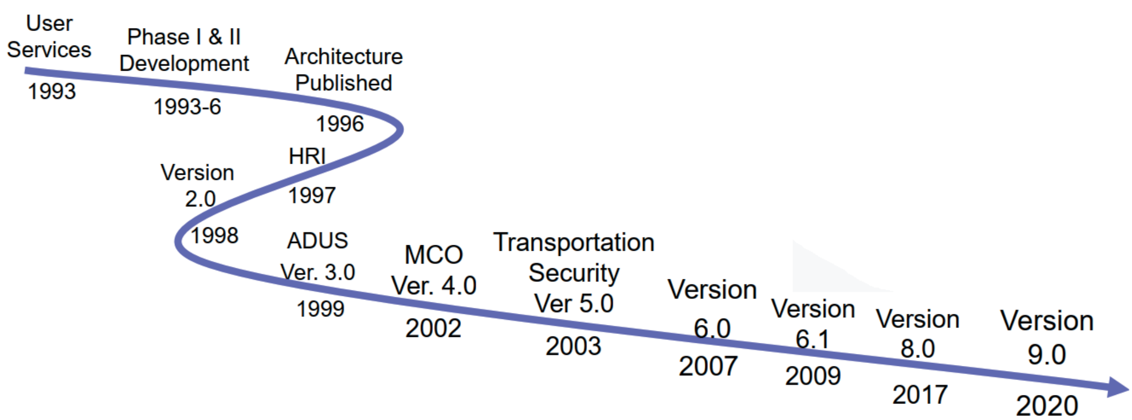

Figure 65. Continuous Development of ITS Architecture in USA
(Office of the Assistant Secretary for Research and Technology, 2017)

ITS architecture of the US comprises of four layers which are enterprise view, functional view, physical view and communications view (ARC-IT). Description and depiction of these views is depicted in Figure 66. Cooperative working discipline of these views is shown in Figure 67.

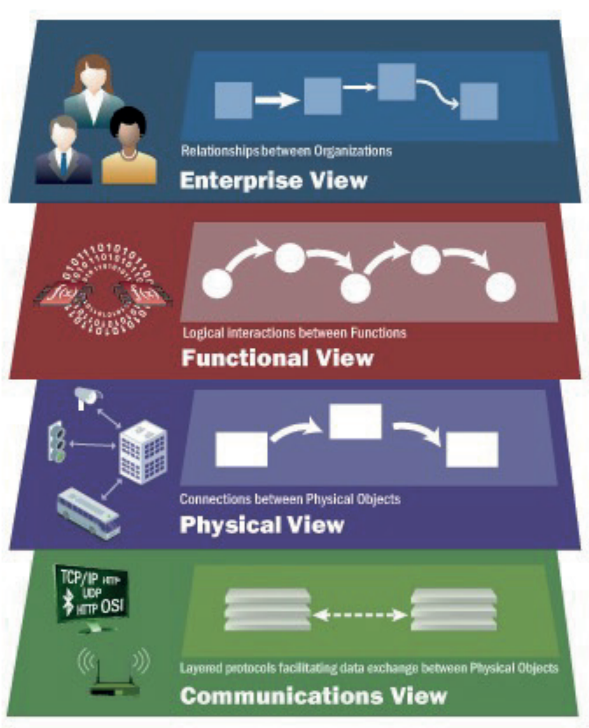

Figure 66. Views of ITS Architecture of USA (Source: ARC-IT)

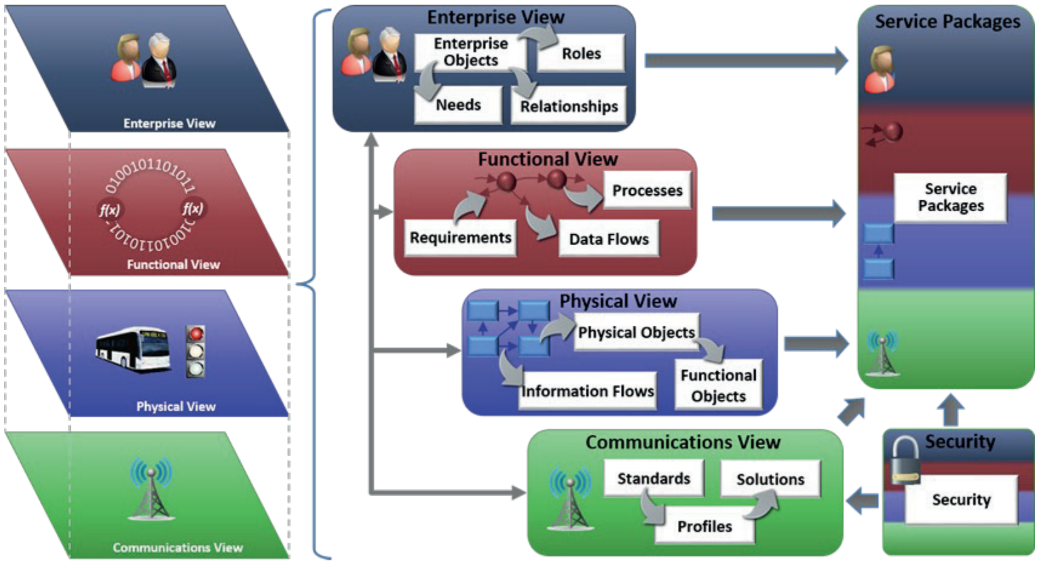

Figure 67. Cooperative Working Discipline of ARC-IT Views (Source: ARC – IT)

Enterprise view has been established to supply the ITS planning and project development which aims to provide for the needs of the users of the system. Enterprise view determines the goals and needs of the program and deals with the policies, financial sources and processes which support ITS programs. Additionally, it provides a foundation for determining the operators of the system and their roles. Also, this view includes the policies and processes in the architecture which supports the transportation planning and projects. The main roles of the enterprise view are ensuring the information exchange, managing the systems and ensuring the systematic operation of the systems. The stakeholders of this view can be exemplified as the ones such as Traffic Management Centre Managers and Transit Agency Executives. Many of the concerns raised by stakeholders taking on an acquisition, maintenance, installation, operations, certification, policy, or user role will be addressed by the Enterprise Viewpoint.

Functional view provides the analyses of abstract entities and their logical relationships. This view focuses on the application of the processes exchange of the information, protocols and methods which are used. Functional view aims to determine the data and functionality capability which is needed to apply a certain service. Functional view involves data collection, data transformation, data generation, data generation or processing. In Figure 68, depiction of processes related to the functional view of ITS architecture is depicted.

