Intelligent Transport Systems (ITS) in Indonesia

Progress, Challenges & Opportunities

2022

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Executive Summary

Through the Directorate of Land Transportation, the Ministry of Transportation continues to encourage innovation through digital transformation by developing a Smart Transportation System or Intelligent Transport System (ITS) to facilitate public transportation users in Indonesia. ITS is believed to make it easier for users of public transportation services, including transportation users with special needs. The ten-year framework for ITS development is based on assessing the responsibilities and capacities of transportation sector players, both public and private. Taking this strategy will ensure that ITS Indonesia's future development goals are a success. The anticipated impacts and advantages of developing this ITS planning framework span three dimensions: the economy, the environment, and quality of life.

Indonesia's ITS framework has been designed around eleven major systems that have the potential to be implemented during the next ten years (2020-2030), as detailed below.

a. Advanced traffic management system
b. Advanced road user information system
c. Advanced traffic safety and vehicle control system
d. Commercial vehicle operating system
e. Advanced public transport system
f. Electronic payment system
g. Emergency management system
h. Advanced rural transport system
i. Advanced travel request management system
j. Advanced parking management system
k. Autonomous Driving System

The development of the mass transportation system carried out must also pay attention to the accessibility of urban public transportation services available 80% of the length of the road. With this target, each region must have a local transportation service network/feeder integrated with the principal network through one urban transportation node. The urban transportation node must also have facilities for pedestrians and park and ride so that changing modes to public transportation is easy and fast. Currently, in 2021, BPTJ (Indonesia Toll Road Authority) has launched an online monitoring dashboard for the implementation of RITJ (in the network) or a special online called the Greater Jakarta Transportation Master Plan Monitoring and Information System (SPIRIT JABODETABEK). This online system can also be used as a database in carrying out evaluations for each period. Through a username and password, all stakeholders who are directly involved in the implementation of RITJ can access and utilize this system. Until the end of 2021, the performance of RITJ is still experiencing problems and has not reached the real target, especially during the pandemic. Transporting passengers, goods, and logistics, either rental or charter, are directly affected, especially the Greater Jakarta Metropolitan Area. The Government policy has caused a decline in passengers that stop public activities and restrict the public from going out of the house for activities like schooling, attending lectures, working, and worship. Since the Indonesian government declared PSBB (semi lockdown) in 2020, urban mobility in GJMA decreased significantly, and no movement (stay at home) increased.

Many efforts to develop public transport are needed to fill the gap. Integration is significant in the use of public transportation. The efforts to organize an integrated transportation system are possible by referring to Presidential Decree (Perpres) Number 55 of 2018 on the Greater Jakarta Transportation Master Plan (Rencana Induk Transportasi Jabodetabek -RITJ) signed by President Joko Widodo. The presence of this Presidential Decree has marked a new chapter in the handling of integrated urban transportation in the Greater Jakarta area, both by the Ministry of Transportation and Regional Governments throughout Jakarta, Bogor, Depok, Tangerang, and the Bekasi. In addition, there is also a policy in public transportation called as Public Transportation Use Promotion Policy. The rising population growth in the urban area has caused an increase in the number of passenger cars, which resulted in insufficient capacity in the road network. One of the critical steps towards alleviating the traffic congestion problem is to increase the number of public transportation users. The current challenges of urban transportation include the high use of private vehicles, both motorcycles and cars. The number of users of public transport modes is still relatively small. In addition to the traffic issues mentioned above, another issue worth noting is the continuously increasing number of vehicle purchases that impacted the travel pattern. It may have resulted from the growing number of automobile sales that offer an effortless and more attractive purchase scheme that has outnumbered the public transportation development. For effective implementation, it is necessary to present the benefits of public transportation effectively and promote its services sufficiently to influence the modal split in favor of public transportation usage.

Despite the introduction of legal rules governing the implementation of ITS with the release of the Minister of Transportation Regulation 76 in 2021 concerning Intelligent Transportation Management Systems in the Road Traffic and Transportation Sector, there are still some obstacles affecting the implementation of ITS in Indonesia. They include low interoperability of the system making it difficult to integrate an ITS-based transportation system, the lack of involvement of relevant agencies to build long-term commitment and awareness of the benefits of the ITS project, political problems, weak coordination between stakeholders, and also the clarity of responsibilities between the central and local government need to be improved. With many projects depending on a budget of the central government, the sustainability of funding is still a problem. Local governments need to take an active role in ensuring the sustainability of transport service.

Chapter 1. General Features on Indonesia

1.1 General Information about Indonesia

Indonesia is the largest archipelagic country globally, located in Southeast Asia. The number of islands owned by Indonesia is 17,508 islands with a total area of 1,904,569 km2. The main islands of Indonesia are Sumatra Island, Kalimantan Island, Java Island, Sulawesi Island, and Papua Island. As the largest archipelagic country in the world, Indonesia is also one of the countries with the longest coastline in the world.

Geographically, Indonesia, which is between the continents of Asia and the continent of Australia, is located between 6°N – 11°08'LS and from 95°'E – 141°45'BT. Besides being flanked by two continents, Indonesia is between the Pacific Ocean and the Indian Ocean and is crossed by the equator. Based on its broad geographical location, the territory of Indonesia is divided into three time zones, namely WIB (Western Indonesian Time), WITA (Central Indonesian Time), and WIT (Eastern Indonesian Time). There can be a time difference of up to 8 hours from one island to another. Indonesia shares land borders with Papua New Guinea on the island of Papua, Malaysia on Borneo, and Timor Leste on the island of Timor. While the countries bordering the sea with Indonesia are Singapore, the Philippines, Australia, and India (Andaman and Nicobar Islands).

The coastline of Indonesia is 99,093 km2. 3 Its land area reaches about 2,012 million km2, and the sea is about 5.8 million km2 (75.7%), 2.7 million square kilometers of which are included in the Exclusive Economic Zone (EEZ). Land areas certainly have enormous potential in terms of natural wealth and environmental services that can be utilized to support economic development at the local, regional, and national levels. Indonesia has a population of 275,122,131 people (2021), making Indonesia the fourth most populous country globally.

CLIMATE

Indonesia has a tropical climate (group A in the Köppen climate classification). The warm waters in Indonesia play a significant role in keeping the temperature on land constant, with the average temperature in the coastal areas of 28 °C, in the interior and highlands of 26 °C, and the mountainous areas of 23 °C. Humidity ranges from 70 to 90%.

The main factor influencing Indonesia's climate is not air temperature or pressure but rainfall. Seasonal variations in Indonesia, namely the rainy and dry seasons, are related to the movement of monsoon winds. The westerly monsoon that blows from Asia to Australia via Indonesia from October to February results in heavy rainfall, especially in western Indonesia. Meanwhile, the east monsoon moves in the opposite direction from April to August, does not carry much water vapor and causes rain. In addition, there is also a transitional season when the sun crosses the equator, which causes the wind to blow weakly and move erratically.

GEOLOGY

Tectonically, most of Indonesia's territory is very unstable because of its location at the confluence of several tectonic plates, such as the Indo-Australian Plate, the Pacific Plate, and the Eurasian Plate. The country is located on the Pacific Ring of Fire, so it has many volcanoes and experiences frequent earthquakes. The volcanic arc runs from Sumatra, Java, Bali, and Nusa Tenggara, then to the Banda Islands in Maluku to the northeast of Sulawesi. Of the approximately 400 volcanoes, around 130 of them are still active.

Until now, transportation technology continues to develop effectively and efficiently according to human needs. The development of transportation technology in Indonesia is strongly influenced by Indonesia's geographical conditions and foreign cultural influences such as Indochinese, Indian and European cultures. Indonesia's geographical state, an archipelagic country with many mountains, presents challenges for the development of transportation technology. Adoption of transportation technology needs to take into account various geographical conditions in different locations in Indonesia.

TRANSPORTATION

Indonesia has many forms of public transportation. Some are non motorized public transportation while the others are more advanced systems. *Becak* (the three-wheeled pedicab) is the most common non motorized public transport mode. In contrast, the *Bajaj* (a motorized pedicab) is the traditional motorized public transportation that can only be found in Jakarta (Tjahjono, 1995). In the '70s, motorized public transport came into operation in medium-sized cities. The big bus is usually operated by the government owned company, PT DAMRI, and it is limited only in the big and metropolitan cities (Tjahjono, 1995). Not only does it provide the big bus, PT DAMRI also has a smaller bus named Angkot. The vehicle can only take up to 10-12 people.

Technological developments in the public transportation system in Indonesia are increasingly advanced. In 2004, PT Transport Jakarta launched the first BuS Rapid Transit (BRT) transportation system in Southeast and South Asia (CNBC, 2021). Transjakarta is designed as a mode of mass transportation to support the busy city activities of Jakarta. Unlike Angkot, where passengers can get on and off along the road, Transjakarta already has shelters that are organized so as not to cause traffic jams along the arterial roads. Transjakarta was established to provide bus-based mass transportation services or Bus Rapid Transit (BRT), including feeder transportation services, by implementing innovation and creativity in realizing quality sustainable growth. Various developments in the management of Transjakarta continue to be carried out, including bus driver vacancies that are open to women, implementation of special zones for women and buses for women, trials of the contra-flow system, and services for users with disabilities under the name "Transjakarta Cares." As of December 31, 2020, Transjakarta has managed 13 corridors with a total length of 584.8 km. Transjakarta has operated 2,789 bus fleets serving 150 routes. Transjakarta recorded that it could transport up to 132,160,074 customers throughout 2020, with a daily average of 362,082 customers per day. Based on the customer satisfaction survey, the modern aspect (including Transjakarta's program in repairing bus stops, improvements in Tije Application which enables customers to make payments by using QR Code) has increased by 0.25%.