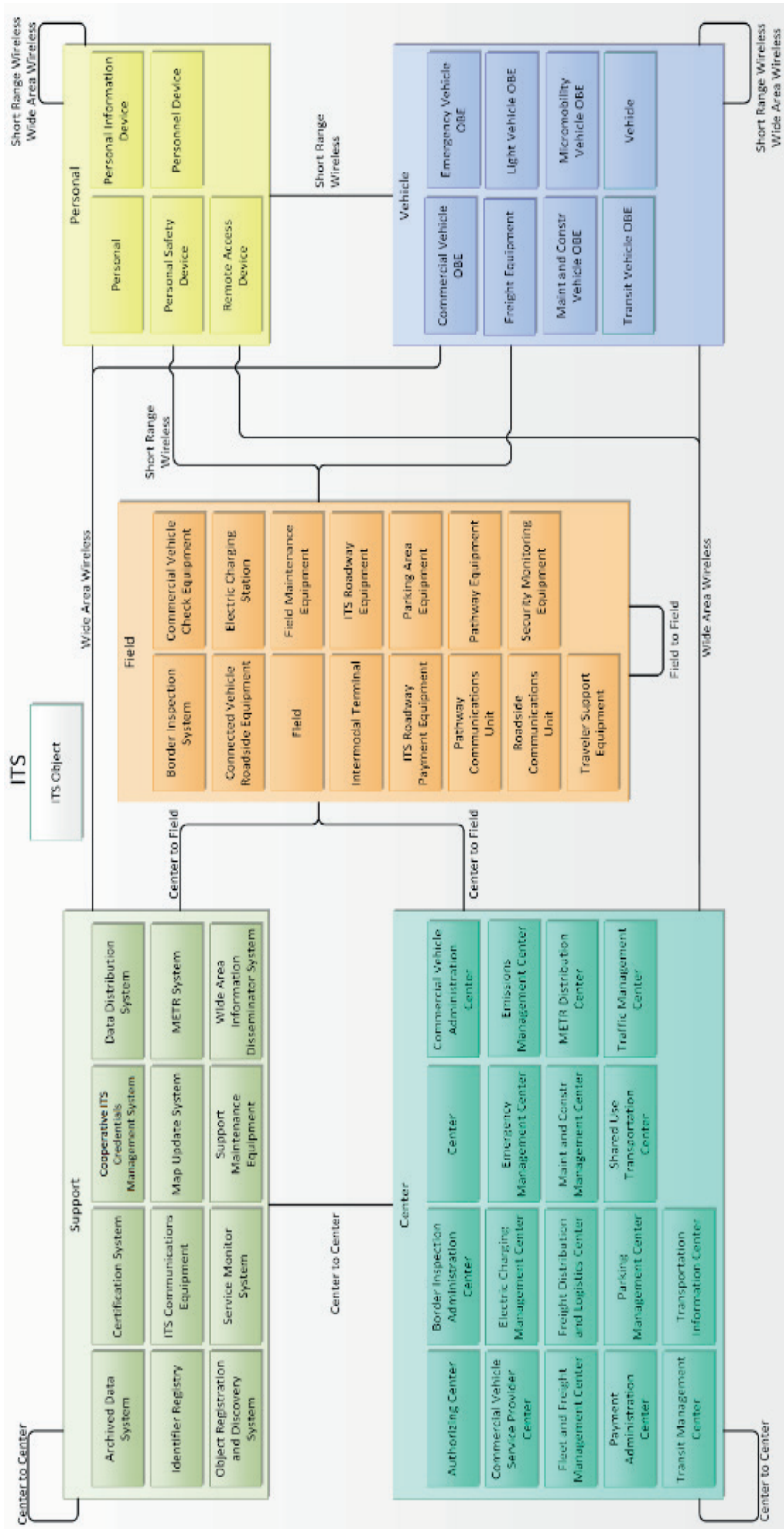

Figure 68. Functional View of ITS Architecture (Yokota & Weiland, 2004)

Physical view represents the physical entities which are deployed at the field and the centres. This view also shows their functionality and the connection between these physical entities. This view focuses on the design end of ITS and directly provides link to the communication view. The capabilities of the physical view entities are determined by the stakeholders of the enterprise view and enlists the information from functional view. Physical view provides a foundation for service packages which transmits the information. It also aims to determine the physical entities which need to take place for presentation of a certain service, appointment of the certain functions to the physical entities, safety issues for the physical entities and the information which are exchanged between the physical entities.

There are five physical object classes within the physical view. These are centre, field, support, vehicle and personal classes (See Figure 69). Centre defines the physical entities which are far from the transportation infrastructure and are entities which provide management and support functions. Field defines the infrastructure, which is located close to the transportation network where applications such as monitoring, data collection and traffic control are conducted. Support centres provides support for transportation operations; however, this service is not unique to transportation services.

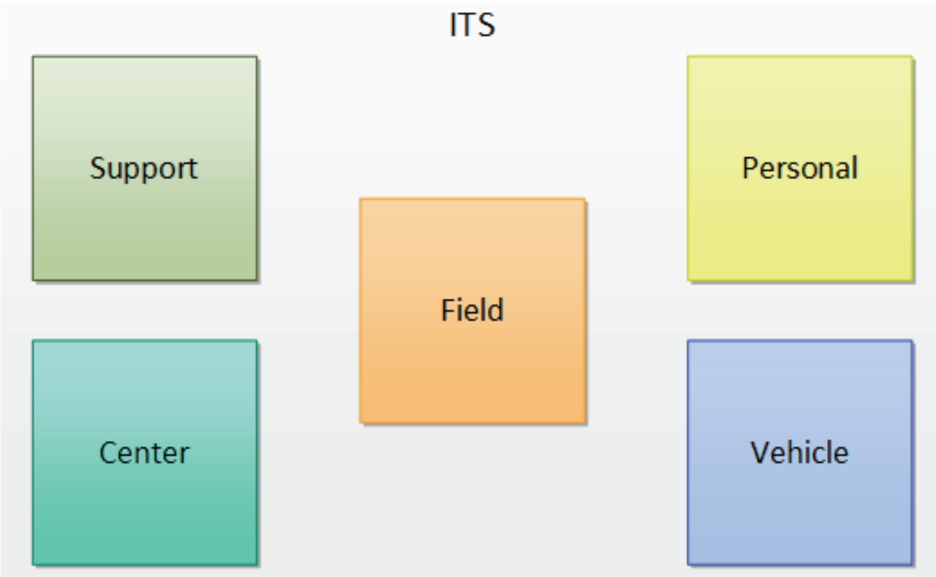

Figure 69. Classes of Physical View (Source: ARC-IT)

Personal defines the equipment, which are used by passengers to access the transportation services. Vehicle defines the physical entities that include driver information and safety systems. The hierarchy of the subsystems of physical view is depicted in Figure 70.

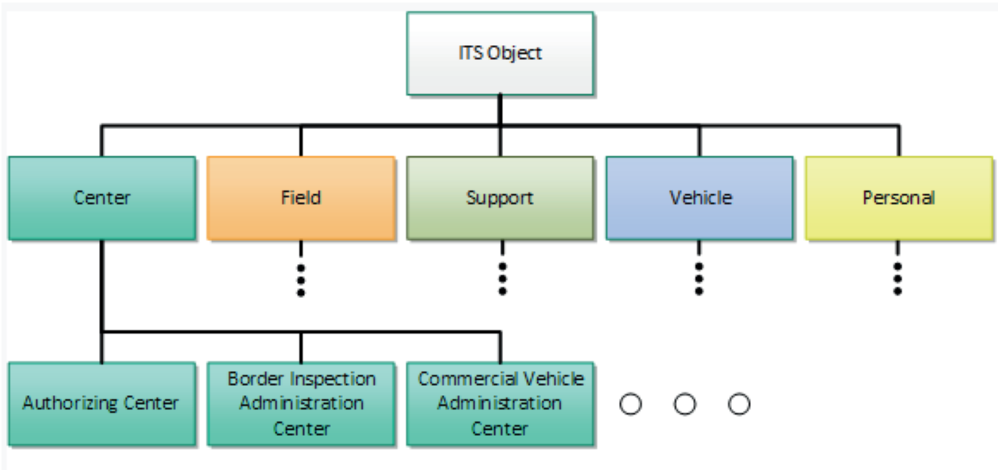

Figure 70. Hierarchy of Physical View Classes (Source: ARC – IT)

Communication view provides the framework for the exchange of information between physical objects. This view aims to determine the communication protocols to be utilized. These protocols are used for foreseeing the possible problems and their impacts of utilizing such protocol, controlling the gaps in data usage, communication functionality, safety and management and determining the corporations which will be responsible about data, communication, safety and management standards.

This view evaluates the necessities and needs of cooperation process of the equipment in the ITS architecture while providing the foundation for the data and information exchange between these equipment.

3.5.2 ITS Applications in the United States of America

Advanced Traffic Management Services (ATMS)

There are various Advanced Traffic Management Services technologies and applications throughout the highways of the US. Some of the examples of these services are Variable Speed Limits (VSL), Ramp Metering, Queue Warning, Dynamic Lane Control and Dynamic Shoulder Use.

Variable Speed Limits are applied throughout the highways of the US in order to harmonize the speed limit according to the changing road and traffic conditions. It has been reported by ITS JPO that VSL reduced traffic accident rates in I-77 highway in Virginia by half. Variable Message Sign– (VMS) can be seen which are utilized to enforce VSL and other traffic management strategies (USDOT, 2021). (See Figure 71)

Figure 71. Variable Message Sign in USA

Ramp metering is utilized in many highways' mainline entrances in the US. Ramp Metering, as opposed to fixed time, are applied by adaptive algorithms and mitigates the delays and traffic congestion throughout the highways of the US. A Ramp Metering application is shown in Figure 72.

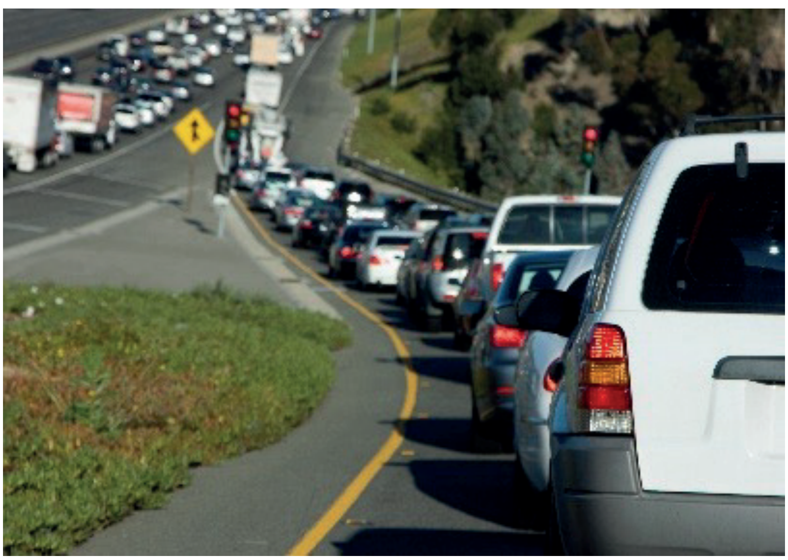

Figure 72. Ramp Metering Application in USA

In last years, the concept of lane management for improving traffic management has gained popularity in the US. Lane management is applied by allowing only certain types of vehicles to enter certain lanes. The examples to those can be given as Truck Only Toll Lane (TOT Lane) and High Occupancy Vehicle Lane (HOV Lane). HOV Lanes are applied to incentivize ridesharing. The aim of the application is to mitigate traffic congestion and increase the capacity of the roadways. An example of HOV Lane entrance sign is depicted in Figure 73.

Figure 73. HOV Lane Entrance Sign

The establishment of Traffic Management Centres dates back to 1960s in the US. Speed data, traffic congestion, weather condition and traffic events are collected and processed in these centres. The Traffic Management System deployed at I-66 highway in Northern Virginia can be given as an example for the best practices. The system covers approximately 20 kms length, and the primary ITS strategies such as VSL, Hard Shoulder Running (HSR) and Lane Use Control Signals (LUCS) are implemented throughout the highway. HSR allows shoulder lanes to be dynamically opened depending on the road and traffic conditions by the Traffic Operations Centre. LUCS are used to warn drivers about lane blockages in advance of the blockage. In Figure 74, a Traffic Operation Centre from Virginia is depicted.

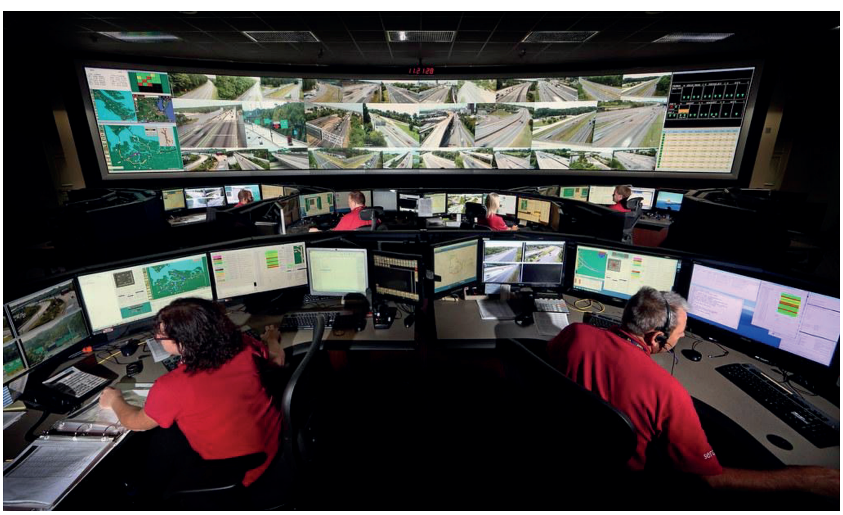

Figure 74. Traffic Operations Centre

In Freeway Network of the US, more than two thirds of miles are covered by CCTV cameras which are used for monitoring the traffic. 71% of the transportation agencies use radars in freeways and bluetooth probe readers are used by 27% percent of the agencies. 60% of the signalized intersections in arterial roads in the US are monitored by CCTV cameras (USDOT ITS JPO, 2020c).

Electronic Toll Collection Systems (ETCS)

In various spots in highway network of the US, Electronic Fare Collection Systems (ETCS) are implemented. ETCS consists of four subsystems: Automatic Vehicle Classification (AVC), Violation Enforcement System (VES), Automatic Vehicle Identification (AVI) and transaction processing systems.

AVC are utilized by laser detectors, infrared detectors or inductive loops. The purpose of VES is to detect the evading of toll by the infrastructure users with the help of automated license plate recognition systems. Other application methods of VES are police enforcement and toll gates. Automated license plate recognition systems serve both video tolling and enforcement services. AVI systems are used in order to charge the customers based on the vehicle type. The primary AVI systems include bar-coded labels, proximity cards, automated plate recognition and radio or infrared transponders. Most of the AVI systems are utilized by RFID and automatic plate recognition systems in the US (Texas A&M Transportation Institute). An electronic toll collection gate from the US is shown in Figure 75.

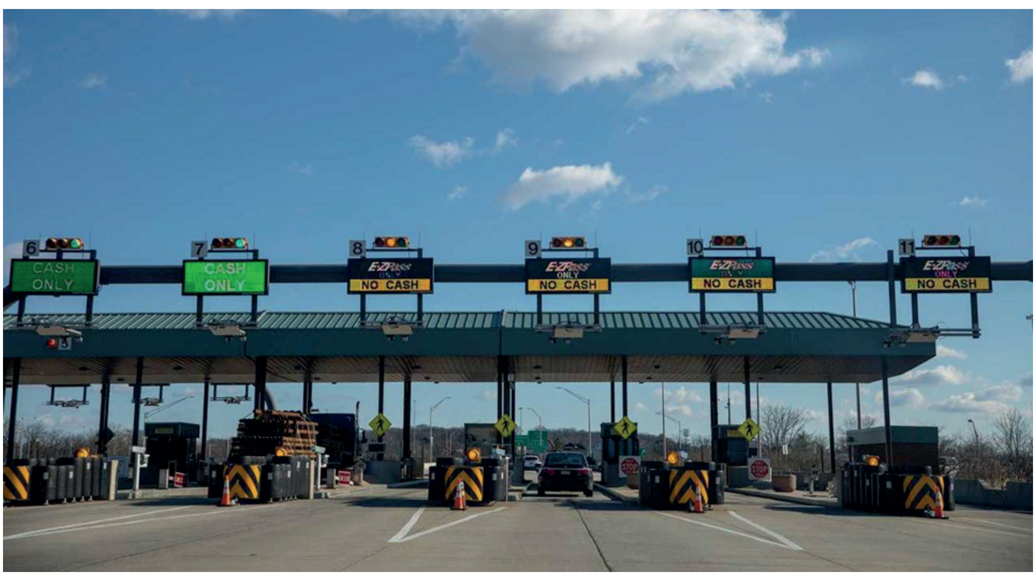

Figure 75. Electronic Toll Collection Gate in the US

Another way of electronic toll collection which is applied in US is toll collection via mobile applications. Georgia State offers electronic toll collection system via "Peach Pass Go". The user interface of the application is depicted in Figure 76.