Based on the History of Indonesian Railways (Telaga Bakti Nusantara, 1997), in 1842 the Dutch colonial government built a railway line connecting Semarang, Yogyakarta and Surakarta. The railway line construction was carried out by the private railway company Nederlandsch Indische Spoorweg Maatschappij (NISM). This train is called the Commuter Line, which runs using electricity in its development. This Commuter Line operates in 6 major cities, namely Jakarta, Bogor, Depok, Tangerang, Bekasi, and Lebak.

In 2008, the Mass Rapid Transit (MRT) was also built following the government's initiative since 1985. At that time, the MRT project had not been declared a national project. In 2005, the President of the Republic of Indonesia confirmed that the Jakarta MRT project was a national project. Departing from this clarity, the Central Government and DKI Jakarta Provincial Government began to build the MRT. Currently, the MRT is the backbone of public transportation in Jakarta. Since operating, MRT Jakarta has served 34,340,837 service users during 2019 – 2020, with an average of 52,913 service users per day. MRT Jakarta has 13 stations with 6 underground stations and 7 elevated stations. MRT Jakarta stations operate from 05:00 to 24:00 (before the pandemic) and from 05:00 to 22:00 (during the pandemic following the directions of the DKI Jakarta Provincial Transportation Service). MRT Jakarta serves various types of tickets that can make it easier for users to ride MRT—ranging from electronic money cards, Single Trip Tickets (STT) cards, Multi-Trip Tickets (MTT) cards, and QR Code Tickets.

MRT Jakarta continues to maximize non-ticket revenues from several primary sources: advertising services for the Ratangga (from Sansekerta language means 'train') station and train operational areas, outdoor media advertising services for pillar media, telecommunication services, station naming rights, and payment for digital MRT Jakarta tickets, as well as retail. Non-ticket revenue innovation is also applied to the Company's digital assets as a form of MRT Jakarta's commitment to becoming the center of digital economic growth. Efforts that have been made include the development of the Jakarta MRT mobile application. The application is also an alternative for purchasing and paying for tickets through the QR code system, which is part of the Company's commitment to improving services for service users. To support this innovation, the Company has partnered with financial technology companies, namely Dana, LinkAja, OVO, and GoPay.

The construction of the MRT has a significant impact on reducing congestion in the capital city. According to Tomtom Traffic Index data, Jakarta's congestion level has dropped from rank 3 to 31 (Tomtom Traffic Index, 2022). Even so, traffic jams still occur at several points in the capital city of Jakarta. One of them is on Toll Road. In response, the Government continues to innovate to tackle congestion and promote a healthy environment.

Light Rail Transit (LRT) was then built in 2017 on several roads, namely Cibubur, Cawang, East Bekasi, and Dukuh Atas. In addition, there is also LRT planning in Jabodetabek (Greater Jakarta) expected to make commuter trips in this urban oligomerization area more effective and efficient. To be directly operated by Kereta Api Indonesia (KAI), the system will connect the Jakarta city center with suburbs in Greater Jakarta such as Bogor, Depok, and Bekasi. As of September 2021, the progress of the Jabodebek LRT reached 94.36 percent with the following details: Cross Service I Cawang-Harjamukti by 98.98 percent, Cross Service II Cawang - Dukuh Atas by 90.7 percent, Cross Service III Cawang - Jatimulya by 91.8 percent, Station access 42.71 percent, Depot construction 51.39 percent, Facilities 64.70 percent and Integration 35.49 percent.

1.2 Why ITS is needed?

Intelligent Transportation System is principally the application of advanced technology in electronics, computers, and telecommunications combined with strategic management principles to improve the overall function of transportation. The four components are the means of transport (vehicle), users (users), infrastructure, and communication systems. This system can provide information to the owner of goods or passengers as well as transport operators in such a way that the transportation process can run effectively and efficiently. In Indonesia, ITS implementation has been started in Jakarta since 2010. Jakarta is one of the cities in Indonesia that has started to develop and implement an Intelligent Transportation System, namely the DKI Jakarta Transportation Agency, in collaboration with the DKI Jakarta Provincial Government, Jakarta Transportation Council, and PT. Transjakarta.

An ITS manages and uses data sources that are shared between various information management systems that generally use several tools, namely through CCTV, Auto Traffic Control System (ATCS), and Camera Counting. Through this system, the government hopes that transportation can work effectively and efficiently. The government's idea is responsive enough to answer the community's need to solve congestion in Jakarta. But unfortunately, the implementation of this system is not accompanied by education to the public. The community certainly hopes that the government can seriously develop this system. Some of the performances have already been realized, and some are still in process. The ITS concept will be refined and developed in other areas in DKI Jakarta and become the basis for preparing the ITS Grand Strategy in DKI Jakarta in 2019. Previously, in 2011, the DKI Jakarta Transportation Agency conducted a study on improving the 2012 DKI ITS Grand Strategy Development. Intelligent Transportation System Technology (ITS) is a technology that has only been developed in recent years to overcome traffic congestion in several developed countries. The ITS application in DKI Jakarta is currently still being carried out partially and has not been integrated into a whole unified system.

In its application, the development of ITS can depart from the application of the technology groups offered, such as ATIS, ATMS, etc. However, for adjustment to the management group, a vision of a high-level logic architecture (logical architecture) can be developed which groups the needs of certain stakeholder features in ITS management. An architectural description can be given, as shown in the following figure.

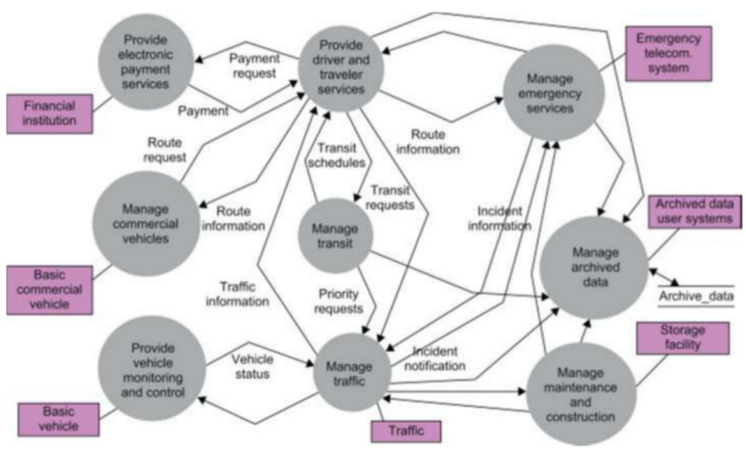

Figure 1.1 High-Level ITS Logic Architecture
Source: Khan, 2017

The application of process features in the logic architecture is carried out by sensor systems, computing systems, and communication systems that can be grouped according to interests and locations where stakeholders or components of transportation assets are located. Figure 1.1 shows the physical architecture in the form of (sub) systems and communications that support the logical process architecture it supports, from the perspective of stakeholders or assets: drivers, vehicles, roads/tolls, management control center.

ITS aims to integrate road users, transportation systems, and vehicles through information systems and communication technology and help the transportation system as a whole work effectively and efficiently.

According to Kusnandar (2011), the purpose of the ITS system is to reduce traffic congestion, reduce travel time, improve safety, improve environmental quality, and ultimately have an impact on increasing economic productivity. Sharing this information allows road users to learn more about the problems and the more significant benefits with less impact on the environment. Some of the benefits of applying the ITS system to road transportation systems are as follows:

1. Enables vehicles to communicate directly with the infrastructure around them, allowing the drivers to make better decisions about the route chosen and respond to warnings about congestion and accidents that occur;
2. Keep vehicles at a safe distance from each other;
3. The driver is informed of the speed limit that he must do
4. Informing the driver of the signs of fatigue and at the same time informing him that it is time to take a break;
5. Provide public transportation users with information on service times (departure, arrival, and other obstacles) as well as ticket provision;
6. Integrate public transport into the traffic management system, prioritizing buses and trams;
7. Enable public transport operators and customs authorities to share information about consignments and track their position and status, as well as provide information on the most efficient, economic and safe routes for carriage;
8. Improve the efficiency of passenger and freight transport and reduce congestion on the network with clear network and environmental benefits;
9. Provide reliable real-time travel information anywhere and anytime

Efforts to reduce traffic congestion in DKI Jakarta according to the DKI Jakarta Macro Transportation Pattern can be carried out through 3 (three) strategies, namely:

1. Development of a mass public transportation system;
2. Traffic restrictions (3-in-1, electronic road pricing, etc.);
3. Increasing network capacity (such as: road network development and ATCS).

Intelligent Transportation System (ITS) technology is a technology that has only been developed in recent years to overcome traffic congestion in several developed countries. The ITS application in

DKI Jakarta is currently still being carried out partially and has not been integrated into a whole unified system.

In line with ITS initiatives worldwide, the Government took the initiative to develop ITS in Indonesia through the Ministry of Transportation. In 2013 the DKI Jakarta Transportation Agency started operating ITS with three subsystems:

1. Bus Tracking System (BTS) to track the whereabouts of Trans Jakarta buses and manage their operations;
2. Area Traffic Control System (ATCS) regulates traffic lights, mainly when traffic jams occur. Since February 2013, 90 Trans Jakarta bus fleets serving Corridor 1 equipped with GPS and 12 intersections have been connected to ATCS. In Jakarta, there are around 250 intersections that were planned to be connected to ATCS in stages.
3. Traffic Information System (TIS), namely electronic information in messages, images, symbols, or dynamic writing for road users.

The purpose of procuring this system is to integrate road users with transportation and vehicle systems through the use of information and communication technology. Not only monitoring but this system is also expected to take anticipatory and reactive steps to traffic conditions in the field. The implementation of this monitoring system is also used to help facilitate the operation of the Bus Rapid Transit, known as the TransJakarta Bus.