Figure 76. User Interface of Peach Pass Go

In order to increase the quality of life in city centres by decreasing private vehicle transportation and their environmental effects, in several areas in the US, toll collection policies are being conducted. The aim of these applications is to balance the modal share throughout all modes in city centres and especially to increase the modal share of public transportation and cycling. In arterial roads in the US, in the case of traffic congestion High Occupancy Toll Lane (HOT Lane) application is utilized, and drivers who use these lanes are subjected to toll collection. An example of HOT Lane can be seen in Figure 77.

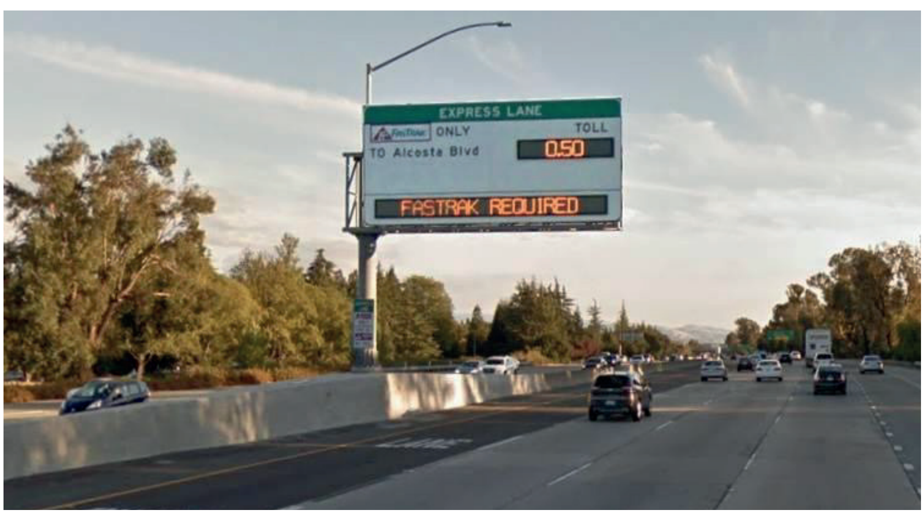

Figure 77. High Occupancy Toll Lane Sign

Advanced Traveler Information Systems (ATIS)

Various traveler information systems in the highway network of the US are applied. The most prevalent system for traveler information in freeways of the US are Dynamic Message Signs which are used by 96% of the freeway agencies. A DMS from highway network of the US can be seen in Figure 78. It is followed by social media and websites which are used in 81% and 80% across the freeway agencies, and 38% and 35% across freeway and arterial agencies, respectively. Amongst all the freeway agencies in the US, 28% resort to use of mobile applications, and 22% of the arterial agencies use mobile applications (USDOT ITS JPO, 2020c).

Figure 78. Dynamic Message Sign

Traditionally, 511 systems and highway advisory radio (HAR) systems are used for traveler information across highway network of the US. 511 systems are nationwide traveler information systems which supply information via "511" telephone number.

Traveler information systems in the US provide information about traffic, transit systems, incidents, events and parking. Emergency traveler information and traveler services information are also supplied. Services that are provided by these systems throughout the US are single and multi-modal trip planning, route options and route guidance.

In San Francisco, SFPark mobile application is used in several parking lots. The application provides pricing information about parking lots and utilizes a pricing method directing the users to less preferred parking lots. The user interface of the application is depicted in Figure 79.

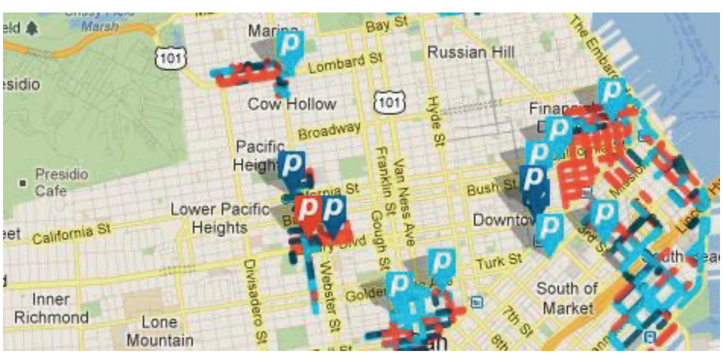

Figure 79. User Interface of SFPark

Advanced Public Transportation Systems (APTS)

Transit agencies in the US provide information to public transportation users via various methods such as websites, social media, mobile applications, e-mail, SMS, DMS in stations, stops and vehicles, 511. The most prominent real-time traveler information method used by agencies in US are mobile applications which 75% of the transit agencies throughout the metropolitan areas of the US are using. 72% of the agencies are using websites and 67% of the agencies are using social media for supplying traveler information to public transportation users. DMS are also a significant actor in providing information to public transportation users. As of 2020, 55% of the transit agencies are equipped with DMS in their stations and 25% of the agencies provide service via DMS in vehicles. In in-vehicle traveler information technologies, the most prominent method is Automatic Voice Announcement (AVA) systems, which are equipped in 84% of the transit agencies. Dynamically updating information displays are equipped in 42% of the transit agencies (USDOT ITS JPO, 2020d).

UBER is one of the primary ridesharing applications used in the context of public transportation. Via UBER, passengers which aim to travel to close proximities match and share the ride, and transportation cost is reduced which can be paid via the application. LYFT is another ridesharing application, which is similar to UBER. User interface of LYFT application is shown in Figure 80.

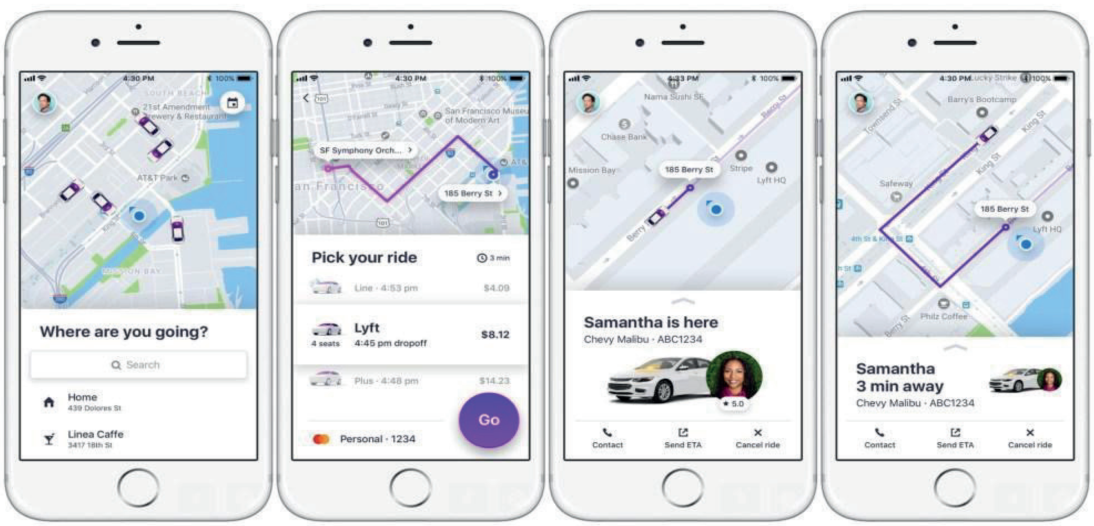

Figure 80. User Interface of LYFT Application

Transit Now is one of the popular public transportation mobile applications in the US which provides route guidance, real time bus arrival and location data to the users. User Interface of the application is depicted in Figure 81.