Chapter 2. Current Status of ITS in Indonesia

2.1. Background

Transportation is the backbone of the economy and a barometer of a country's success. If transportation circumstances are favorable, the country's economic position will likewise be good, and vice versa. The availability of road infrastructure is one of the variables that contribute to developing an effective transportation system. The decisive factor is the quality of transportation carrying capacity. Numerous variables contribute to the quality of the experience, including feasibility, signage, navigation, transit resources, and geographic structure. It is essential to highlight that these supporting variables must be managed both manually and digitally. The transportation system is composed of facilities and infrastructure that are controlled and staffed to build a network of infrastructure and service networks. Transportation issues in Indonesia, particularly land transportation, are quite complicated. Due to the interconnected nature of transportation, any problem that develops in one unit or network will affect the entire system. Transportation difficulties exist in nearly every network, down to the smallest unit. The causes that contribute to the creation of inland transportation difficulties in Indonesia are numerous and include

a. population growth
b. a large number of motorized vehicles
c. a lack of public knowledge, and
d. a lack of bureaucracy on the part of those with authority in the bureaucratic system

To enhance and develop a more efficient and effective transportation system in Indonesia (including all transportation supporting factors), the Ministry of Transportation, the Directorate General of Land Transportation, and the Directorate of Urban Transportation have prepared a grand design for the Indonesian Intelligent Transportation System (ITS). The Intelligent Transportation System (ITS) is a transportation management solution that leverages technology to integrate systems, applications, networks, and hardware-based on intelligence technology. The system aims to make cities' transportation systems in Indonesia safer, more coordinated, and more closely monitored. The grand design is expected to guide the implementation of ITS in a systematic, standardized, and integrated manner to ensure that ITS is efficient, effective, and appropriate in Indonesia. It will also help in planning the stages of ITS implementation along with gradual indicators to facilitate control, monitoring, and evaluation of program implementation.

2.2. Indonesia ITS Framework

Through the Directorate of Land Transportation, the Ministry of Transportation continues to encourage innovation through digital transformation by developing a Smart Transportation System or Intelligent Transport System (ITS) to facilitate public transportation users in Indonesia. ITS is believed to make it easier for users of public transportation services, including transportation users with special needs. For this reason, a national vision is needed, namely:

ITS INDONESIA VISION

"***Implementing ITS in Indonesia to improve efficiency and transportation services in an effort to help transportation users get information, simplify transactions, increase infrastructure capacity, reduce congestion,improve safety and comfort, and reduce environmental pollution"***

The ten-year framework for ITS development is based on assessing the responsibilities and capacities of transportation sector players, both public and private. Taking this strategy will ensure that ITS Indonesia's future development goals are a success. The anticipated impacts and advantages of developing this ITS planning framework span three dimensions: the economy, the environment, and quality of life.

Indonesia's ITS framework has been designed around eleven major systems that have the potential to be implemented during the next ten years (2020-2030), as detailed below.

l. Advanced traffic management system
m. Advanced road user information system
n. Advanced traffic safety and vehicle control system
o. Commercial vehicle operating system
p. Advanced public transport system
q. Electronic payment system
r. Emergency management system
s. Advanced rural transport system
t. Advanced travel request management system
u. Advanced parking management system
v. Autonomous Driving System

2.3 Scope of ITS in Indonesia

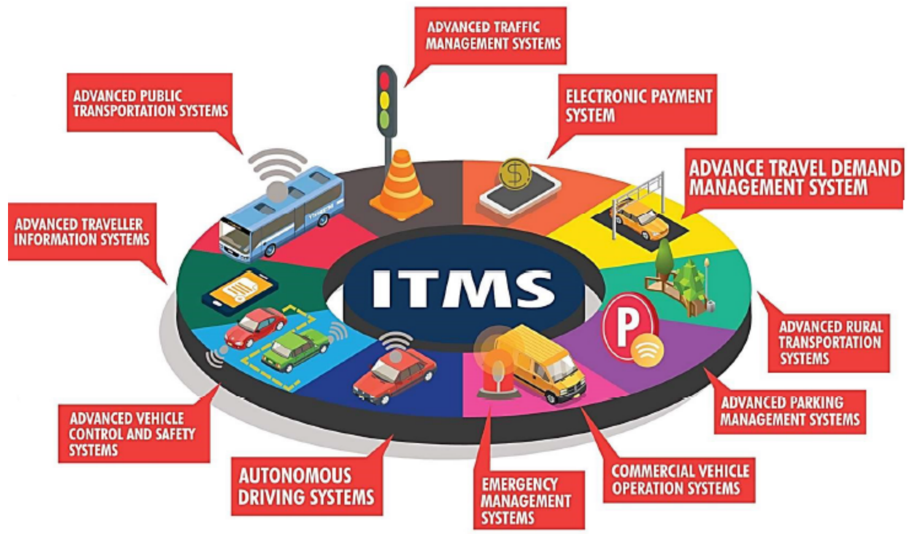

Figure 2.1 Scope of ITS in Indonesia

2.4. Indonesia ITS National Architecture

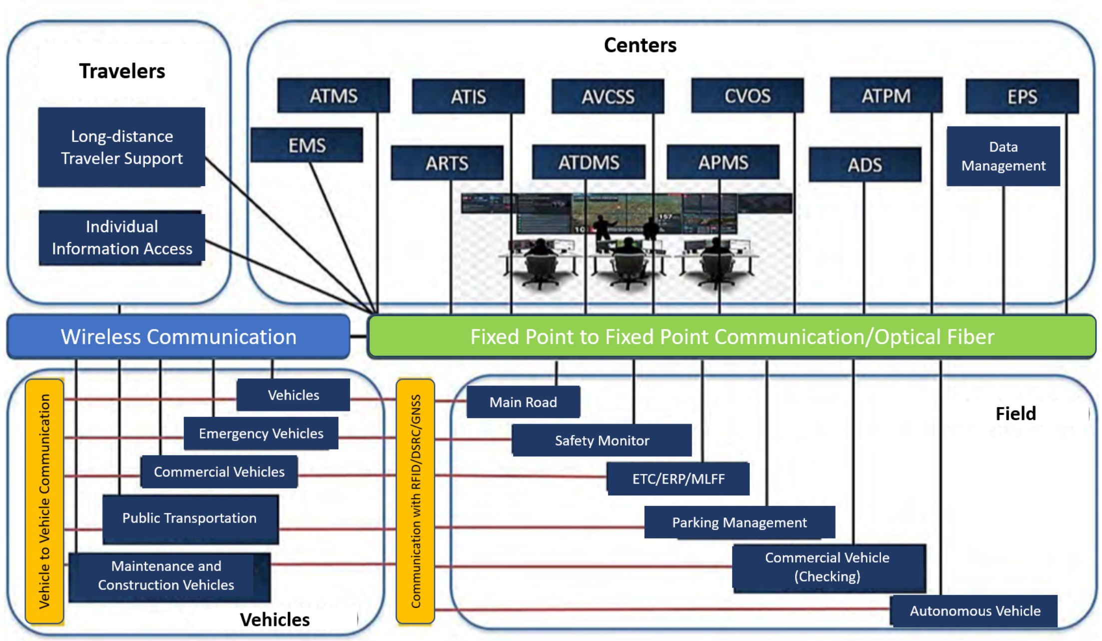

Figure 2.2 Indonesia ITS National Architecture

2.5 Applications and Their Progresses

2.5.1. S-ITS 01: Advanced traffic management system

The advanced traffic management system is a traffic management system that functions to increase vehicle traffic flow and provide real-time information for road users that is integrated with the traffic control center. The advanced traffic management system consists of the following sub-systems:

a. Regional traffic regulation and control area traffic control system);
b. Real time traffic monitoring
c. Electronic beacon monitoring and control
d. Accident monitoring
e. Connecting road monitoring
f. Electronic traffic law enforcement
g. Travel time detection
h. Automatic bus priority detection

The following figure shows the communication system and ATMS architecture developed using the baseline from the survey results and benchmark standards in the implementation of ITS.

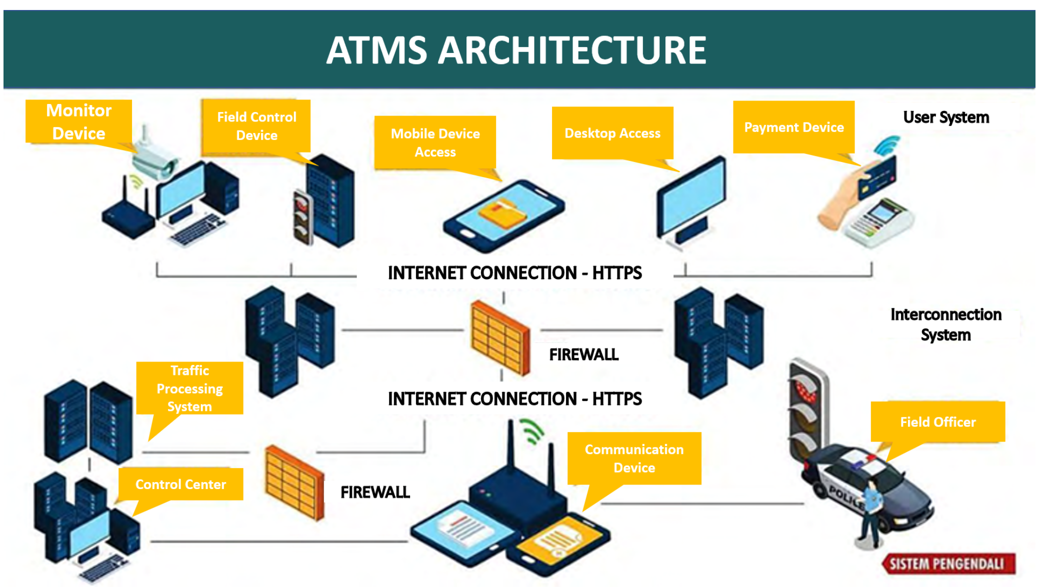

Figure 2.3 ATMS Communication System and Architecture

Outside of control and supervisory systems, systems relating to users may be classified into four broad categories: monitoring devices, field control devices, mobile access devices, desktop access devices, and payment devices. Surveillance equipment include Close Circuit Television (CCTV) cameras, piezoelectric cameras, infrared cameras, mobile phone cameras, and vehicle detection devices. Other. Field control devices are transportation-related equipment that users must obey, such as traffic lights, display device announcements, and traffic signs. A mobile or fixed access device is a device that users of transportation routes may use to get or submit information about the route they took into or out of the ATMS management system. Payment devices include credit cards, debit cards, electronic payment apps, electronic money (e-Money) devices, and radio frequency identification (RFID) devices.