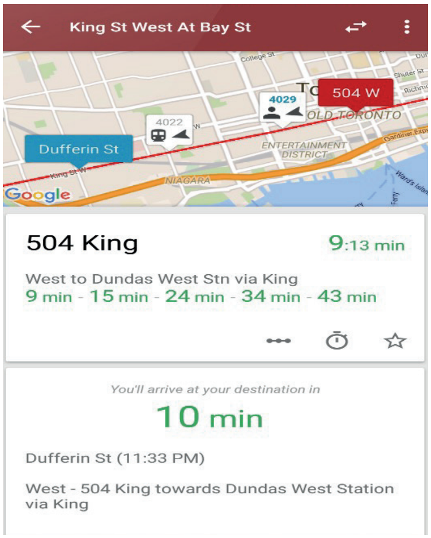

Figure 81. User Interface of Transit Now

The most prevalent technologies which are used in public transportation vehicles in transit agencies in the US are Automatic Vehicle Location (AVL), Computer Aided Dispatch Systems (CADS), Mobile Data Terminals (MDT), Automatic Passenger Counters (APC), Maintenance Management Systems (MMS) and Transit Signal Priority (TSP). TSP is used in order to reduce the dwelling time of transit vehicles at traffic signals by lengthening the green phase for public transportation vehicles. A transit signal in the US is shown in Figure 82.

Figure 82. Transit Signal in USA

Emergency Management System (EMS)

The US has had the singlified nationwide emergency call number 9-1-1 since 1968. 9-1-1 Emergency Line helps dispatching all emergency entities such as police, fire, medical, coast guard. Next generation 9-1-1 project started in 2003 with the purpose of enhancing the current emergency management system. US DOT ITS program has delivered the design for the next generation 9-1-1, aiming to provide faster delivery of first responders and more accurate information to public and first responders. This will be made possible by supporting the data by images and videos as opposed to traditional 9-1-1, achieving a better data transfer process and enabling the call access between public safety answering points (USDOT ITS JPO).

Response, Emergency Staging, Communication, Uniform Management and Evacuation (R.E.S.C.U.M.E.) is a set of ITS application systems aimed at emergency management by informing information in the event of an accident. RESUME consists of four systems: Advanced Automatic Crash Notification Relay (AACN-RELAY), Scene Pre-Arrival Preparation Guide for Emergency Responders (RESP-STG), On-Scene Work Zone Alerts for Drivers and Workers (INC-ZONE), and Evacuation Emergency Communications (EVAC) (Battelle Memorial Institute, 2012). Representation of R.E.S.C.U.M.E. can be seen in Figure 83.

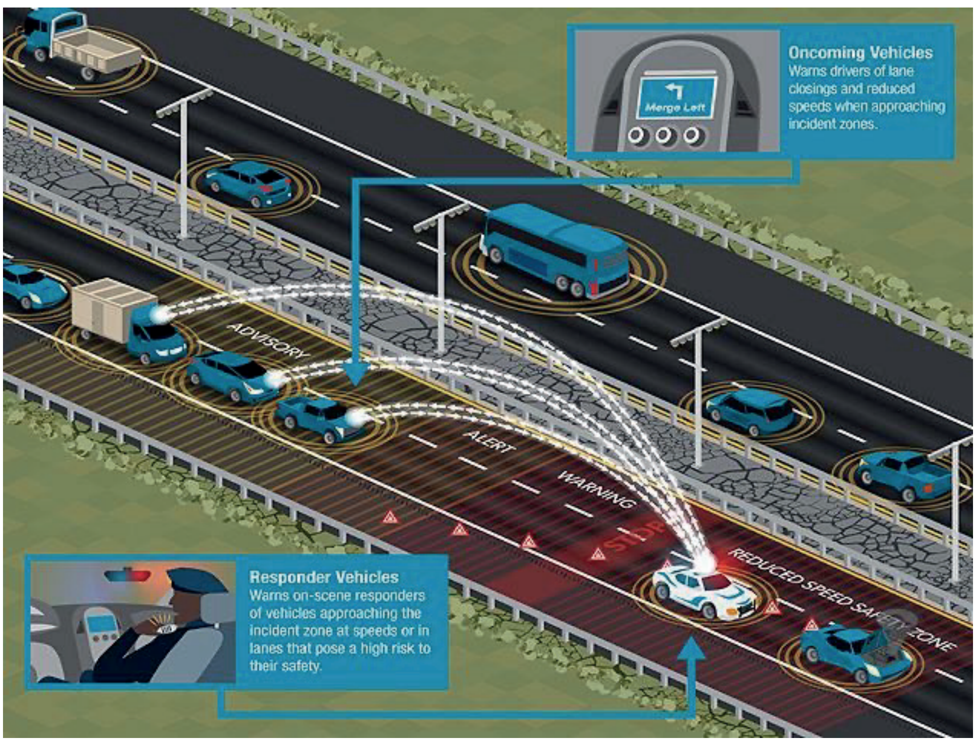

Figure 83. R.E.S.C.U.M.E. Application (Source: USDOT ITS JPO)

3.5 Comparison of the Case Studies

This section compares case studies from OIC Member Countries in terms of planning and development, implementation and operationalization, monitoring and evaluation strategies and actions of the sample countries, and non-OIC non-member countries of the US as best practice.

Türkiye has made significant progress in its transportation infrastructure in the 100 years since it was founded in 1923. Road networks increased from 18,300 kms in 1960 to 70,000 kms in 2022. Türkiye has reached important milestones especially in the last twenty years and charted a course towards continuous development. In the IT, communication technologies and transportation sectors. As predicted in the 2022 Transportation and Logistics Master Plan, Türkiye's passenger and freight mobility will continue to increase in the next 30 years.

Türkiye has already prepared 2020-2023 Intelligent Transportation Systems Strategic Action Plans and determined its national goals for reaching quality standards and ensuring the prevalence of ITS applications. With the Action Plan, ITS vision of the country has been created, and five strategic objectives have been determined within the scope of the mission. In line with these strategic objectives, it was aimed to carry out thirty-one actions. For each action, responsible organization has been also determined. Systematic monitoring of implementation and effectiveness of strategies stated in Action Plan, SEPSİS (Strategy and Action Plan Monitoring and Evaluation System) System will be used (Republic of Türkiye Ministry of Transport and Infrastructure, 2020).

As another mid-level income country, Malaysia have shown promising improvement in ITS area especially in the last 25 years after the release of ITS Strategic Plan in 1999. The ITS Master Plan was released in 2004 with the goals of advancing the ITS Strategic Plan's work and providing more precise guidance, direction and framework for the development and implementation of ITS in Malaysia. Then, in 2007, as a continuation of the ITS Master Plan, the Ministry of Works released the ITS Architecture. The System Architecture offered a comprehensive account of the interactions between roadside devices, control centres, vehicles, and travelers, thereby creating a unified framework for the coordinated implementation of ITS in Malaysia. Lastly, The Malaysian ITS Blueprint (2019-2023) was published in which the way forward for collaboration and integration is explained in the development of ITS in Malaysia. In 2019-2023 ITS Blueprint, there are five objectives that have been specified to be achieved which are Seamless Intelligent Mobility, Congestion-Free Network, Safety, Commercial Vehicle Operation and Collaboration between Agencies. In the Blueprint, also the service packages have been also defined. All the applications which are in the service packages are not in action today in Malaysian road networks, but the roadmap is constructed by the documentations. There are, however, key challenges, issues and needs about the development of ITS in Malaysia. The ITS deployments mainly are concentrated around Klang Valley in Malaysia, the deployment and applications of such systems that are exemplified in this section must be made prevalent throughout the country. In addition, the inter-operability and coordination of the systems must be developed. Malaysia have reached a significant point in means of application of ITS in-road networks, but the development of strategies and continuity of deployments must be ensured.

On the other hand, as an oil exporting country Iraq's major cities suffer from traffic congestion, pollution and traffic safety vulnerabilities because of the inadequacy of transportation infrastructure and the fact that there have not been major infrastructure improvements over the years and the scarcity of ITS applications in the road network of the country. The number of private vehicles is increasing day by day in Iraq; however, the investment on ITS are proven to be scarce and incompetent. As seen from the academic literature, there are several studies focused on mitigating the transportation problems of Iraq by the implementation of various ITS applications in the road networks of major cities of Iraq, although there has not been lack of planned deployment strategies. There have been various applications such as reactivating the traffic signals in Baghdad and deployment of radars and CCTV cameras; however, such applications need to be extended and supported also with infrastructure development to provide a sustainable transportation in Iraq's major cities.

The Gambia, as an African country, has very primary needs and necessities to improve urban and intercity transportation systems. The road network needs to be expanded, capacities should be increased and maintenance work in the transportation infrastructures need to be promoted. The implementation of ITS in-road networks of The Gambia are very limited and does not exceed few applications of traffic signals and traffic cameras. There have not been applications of various communication technologies in managing the traffic in The Gambia's urban areas. However, there is ambition to improve the current situation, as mentioned in the "Improving Human and Institutional Capacity for the Development of an Institutional Framework for Intelligent Transportation System (ITS) in The Gambia" project. Similar projects must be carried out to provide a background for implementation of ITS in The Gambia's road networks.

In this study, the US has been selected as a developed country where best practice applications in ITS can be evaluated. The US with the strength of its legislative and political background, investment in research and development, ITS architecture and standards, are one of the pioneers worldwide in the matter of ITS. In the last 10 years, 2015-2019, 2017-2021 and 2020-2025 Strategic Plans have been released, and the US have set their goals for continuous improvement of ITS in terms of deployment, strengthening the architectural background, supporting research and development and monitoring and evaluation. Many developed and developing countries in the world have reached significant milestones in the matter of ITS; however, the US proves itself to be one of the prominent countries in the matter, mainly because of the strength of the country in research and development, strength the structure of ITS architecture and standards and the legislative and political structure.

When the situation is evaluated in terms of ITS, it becomes clear that countries should have forward-looking plans and road maps in parallel with technological developments. Below Table -2 shows the existence of such plans comparatively.

Table 3. Guiding Principles Examination for Case Study Countries

	USA	Türkiye	Iraq	Malaysia	The Gambia
Planning and Development					
Operational plan for ITS integration	X	X	N/A	X	N/A
Stakeholder engagement	X	X	N/A	X	N/A
ITS architecture	X	N/A	N/A	X	N/A
Enterprise view	X	N/A	N/A	X	N/A
Budgetary plans for ITS development	X	N/A	N/A	X	N/A
Human resource capabilities	X	N/A	N/A	N/A	N/A
Aligning ITS initiatives with global standards and frameworks	X	N/A	N/A	N/A	N/A
Implementation and Operationalization					
ITS implementation activities					
(Deployment Strategies)	X	X	N/A	X	N/A
Policy advocation ITS Development	X	X	N/A	X	N/A
Monitoring and Evaluation					
Governance structure for ITS	X	X	N/A	X	N/A
Establishing criteria and metrics for evaluating ITS impact	X	X	N/A	X	N/A
Monitoring ITS operational performance	X	N/A	N/A	N/A	N/A
Updates of ITS strategies	X	N/A	N/A	N/A	N/A
Developing a framework for continuous improvement	X	X	N/A	X	N/A

CHAPTER 4:

POLICY RECOMMENDATIONS

4.1. Planning and developing a national ITS Strategic Plan for smooth acceleration and coordination of ITS Deployment in the OIC Member Countries

An Intelligent Transportation System (ITS) Strategic Plan is a framework that must be developed at the national level to accelerate and coordinate the deployment of ITS applications. The primary objective of the Strategic Plan is to ensure the compatibility and interoperability of systems developed within the ITS framework, facilitate the continuity and accessibility of ITS services for society, and promote more sustainable transportation. A review of case countries reveals discrepancies in their approach towards ITS deployment. To ensure a unified approach to ITS development among OIC Member Countries, each nation should develop its own ITS Strategic Plan to foster the smooth acceleration and coordination of ITS deployment.

A comprehensive ITS Strategic Plan is essential for establishing a national level ITS architecture. This architecture will define the interactions between the physical components of transportation systems, including travelers, vehicles, roadside devices, and control centres. Furthermore, it will specify the necessary functions assigned to system elements to ensure interoperability, seamless information flow, and standardization of equipment within the ITS ecosystem. An ITS architecture also clarifies the relationship between ITS standards, services, functions, and technologies. For the development of a national level ITS architecture, the following actions should be taken into consideration:

1. **Determining ITS Architecture:**

    - Analyzing best-practice countries: Analyze the ITS deployment strategies of leading countries such as the US, the UK, Japan, Republic of Kore and Germany. This comparative study will provide insights into successful implementation models and potential challenges.
    - Specifying the country's specific needs
    - Defining the roles and responsibilities of key stakeholders, including government agencies, private sector partners, and academic institutions

2. **Developing National ITS Architecture:**

    - Defining service packages: Develop specific service packages for critical ITS functions, such as traffic signal control, congestion management to meet the needs.
    - Specifying the framework: Select and specify the framework or standards that will be used to develop the national ITS architecture, ensuring consistency and interoperability.
    - Defining the methodology: Establish a clear methodology for the design, development, and deployment of the ITS architecture.
    - Addressing security: Develop a comprehensive approach to addressing security concerns throughout the architecture, including data protection, system resilience, and cybersecurity measures.

3. Fostering collaboration and engagement of stakeholders:

- Training and knowledge sharing: Organize stakeholder training sessions to build capacity and enhance understanding of ITS technologies and applications. Knowledge-sharing sessions will help create a unified approach and foster innovation.
- Seminars and Conferences: Facilitate regular seminars, workshops, and conferences to bring together experts, officials, and stakeholders to promote collaboration.

4.2. Developing standards for ITS architecture to ensure interoperability, seamless information flow and standardization of equipment within the ITS ecosystem

A critical objective in the formulation of ITS architecture is ensuring the interoperability of services across various components, subsystems, and stakeholders. Achieving this interoperability necessitates the development and adoption of comprehensive standards. These standards define the interconnectivity, data-sharing protocols, and service delivery mechanisms for systems, devices, and products operating within a transportation network. Essentially, ITS standards are the technical specifications that facilitate communication between different ITS components, enabling them to function cohesively. Through a common communications interface, ITS standards enable direct data exchange and interpretation between similar and dissimilar ITS devices and equipment.

For achieving interoperability, seamless information flow and standardization of equipment within ITS ecosystem, first of all ITS standards should be examined, classified and following actions should be taken into consideration:

- Conducting comprehensive analysis of current standards
- Identifying relevant standards for ITS
- Incorporating relevant standards into the ITS Architecture

For future merging and integration throughout OIC Member Countries, it is recommended to develop common standards for ITS. It is for sure that collaborating on standards based ITS initiatives can significantly expand the scope and impact of ITS infrastructure investments of OIC Member Countries.