All ATMS-related systems will be immediately connected to the internet system's interconnection system. A mobile or fixed access device is a device that users of transportation routes may use to get or submit information about the route they took into or out of the ATMS management system. Payment devices include credit cards, debit cards, electronic payment apps, electronic money (e-Money) devices, and radio frequency identification (RFID) devices. All ATMS-related systems will be immediately connected to the internet system's interconnection system. A mobile or fixed access device is a device that users of transportation routes may use to get or submit information about the route they took into or out of the ATMS management system. Payment devices include credit cards, debit cards, electronic payment apps, electronic money (e-Money) devices, and radio frequency identification (RFID) devices. All ATMS-related systems will be immediately connected to the internet system's interconnection system.

To connect all of these devices, fiber optic communication cables are utilized as the primary communication medium. The use of communication lines optical fiber This is primarily about the amount of data that can be transferred in a given amount of time (bandwidth) and the fact that data propagation from one place to another is quicker than data transmission over copper cables (the speed of propagation in copper is about 75 percent the speed of copper conductors). Light). These two considerations make fiber optics an attractive option for picture transmission systems from CCTV that are often big in size and require rapid deployment to accomplish monitoring and control systems.

The interconnectivity system that utilizes the internet as a means of communication is a system that is created on a fundamental level, such as a website portal service to serve desktop accessors and is equipped with web services to serve mobile devices. Additionally, the process of sharing and distributing information on transportation regulation and supervision in the region where ATMs are located may be carried out via this website service and web-service server. The controller and supervisor systems will always communicate with these two types of servers. To ensure the security of data and applications stored on two different types of servers, the interconnection system must have a firewall and a secured internet connection (Hypertext Transfer Protocol Secure – HTTPS). Secured internet connections and firewall service devices are used to anticipate different activities or assaults that might disrupt ATMS services or compromise the integrity of data received or delivered by ATMS users outside the control and supervisory system.

The interconnection system's placement inside the internet communication system can also be utilized to anticipate unforeseen disruptions in the central control and monitoring system. When these conditions exist, the full process of control and supervision can continue, albeit with certain restrictions. Dissemination of information on transportation routes can continue to be accomplished using mobile and fixed access devices. Control and supervisory systems are critical to the ATMS process as a whole.

This physical control and supervision system might be centrally placed or spread across the region. This system is functionally split into two distinct components: the traffic processing system and the traffic command center. The traffic processing system's responsibility is to gather, store, process, and analyze all data received from field supervisors and controllers. The traffic command center section is responsible for showing data gathered, processed, or analyzed by the traffic processing system section in the form of visuals or numbers that officers may use to make choices about current or future monitoring and control operations. Assume that more action is considered required. In this instance, officers in the traffic command center can communicate with field officers through current communication means (such as telephones, communication applications on mobile devices, or short-wave radio equipment) (such as the police). As required, the fire department, ambulance, and other emergency services).

A traffic light used as a traffic signaling device (APILL) is one of the ATMS's traffic devices. ATMS should be used to regulate all traffic signals. Centralized regulation through ATMS enables the duration of the lights to be regulated not only for a single intersection site, but also for several intersections, allowing for constant management of traffic density and reduction of congestion on other related routes. The procedure performed in this function is depicted in Figure below.

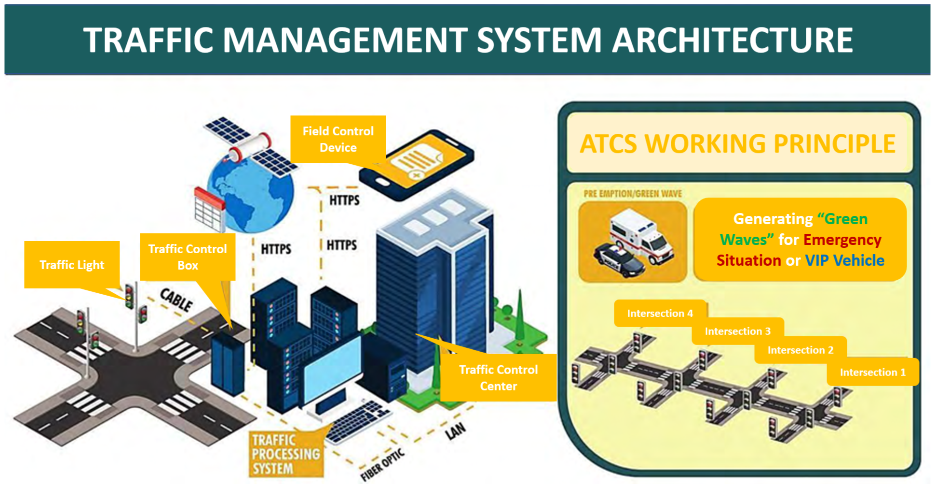

Figure 2.4 Traffic Light Management

At the traffic command center portion, the procedure of installing traffic signal equipment is completed. Officers can handle all traffic light devices registered in the ATMS management system in this part. The traffic processing system section stores the control data sent to the traffic command center part. The traffic processing system will communicate with the traffic box controller through fiber optic or internet communication connections in order to regulate traffic light devices. These two routes are required to account for the possibility of unusual circumstances occurring in each lane. If a communication channel fails, the control process can continue to operate utilizing alternate communication lines.

The control procedure is likewise prepared in this system via an application on the field controller device. This program may be used to automate the operation of traffic signal devices in response to certain situations. Control data collected using this application will be transmitted to the traffic box controller via the internet and kept in the traffic processing system. Additionally, this program can be utilized if the whole traffic processing system or traffic command center is having issues. Along with control data, the traffic processing system stores a variety of other information about the traffic lights. These records include physical and technical information on traffic lights, as well as traffic light problem reports and corrective action information, as well as a history of the light's repair or maintenance. All of these data are deemed critical to managing in ATMS in order to predict and resolve different issues that may impair the smooth operation of transportation routes. Not only is the technique of regulating traffic lights used to forecast traffic density along a transportation route, but it may also be used to forecast certain special events (e.g., VVIP guest convoys, ambulance vehicles or western firefighters that will pass, and so on). All of these data are deemed critical to be maintained in ATMS in order to predict and resolve different issues that may impair the smooth operation of transportation routes. Not only is the technique of regulating traffic lights used to forecast traffic density along a transportation route, but it may also be used to forecast certain special events (e.g., VVIP guest convoys, ambulance vehicles or western firefighters that will pass, and so on). All of these data are deemed critical to be maintained in ATMS in order to predict and resolve different issues that may impair the smooth operation of transportation routes. Not only is the technique of regulating traffic lights used to forecast traffic density along a transportation route, but it may also be used to forecast certain special events (e.g., VVIP guest convoys, ambulance vehicles or western firefighters that will pass.

2.5.2. S-ITS 02: Advanced traveler information system

Advanced road user information system (ATIS) provides real-time information to motorists regarding environmental and road traffic conditions that impact route selection, mode selection, and optimal travel times. The ATIS idea is that information may be accessible in general via websites, mobile phones, or electronic signs and that information systems located across an area/area present the most up-to-date condition information. The objective of this innovative technology-based system is to increase passenger safety and contribute to traffic congestion reduction. More precisely, information on the state of the road environment can be given in the form of meteorological data (rain, overcast, cloudy), parking conditions, public transportation schedules and trip times, and pollution levels. Meanwhile, information about road traffic conditions, such as driving speeds on certain roads, travel times to specific places, traffic jams in particular areas, accidents, incidents, and road construction, as well as alternate routes to avoid congestion, is available. ATIS is distributed to passengers via roadside signs, the internet, radio, telephone, fax, and mobile phones.

The system design of advanced traffic information systems (ATIS) is centered on providing users with real-time traffic information (client). Since a diverse range of users will use this system with varying degrees of expertise in communication systems, the access and display of data are kept as easy as possible through a client-based application.

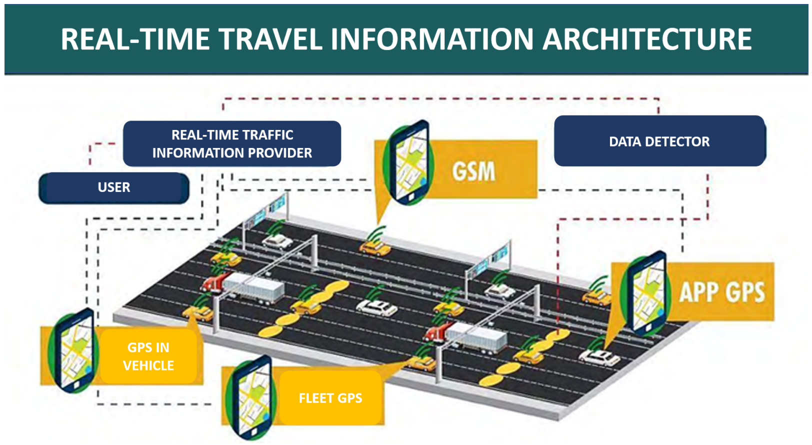

Figure 2.5 Traffic Information System Architecture in Real Time

Additionally, because the ATIS architectural system is an open system, it may be utilized to give information on public transit modes or any other type of information that may be required. There is a traffic processor component in the setup of the ATIS architecture. A traffic processor is a computer interface between a regional computer and a traffic information system. The processor collects traffic data from regional computers and processes it according to the format specified in the traffic database. The most often used traffic detection technologies include loop detectors installed on the pavement to gather data on speed and traffic flow, as well as CCTV (video detection) to collect data on wait length. Loop detector and video detection data are sent to traffic control boxes and ultimately to the regional computer. The data is subsequently transmitted to the traffic control center's traffic processing system. If GPS technology is used to gather data, the information can be transferred to a regional computer or directly to a computer traffic processor.

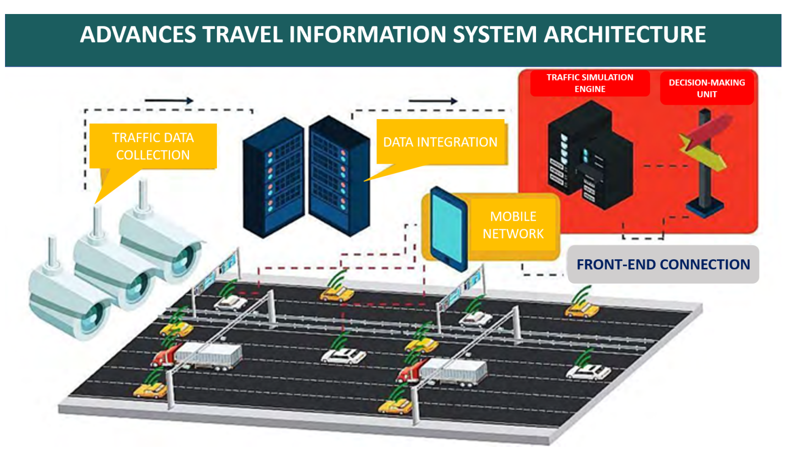

Figure 2.6 Advanced Travel Information System Architecture (ATIS)

2.5.3. S-ITS 03: Advanced Vehicle Control and Traffic Safety System

The advanced vehicle control and safety system is a vehicle control system with the support of an intelligent system that functions to increase vehicle stability while running, which aims to improve driving safety and make the trip safer and more efficient. AVCSS involves several important safety functions such as longitudinal and lateral control of the vehicle. The system is required to be able to prevent or reduce hazardous conditions. The system must be able to tolerate failure. In addition, this advanced vehicle safety and control system is a vehicle- controlled program, which is part of the smart highway initiative (also known as intelligent vehicle highway system (IVHS) that is part of ITS.

The advanced vehicle control and safety system has the working principle of providing warnings in the form of voice messages, picture messages or written messages to vehicle drivers regarding conditions that endanger private vehicles and other road users. The following figure shows the communication system and AVCSS architecture that was developed using the baseline from the survey results and benchmark standards in the implementation of ITS.

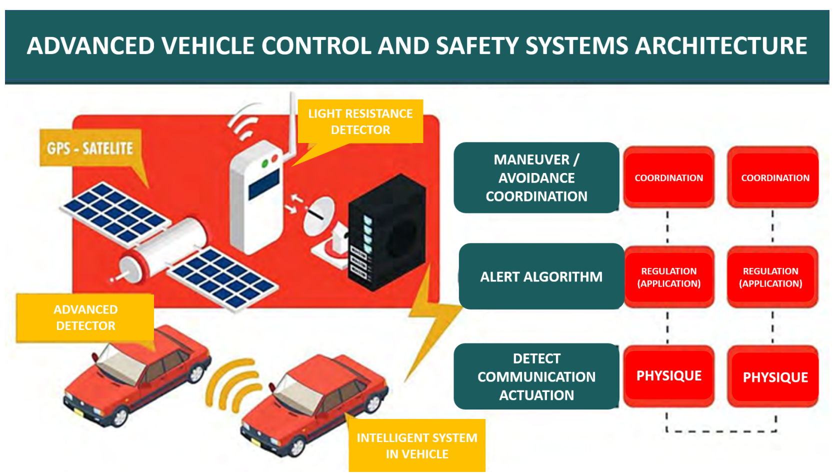

Figure 2.7 AVCSS Logic Architecture

Under this architecture, each system builds its own layer of control structures. Between layers, information is passed to facilitate the specified function. For example, the coordination layer receives from the regulation layer the exchange vehicle status information so that coordinated maneuvers can be planned. The regulation layer receives sensor measurements from the physical layer, while the actuators input commands to the physical layer. Between the two systems, if information exchange is required, it is routed through communication or network hardware and sent to the regulatory coordination layer for processing. For example, for a case study of a frontal collision warning or avoidance system, the physical layer includes radar, lidar, camera, and warning display. The regulation layer contains algorithms for obstacle detection, tracking, and threat assessment. The coordination layer involves coordinated vehicle control through the use of vehicle-to-vehicle or vehicle-infrastructure communication.

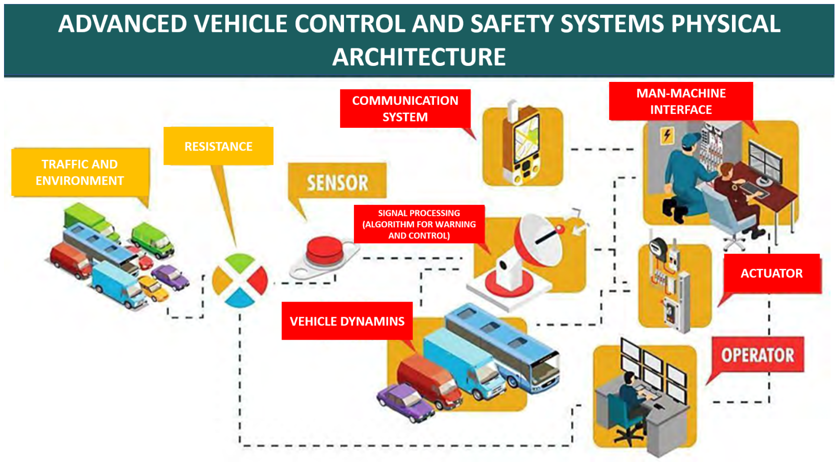

Figure 2.8 Physical Architecture of AVCSS

2.5.4. S-ITS 04: Commercial Vehicle Operation System

The commercial vehicle operating system is an operations management for commercial vehicles that functions to manage and provide services, reduce route disruptions, reduce travel delays, maintain safety levels and cost efficiency levels. The commercial vehicle operations system consists of the following sub-systems:

a. Vehicle classification system
b. Over dimension and overloading detection system; and
c. Moving load measurement system (weight in motion).

In addition, the commercial vehicle operating system must meet the following working principles:

a. provide volume data and vehicle classification on roads;
b. provide data on dimensions and weight of vehicles on roads;
c. provide vehicle speed data on roads;
d. provide data on the origin of the destination of the vehicle;
e. provide data on the type of goods being transported; and
f. develop a commercial vehicle violation enforcement system.

The following figure shows the communication system and CVOS architecture that was developed using the baseline from the survey results and benchmark standards in the implementation of ITS.

The CVOS architectural system is closely related to ITS functionality in detecting vehicle classification, vehicle size and weight when crossing and using the road. This functionality is needed to ensure that all passing vehicles do not violate the traffic rules that apply to the control lane. This CVOS architectural design can be described below.

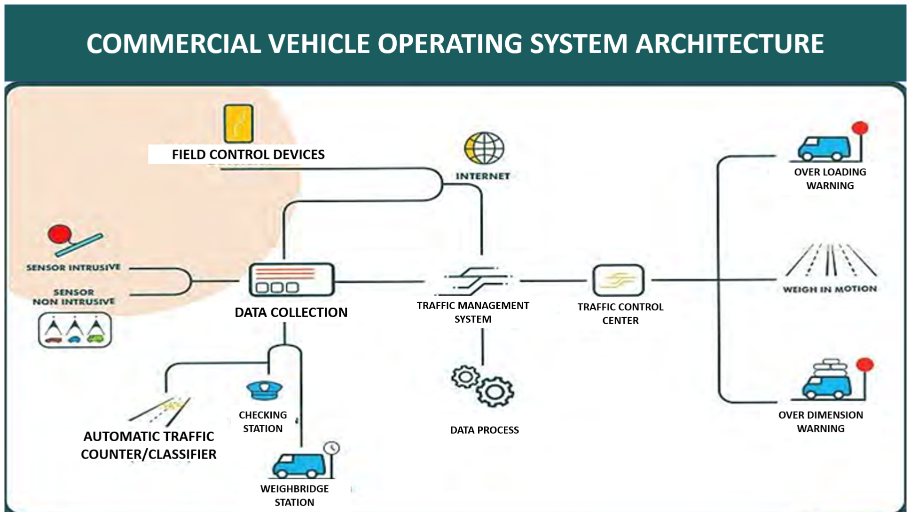

Figure 2.9 Commercial Vehicle Operating System (CVOS) Architecture

2.5.5. S-ITS 05: advanced public transportation system

The advanced public transportation system (ATPS) is the application of a technology-based public transportation system that functions to improve the accessibility of information, improve the safety of public transport users, improve the efficiency of public transport operations and the effectiveness of road facilities and infrastructure. In addition, the advanced public transportation system consists of the following sub-systems:

a. Public transportation information system;
b. Public transportation traffic management

Furthermore, the working principle of the advanced public transportation system is as follows:

a. Provide route information
b. Provide scheduling information
c. Provides information on estimated departures and arrivals
d. Uses a bus priority signal system for phase change settings and special signals at signalized intersections
e. Reducing the delay time of priority public transport at signalized intersections.