4.3. Developing/Improving monitoring and evaluation systems to assess the effectiveness of ITS implementations

To ensure the continuous development of ITS, it is essential to implement a monitoring and evaluation system aiming at assessing the effectiveness of deployed ITS equipment. Through such a system, the current state of ITS investments can be monitored, identifying gaps that need to be addressed for the formulation of ITS development strategies. It would be beneficial for OIC Member Countries to adopt these deployment monitoring studies to track the implementation processes of ITS and evaluate progress towards strategic objectives. Conducting regular monitoring, as mentioned above, will enable authorities to assess ITS progress from various perspectives.

The US is a good example in best practices for monitoring and evaluation studies. Since 1999, the US has conducted ITS Deployment Tracking Surveys through the ITS Joint Program Office (ITS JPO), focusing on arterial, highway, and public transport management. These surveys are conducted every 2-3 years, targeting transportation agencies in the US metropolitan areas. Such surveys outlined by the ITS JPO are also recommended for OIC Member Countries, for tracking and evaluating the various implementations of ITS.

It is also recommended to conduct benchmark comparisons in OIC Member Countries using the outcomes of monitoring and evaluation studies. This approach will allow transportation authorities to recognize their strengths and weaknesses compared to their peers in the ITS field, facilitating improvements by learning from better practices. For these benchmarking studies, it is suggested to establish performance indicators related to specific performance categories. The proposed performance indicators, grouped under the categories of data collection, traffic management, traveler information and safety, are presented in Table 3.

Table 4. Performance Indicators

Performance Cate-gory	Performance Indicator	Description
1.Data Collection	1.1 Real-Time Data Collection by All Technologies	Rate of area covered by all real-time data technologies to all the area covered by the agency (%)
	1.2 Real-Time Data Collection by Roadside Infra-structure	Rate of area where roadside infrastructure data technologies such as inductive loops, radar/microwave detection, or video imaging detection are used to all the area covered by the agency (%)
	1.3 Real-Time Data Collection by Vehicle Probe Readers	Rate of area where vehicle probe reader data technologies such as bluetooth readers, toll tag readers, cell phone readers are used to all the area covered by the agency (%)
	1.4 Data Collected by Outside Sources	Does the agency collect data from outside sources? (Yes = 1, No = 0)
2. Traffic Man-agement	2.1 CCTV Deployment	Is there deployed CCTV by the agency for monitoring the traffic flow? (Yes = 1, No =0)
	2.2 Adaptive Signal Control Technology (ASCT)	Does the agency use Adaptive Signal Control Technology in arterial road network? (Yes =1, No =0)

2. Traffic Man-agement	2.3 Emergency Vehicle Signal Preemption	Is there deployed Emergency Vehicle Signal Preemption Technology in Signalized Intersections? (Yes =1, No =0)
	2.4 Transit Signal Priority	Is there de-ployed Emergen-cy Transit Signal Priority Technol-ogy in Signalized Intersections? (Yes =1, No =0)
	2.5 Signal Preemption in Rail Grade Crossing	Is there de-ployed Emergen-cy Signal Preemption in Rail Grade Cross-ing Technology in Signalized Intersections? (Yes =1, No =0)
	2.6 Service Patrol Coverage	Rate of area covered by service patrols to all area covered by the agency (%)
	2.7 Integrated Corridor Management	Is there deployment of Integrated Corridor Management (ICM)in arterial roads? (Yes =1, No =0)
3. Traveler In-formation	3.1 Traveler Information by Singlified Phone Number	Does the agency provide traveler information by a singlified phone number? (Yes =1, No =0)
	3.2 Crowdsourcing	Does the agency provide traveler information by a crowdsourcing? (Yes =1, No =0)
	3.3 E-mail or SMS	Does the agency provide traveler information by a e-mail or sms? (Yes =1, No =0)
	3.4 Mobile Application of the Agency	Does the agency provide traveler information by a developed mobile application of the agency? (Yes =1, No =0)
	3.5 Third Party Mobile Application	Does the agency provide traveler information by a third party mobile application? (Yes =1, No =0)
	3.6 Dynamic Message Signs	Does the agency provide traveler information by dynamic message signs? (Yes =1, No =0)

3. Traveler Information	3.7 Websites	Does the agency provide traveler information by websites? (Yes =1, No =0)
4. Safety	4.1 Speeding	Is there automated enforcement for speeding violations? (Yes =1, No =0)
	4.2 Red Light Running	Is there automated enforcement for red light running violations? (Yes =1, No =0)
	4.3 School Zone	Is there automated enforcement for school zone violations? (Yes =1, No =0)
	4.4 Pedestrian Warning Systems	Is there deployed Pedestrian Warning Systems by the agency? (Yes =1, No =0)

Besides surveys and benchmark studies, ICT tools can also be used for streamline data collection, improve transparency, and enhance the efficiency of project tracking and evaluation processes. For example, Türkiye has implemented the "Strategy and Action Plan Monitoring and Evaluation System – SEPSİS" to monitor and evaluate deployed ITS, setting strategic objectives in two strategic action plans to serve as performance criteria for evaluation. SEPSİS is an application designed for the systematic collection of data and the efficient execution of monitoring activities. It allows all responsible and relevant institutions/organizations to access it through the internet.

Incorporating user experience assessments within the scope of ITS services is a critical component of effective monitoring and evaluation. Understanding how end-users perceive and interact with ITS applications can provide valuable insights that drive improvements in system design and service delivery. Various methods can be employed to gather this feedback, ensuring a comprehensive understanding of user needs and satisfaction levels. For instance, mobile applications or kiosks can be deployed to collect real-time user evaluations of ITS services. These platforms offer a convenient way for users to provide feedback during or immediately after their experience, capturing immediate impressions and reactions. More detailed feedback can be obtained through in-depth methods such as face-to-face interviews or focus group discussions. These methods enable a richer understanding of user experiences by exploring their specific pain points, preferences, and suggestions for improvement.

4.4. Implementing ITS to promote sustainable smart mobility in transportation to minimize environmental impacts and maximize efficiency.

Sustainability is an important issue, especially concerning the effective, equitable and long-term utilization of resources. In this context, the United Nations (UN) introduced 17 interrelated social, economic and environmental goals in 2015, which have been globally adopted and whose outcomes are mutually influential. There goals are intended to be achieved by 2030 with particular emphasis on eliminating poverty, protect the planet and ensure that all people enjoy peace and prosperity. One of the sustainability goals established by the UN is to develop sustainable cities and communities. The growing urban population, particularly due to increased migration from rural areas to large cities, necessitates the formulation of new policies to enhance urban sustainability. Implementing ITS and investing in public transportation to ensure reliable mobility for populations within and between cities are increasingly important aspects of sustainable smart mobility.

To achieve sustainable smart mobility with the use of ITS in order to minimize environmental impacts while maximizing efficiency, the following actions should be taken into consideration:

- Adoption & wide usage of ITS applications: Advanced Traveler Information Systems (ATIS) can enable individuals to utilize transportation systems continuously and effectively. Furthermore, within the framework of Advanced Public Transportation Systems (APTS), another application of ITS, the implementation of safety systems can contribute to the reduction of transportation-related accidents and fatalities. In addition to that it is crucial to develop and expand smart parking applications. These applications play a key role in saving both time and fuel by streamlining parking processes.
- Investing in intelligent infrastructure: ITS applications collect and analyze real-time data from sensors, cameras, and radars to improve the daily traffic management of cities and transportation authorities via the Internet of Things (IoT). For example, traffic lights that automatically adjust their timing based on sensor data can improve traffic flow or be modified to ensure the safety of other road users. To meet the communication needs of ITS systems, it is essential to:
    - Execution of the necessary investments in communication infrastructure. Advanced communication systems, such as fiber optic cables, wireless networks, and 4G/5G technologies, should be prioritized.
    - Secure transmission of traffic data, especially against cyber threats, is crucial. Therefore, the communication infrastructure should be supported by robust security protocols.
- Reducing environmental pollution and carbon emissions: This is achievable by mitigating traffic congestion through ITS applications. To decrease carbon emissions, it is crucial to:
    - Promoting the use of clean vehicles, such as electric vehicles and in road transportation, and implement policies and practices supporting this transition.