The following figure shows the communication system and APTS architecture that was developed using the baseline from the survey results and standards benchmarks in the application of ITS.

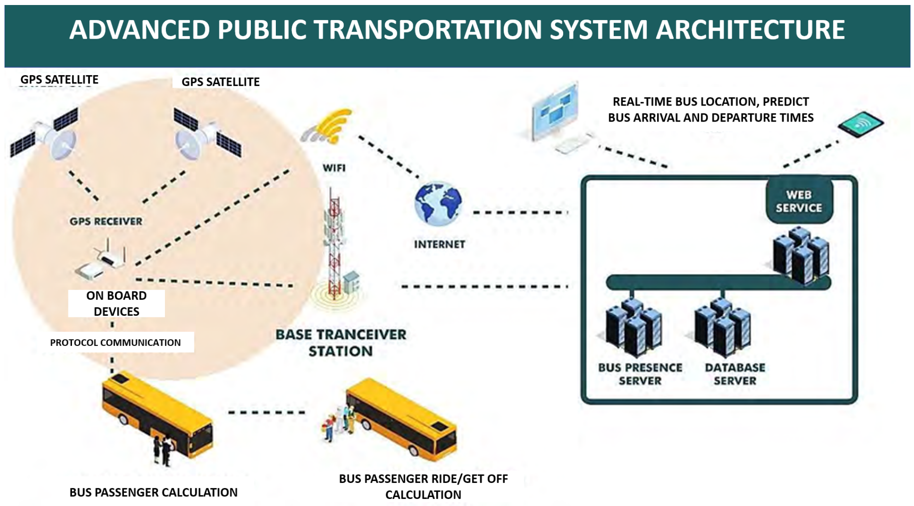

Figure 2.10 Advanced Public Transportation System Architecture

2.5.6. S-ITS 06: Electronic Payment System

Electronic Payment System is an alternative payment system that makes it easy for consumers to make payments via the network or the internet. In an electronic payment system, all payment data is digitized. Another definition of an electronic payment system for transportation is an electronic payment that is used to pay for public transportation services and integrated services. The electronic payment system consists of the following sub-systems:

a. Payment by electronic money.
b. Payment by application service.

In addition, from the application side, there are 2 types of payment systems:

a. Electronic cash/e-cash (token-based system): like a physical cash payment that
b. represents the value of the payment.
c. Credit/debit system (account-based system): in the form of a "message" to transfer
d. payments (does not directly represent the payment value)

EPS implementation has also been carried out in Indonesia using smart cards issued by several banks as shown below. Basically, what these banks do in issuing these smart cards is the same as what has been done in several other countries. It's just that the problem that arises is the unequal process and data structure stored on the card. To overcome this problem, it can be done by making communication standards and smart card data structures. This step will be able to synchronize the process that occurs and smart card users can choose the type of card they want. There are two systems in implementing smart cards in Indonesia, namely server- based and chip-based on the card as shown in the picture above.

The architecture of electronic payments for transportation, especially for the ticket system, can be seen below.

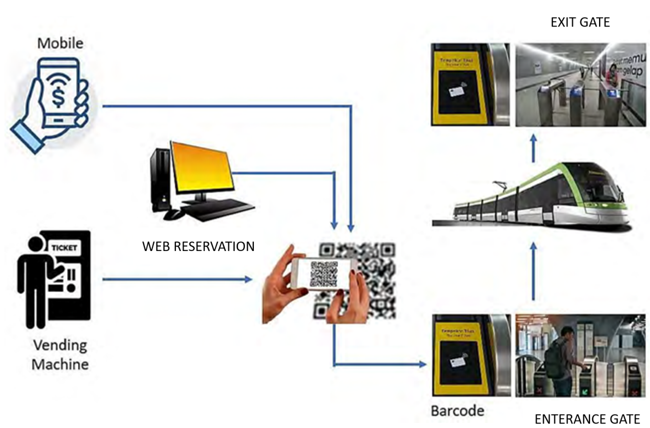

Figure 2.11 Electronic Payment System Architecture for Public Transportation

Furthermore, the following figure shows the communication system and EPS architecture that was developed using the baseline from the survey results and standards benchmarks in the application of ITS.

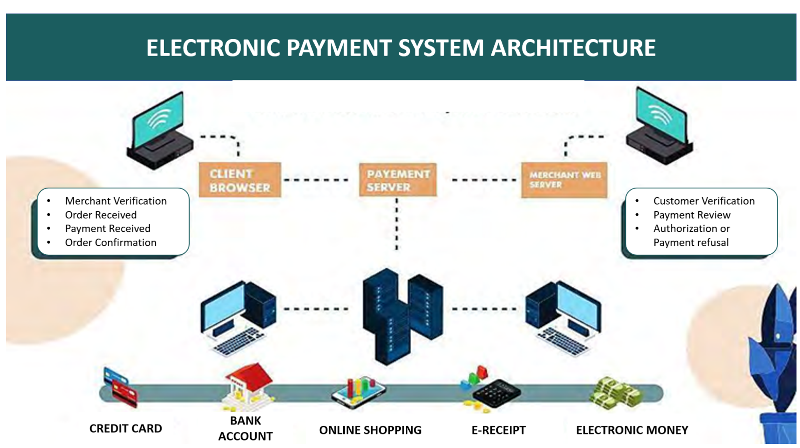

Figure 2.12 General Architecture of Electronic Payment System

2.5.7. S-ITS 07: Emergency Management System

In risk management, ITS through an emergency management system (EMS) allows traffic authorities to coordinate and act more efficiently in the event of plans or unexpected events such as emergency situations. Moreover, the EMS application is able to predict events that have a detrimental impact on road services, which are very unlikely to occur.

EMS or Emergency management system aims to provide information and handling in case of an emergency on the highway. The emergency management system consists of the following sub-systems:

a. Handling information system
b. Emergency handling procedures

The working principle of an emergency management system is to:

a. Providing information and handling accidents
b. Providing information and handling traffic congestion
c. Provide ambulance information
d. Provide information on the nearest hospital
e. Provides tow truck information and fire fight information.

In the past, the emergency management system relied heavily on witnesses of the incident in the field to report via the telephone network and the message would be distributed to the EMS center and then carried out emergency procedures such as sending an ambulance, medical officer or traffic police. Waiting time is highly dependent on the involvement and participation of witnesses (community) to report an incident. Meanwhile, with the ITS-based system via EMS, all vehicle units are equipped with on-board unit-OBU detectors or android/IoS-based OBU electronics which are automatically connected to the control room which immediately sends assistance with satellite assistance (GNSS). Furthermore, the following figure shows the communication system and EMS architecture that was developed using the baseline from the survey results and standards benchmarks in the application of ITS.

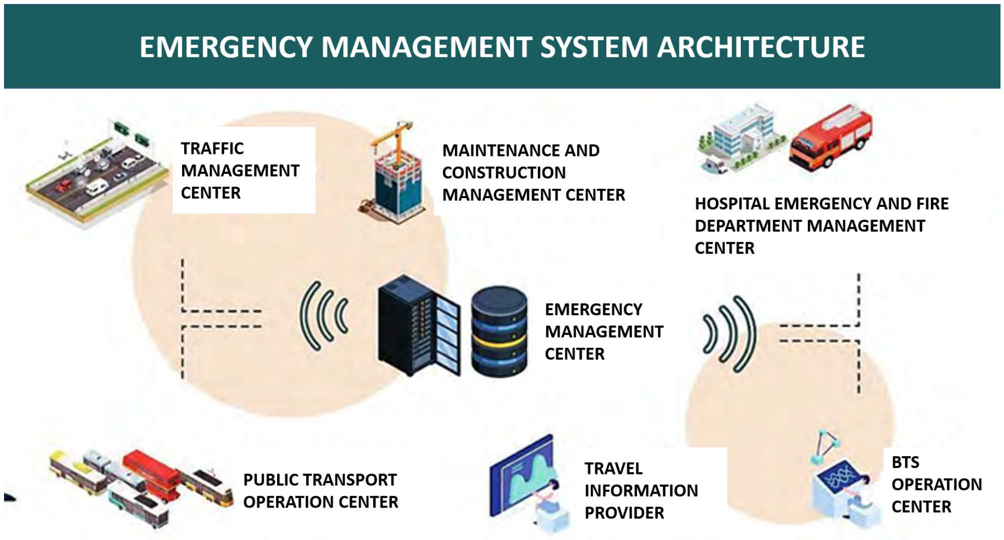

Figure 2.13 General Architecture of Emergency Management System

2.5.8. S-ITS 08: Advanced Rural Transportation Systems

The advanced rural transportation system or called ARTS has the aim of improving the quality of life of rural residents and tourists through the movement of people and goods available to be safer, more secure, and efficient in rural areas (rural) in Indonesia through wise policies from the application of ITS technology. In addition, advanced rural transport systems serve to improve transport efficiency and connectivity with cities. The advanced rural transportation system consists of the following sub-systems

a. Tourism transport management service
b. Freight management services

In addition, ARTS also has the following working principles:

a. Providing tourism transportation information
b. Provide information on freight transportation.

The communication function of the advanced rural transportation system can be seen as the output of the ITS communication layer in a rural environment. This concept is presented in a logical architecture to explain the generation of ITS wireless communication functions in rural areas. For example, for service in tourism, users of the functions provided by web services in the design of information systems are for application developers and direct users of information (end-users), so that collaboration between systems is going well. The design of the information system is supported by the system section, namely data managers, data suppliers and data users. The following figure shows the communication system and ARTS architecture that was developed using the baseline from the survey results and standards benchmarks in the application of ITS.

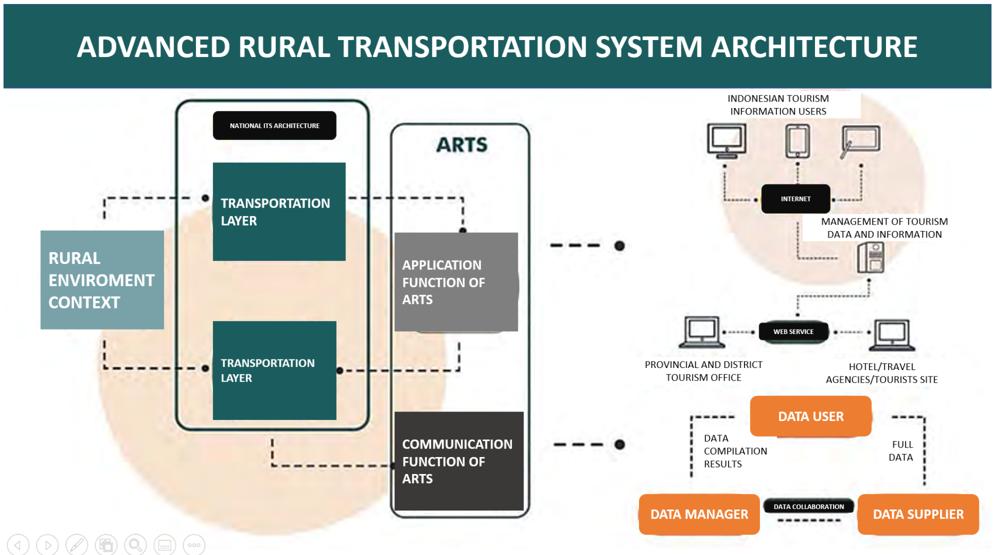

Figure 2.14 ARTS Architecture for Generation of Rural ITS Communication Functions

2.5.9. S-ITS 09: Advanced Travel Demand Management System

Advanced TDMS or advanced demand management system is a system to limit the demand for private vehicle trips by prioritizing public transportation using the ITS technology approach in its application. The advanced travel demand management system consists of the following sub-systems:

a. Restriction of road users with vehicle identification system;
b. Restrictions on road users with a paid road system (electronic road pricing); and
c. Restriction of road users by redistributing trips with a motorized vehicle number sign

In general, the working principle of this ATDMS is through:

a. Application of vehicle type and class identification system;
b. Implementation of an electronic paid road system; and
c. Implementation of a motorized vehicle number sign monitoring system.

The most widely used ITS application for TDMS is related to the implementation of a restricted access area (RAA) and a paid road system (Electronics Road Pricing) to anticipate congestion in an urban area. The figure below shows the overall approach of the ITS assistance strategy centered on important smart city concepts and based on TDMS solutions.

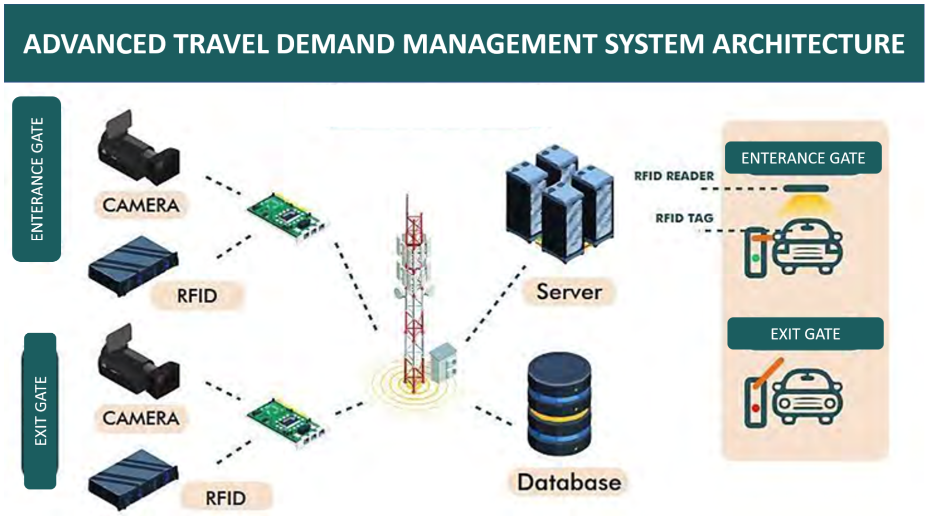

Figure 2.15 Advanced Travel Demand Management System Architecture ERP-RFID

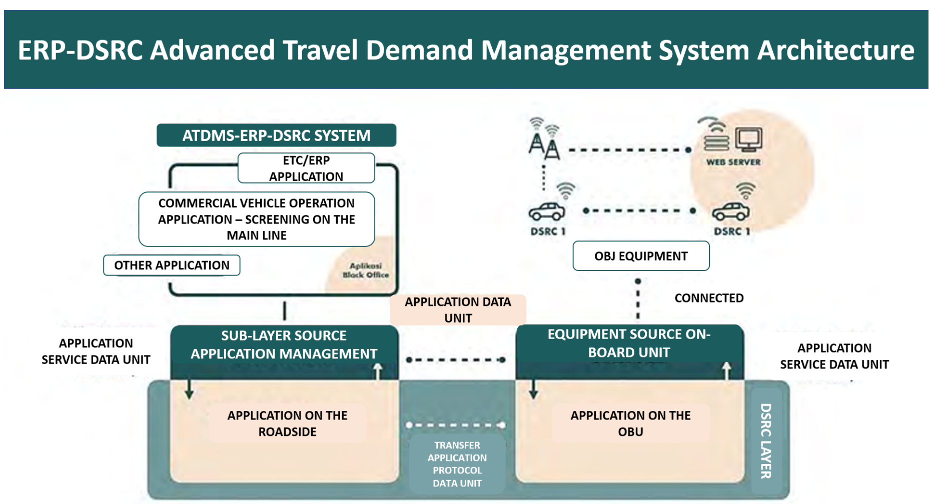

Figure 2.16 ERP-DSRC Advanced Travel Demand Management System Architecture

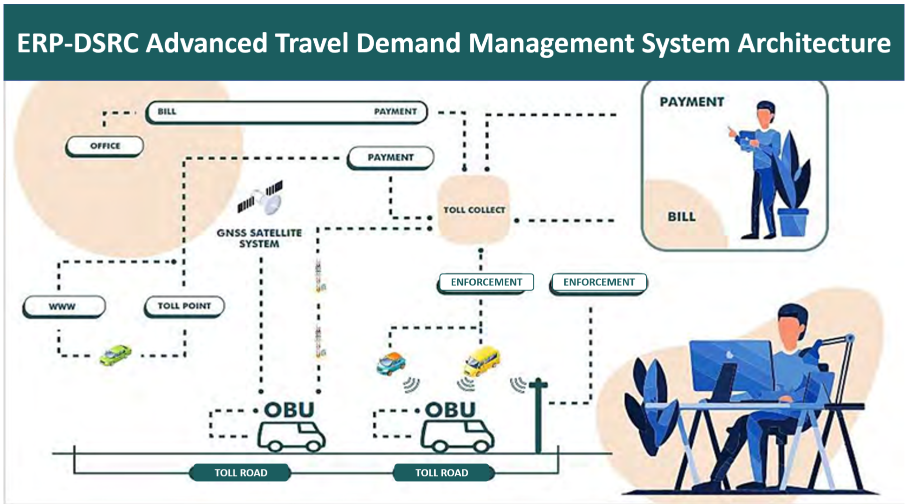

Figure 2.17 ERP-GNSS Advanced Travel Demand Management System Architecture

2.5.10. S-ITS 010: Advanced Parking Management System

Parking is a requirement for all public service arrangements. Parking management is needed to ensure the safety and comfort of users. For this reason, it is necessary to implement a more efficient parking management system through the use of ITS technology such as: Advanced Parking Management System (APMS). Advanced Parking Management System (APMS) is a system that makes it easy for users to find parking spaces, detect crime and an efficient payment system.

In addition, APMS can also be defined as a system that includes monitoring of parking availability, parking reservations, parking prices and policy regulations (such as overstay violations), space optimization, parking guidance, and reduction of search time based on preferences. The advanced parking management system consists of the following sub-systems:

a. on-street vehicle parking system
b. off-street vehicle parking system

The working principles of this APMS are:

a. Provide information on parking availability
b. Electronic parking fee payment system
c. Visual-based parking area monitoring system

In APMS there are several technologies applied such as parking search systems or parking systems parking guidance systems which can be used in building parking. The parking lot is constantly monitored via ultrasonic, TOF (time of flight) and magnetic sensors. This information is collected with the help of a data concentrator and sent to a computer, where the parking system software accurately directs the driver to the vacant parking area. The following figure shows the communication system and APMS architecture that was developed using the baseline from the survey results and benchmark standards in the application of ITS.