- Increasing the number of refueling and charging stations to ensure uninterrupted transportation. These services can be monitored through sensors and cameras, providing reliable information to end-users via Geographic Information System (GIS) platforms, enabling them to locate charging points.
- Promoting the widespread use of public transportation is essential for reducing traffic congestion, lowering carbon emissions, and enhancing sustainable smart urban mobility.

4.5. Providing safe, comfortable, affordable and accessible transport systems by taking into consideration disadvantaged groups

Social inclusion and propositions provide safety, comfort, and use of affordable and accessible transportation systems for all people in society, while also being a critical building block in urban transportation systems. With this feature, it aimed to popularize public transportation; It has brought a solution to an important and sensitive issue for women, children, disabled people and the elderly.

To meet the requirements of social inclusion with ITS, the following actions should be taken into consideration:

- Determining the needs of vulnerable groups in terms of ITS and present solutions
- Identifying physical, cognitive and technological barriers that may prevent these groups from using ITS effectively, such as inaccessible transportation hubs or the lack of digital literacy.
- Determining the projects to enhance the social inclusion of vulnerable groups in terms of ITS.
- Developing pilot programs for increasing their mobility through ITS
- Promoting special services for vulnerable groups to easy access such as:
    - Public transportation systems with internal communication systems that provide both written and audio information to passengers is a significant feature, as it allows visually and hearing-impaired passengers to benefit from these applications.
    - Door-to-door public transportation services for all disadvantaged groups who have difficulty accessing public transportation is also crucial within the scope of ITS.
    - Demand-responsive transportation service such as mobility service provided by service providers in response to passengers' requests to travel to specific destinations in urban areas. Another example is for individuals who have difficulty verbally expressing their public transportation needs, customer communication cards that inform drivers about their travel requirements can be integrated within the scope of ITS applications (Hughes et al., 2020).

4.6. Promoting capacity building of OIC Member Countries through exchange programs in developing regulatory policies for ITS and setting of ITS infrastructure

For having an applicable ITS, administrative structure needs to be well defined. One of the important building blocks of ITS administrative structure is to develop regulatory policies. Such policies must be developed and operated for implementing ITS Strategic Plan, ITS architecture and ITS standards effectively. Regulatory policies are also necessary for establishing communication infrastructure related to operationalization of ITS systems.

Training programs, workshops and seminars for policy makers and technical staff of less developed OIC Member Countries should be organized for knowledge and experience sharing. Introducing exchange programs for technical staff is an effective way for knowledge sharing on best practices and practical ITS knowledge. These exchange programs can also be tailored for raising awareness in professionals of the Member Countries about emerging technological advances in ITS. Such programs also increase international collaboration and lead to expand network between ITS professionals in OIC Member Countries. Following their return, trained professionals can train the others in their own countries, which leads to increase ITS expertise. These professionals also can take part in building regulatory infrastructure as well as implementation of ITS projects.

Existing ITS regulatory framework can also be shared and adapted for less developed OIC Member Countries through capacity building projects. In addition to that, international conferences and congresses should be organized for promotion of the best practice and dissemination of knowledge.

Increasing public awareness is also important for success and acceptance of ITS initiatives. In this regard, "Awareness Campaigns" can be launched to inform public on the advantages of ITS such as improved safety, reduced traffic congestion and environmental sustainability. These campaigns can utilize through various media channels, including TV, social media and billboards to reach wider audience.

CHAPTER 5:

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CHAPTER 6:

ANNEXES

ANNEX-1
QUESTIONNAIRE FOR SITE VISITS

Interview Form

Intelligent Transportation Systems (ITS) Applications

Interviewee Information:

- Name:
- Position:
- Organization:
- Contact Information:
- Date:

Introduction: Thank you for taking the time to meet with us. We are conducting a study on Intelligent Transportation Systems (ITS) under the Standing Committee for Economic and Commercial Cooperation of the Organization of Islamic Cooperation (COMCEC). Our aim is to understand the current state of ITS in your country, including its architecture, implementations, and challenges. Your insights will be invaluable to our research.

Current View of ITS in Your Country

1. Could you provide an overview of the current state of ITS in your country?

ITS Architecture and Standards in Your Country

1. Is there a national ITS architecture in place? If so, can you describe it?

2. Are there any standards or guidelines that govern the implementation of ITS in your country?

Advanced Traffic Management Services (ATMS) in Your Country

1. What advanced traffic management services are currently implemented?

2. How effective are these services in managing traffic flow and reducing congestion?

Electronic Toll Collection System (ETCS) in Your Country

1. Do you have an electronic toll collection system in place? If so, how does it operate?

2. What are the benefits and challenges associated with the ETCS?

Advanced Traveler Information System (ATIS) in Your Country

1. How does the advanced traveler information system work in your country?

2. What types of information are provided to travelers, and through what channels?

Advanced Public Transportation System (APTS) in Your Country

1. Can you describe the advanced public transportation system in your country?

2. How has APTS improved public transportation services and user experience?

Emergency Management System (EMS) in Your Country

1. What emergency management systems are integrated into your ITS framework?

2. How do these systems help in responding to traffic incidents and emergencies?

Tunnel Traffic Management Systems (TTMS) in Your Country

1. Are there any tunnel traffic management systems in place? If so, how do they operate?

2. What technologies are used to ensure safety and efficiency in tunnel traffic management?

Bridge Traffic Management Systems (BTMS) in Your Country

1. Can you describe the bridge traffic management systems implemented in your country?

2. How do these systems contribute to the safety and efficiency of bridge traffic?

Commercial Vehicle Operation (CVO) in Your Country

1. What ITS solutions are used for commercial vehicle operations in your country?

2. How do these solutions enhance the efficiency and safety of commercial vehicle operations?

Weather Information Systems (WIS) in Your Country

1. How are weather information systems integrated into the ITS framework?

2. How do these systems help in managing traffic and ensuring safety during adverse weather conditions?

Smart Traffic Lights in Your Country

1. What is the current status of smart traffic light implementations in your country?

2. How have smart traffic lights improved traffic management and flow?

Intelligent Parking Systems in Your Country

1. Are intelligent parking systems in use? If so, how do they operate?

2. What impact have these systems had on parking management and congestion reduction?

Vehicle Tracking Systems in Your Country

1. How are vehicle tracking systems utilized in your country?

2. What are the benefits and challenges associated with these systems?

Route Management in Your Country

1. Can you describe the route management systems currently in place?

2. How do these systems optimize traffic flow and reduce travel times?

Incident Detection and Management in Your Country

1. What technologies are used for incident detection and management?

2. How effective are these systems in responding to and managing traffic incidents?

ITS Project Implementations in Your Country

1. Can you provide examples of successful ITS project implementations?

2. What factors contributed to the success of these projects?

ITS Implementations in Highways in Your Country

1. What ITS solutions are implemented on highways?

2. How have these solutions improved highway safety and efficiency?

ITS Implementations in Urban Areas in Your Country

1. How are ITS technologies applied in urban areas?

2. What challenges and successes have been experienced in urban ITS implementations?

Closing: Thank you for sharing your insights. Your input is crucial for our study and will help us develop a comprehensive understanding of the current state and future potential of ITS in your country. If you have any further comments or suggestions, please feel free to share them.