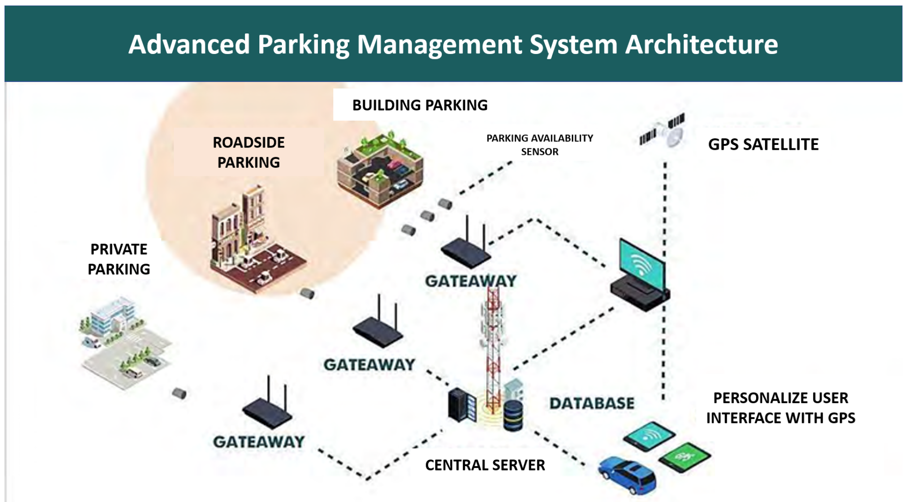

Figure 2.18 Advanced Parking Management System Architecture

2.5.11. S-ITS 011: Autonomous Driving System

Autonomous Driving System is an automatic vehicle driving system without a human driver. Driverless vehicle deployments are equipped with sensors, cameras and radar that can help vehicles see and monitor different objects on the road, as well as track the direction and speed of other vehicles. The working principle of ADS can be explained as follows:

a. The application of Driverless Motor Vehicles is equipped with devices including sensors, cameras and radars that can help Motor Vehicles see and monitor different objects on the road, as well as track the direction and speed of other vehicles.

b. Each device is capable of detecting every object that is around the Motor Vehicle, which is then forwarded to the autonomous device to read the movement of the Motor Vehicle and the function of when the Motor Vehicle runs and stops to continue to provide safety for both passengers and road users and other vehicles.

The Autonomous Driving System consists of the following sub-systems:

a. Level 0 (zero) Full Driver Control: The Driver performs all operations, including steering, acceleration and braking and the Motor Vehicle has no autonomous or self-driving control at all.

b. Level 1 (One) Driver Assistance: At this level, the driver still handles most of the Motor Vehicle functions but with little autonomous assistance.

c. Level 2 (Two) Partial Automation: At this level, it allows the driver to disengage from some driving functions. Second-tier Motor Vehicles can assist with functions such as steering, acceleration, braking and speed keeping, although the driver should still hold the wheel with both hands and be ready to take control if needed.

d. Level 3 (Three) Conditional Automation: Conditional automation allows the driver to sit back and let the car exercise all driving control at speeds of less than 60 km/h. At this level, the vehicle can be said to be completely autonomous, but only under ideal road conditions.

e. Level 4 (Four) High Automation: At this level, the Motor Vehicle is capable of self- driving, accelerating and braking. Motor Vehicles can also monitor road conditions and respond to obstacles, determining when to turn and when to change lanes. Level four autonomous driving can only be activated if road conditions are ideal. At this level, Motor Vehicles cannot face more dynamic conditions such as congestion or other major obstacles.

f. Level 5 (Five) Full Automation: Tier five autonomous driving requires no human interaction. Motorized Vehicles can steer, accelerate, brake, and monitor road conditions such as traffic jams.

The following pictures show the level of autonomous vehicles and communication systems and ADS architecture that were developed using the baseline from the survey results and benchmark standards in the implementation of ITS.

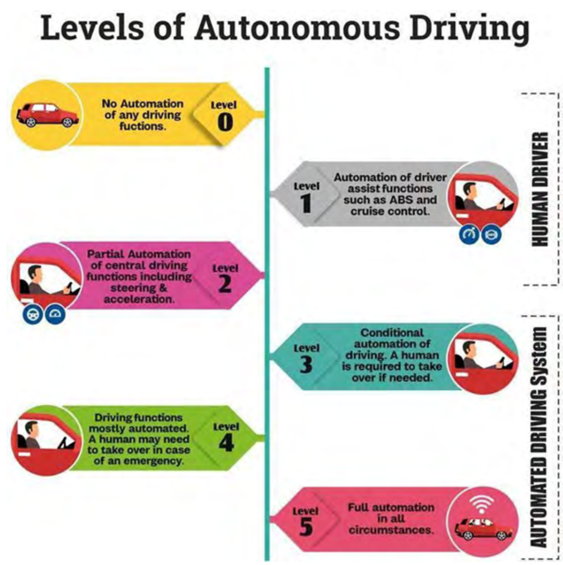

Figure 2.19 Levels of Autonomous Driving

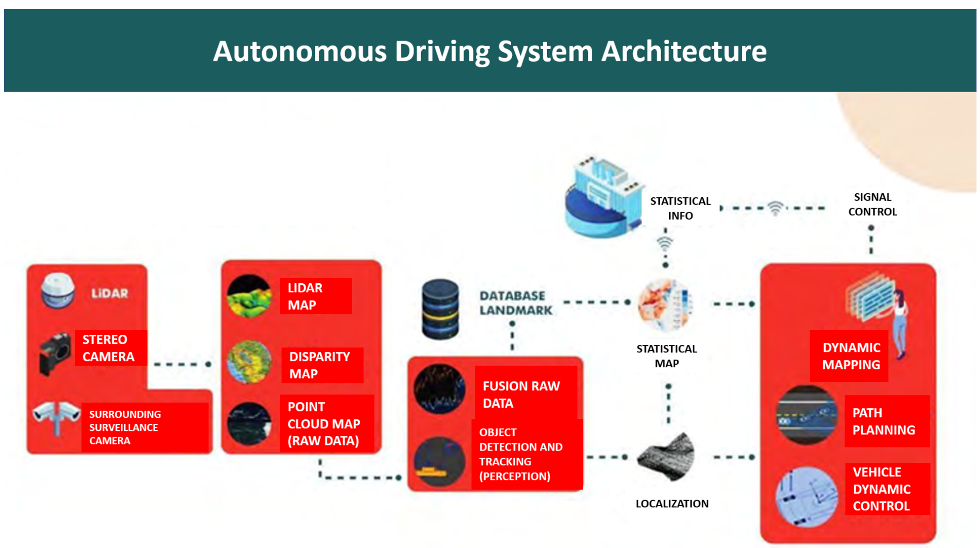

Figure 2.20 Autonomous Driving System Architecture

Chapter 3. Problems and Challenges

3.1 Infrastructure and supporting facilities

The development of the mass transportation system carried out must also pay attention to the accessibility of urban public transportation services available 80% of the length of the road. With this target, each region must have a local transportation service network/feeder integrated with the principal network through one urban transportation node. The urban transportation node must also have facilities for pedestrians and park and ride so that changing modes to public transportation is easy and fast. For this reason, the distance between modes of movement is not more than 500 meters.

Likewise, pedestrian access to public transports is a maximum of 500 meters. Part of the fundamental performance indicators in the RITJ had become a joint agreement with all relevant stakeholders, which are the result of the consensus between all parties, including the Ministry of Transportation and the City and Regency Provincial Governments throughout the Greater Jakarta Metropolitan Area. Currently in 2021, BPTJ has launched an online monitoring dashboard for the implementation of RITJ (in the network) or a special online called the Greater Jakarta Transportation Master Plan Monitoring and Information System (SPIRIT JABODETABEK). The monitoring dashboard for the implementation of RITJ is an initiative of BPTJ, one of which is intended to facilitate all stakeholders of transportation management in Jabodetabek in conveying and monitoring the 18 progress of the implementation of RITJ activities in accordance with their respective authorities. This online system can also be used as a database in carrying out evaluations for each period. Through a username and password, all stakeholders who are directly involved in the implementation of RITJ can access and utilize this system. Until the end of 2021, the implementation of RITJ is still experiencing problems and has not reached the real target, especially during the pandemic. However, it will be accelerated towards 2030

3.2 Regulations Regarding Public Transport Use and Law Enforcement

With this knowledge, efforts to organize an integrated transportation system are possible by referring to Presidential Decree (Perpres) Number 55 of 2018 on the Greater Jakarta Transportation Master Plan (Rencana Induk Transportasi Jabodetabek -RITJ) signed by President Joko Widodo. The presence of this Presidential Decree has marked a new chapter in the handling of integrated urban transportation in the Greater Jakarta area, both by the Ministry of Transportation and Regional Governments throughout Jakarta, Bogor, Depok, Tangerang, and the Bekasi. The RITJ outline accommodates several integrated transportation development programs and strategies.

a. First, the integration of planning and policies related to the development of multimodal transportation services. It includes the integration of development and development plans both by the Regional and Central Governments and between the Government and the community (private).
b. Second, the integration of infrastructure and service networks, both intra and intermodal
c. Third, the integration of transportation modes. The integration of the development of urban transportation modes includes the planning, development, and operation stages (time integration).
d. Fourth, fare/ticket integration. The integration of fares/tickets is possible by implementing an e-ticketing system for intramodal and intermodal services. With the use of electronic payment systems, the integration of the payment system (cashless transactions) and by providing the public with this form of multipurpose service.
e. Fifth, information system integration. Integration of Information systems should utilize information technology that provides information on public transportation facilities and infrastructure accessible by the public. Information about public transportation modes, schedules, and routes will make it easier for people to take advantage of public transportation services that are better than before.
f. Sixth, integration of financing and institutions. The integration of the financing plan is primarily for development financing so that synergies allow support between modes. Meanwhile, institutional integration ensures coordination between institutions in a framework of planning, implementation, and operation of various integrated modes

According to the mandate of the Presidential Regulation No. 103 the Year 2015 regarding Greater Jakarta Transport Authority (BPTJ), the policy of the development and management for urban transportation in the JABODETABEK area directed the following:

1. Integration in the construction and development of transportation infrastructure network system and transportation services network, both intra- and inter-regional modes;
2. Integration in the construction and development of urban transportation between regions in JABODETABEK in one single Urban area;
3. Integration in the operation of urban transportation; and
4. Integration in the urban transportation financing plan.

In addition, there is also a policy in public transportation called as Public Transportation Use Promotion Policy. The rising population growth in the urban area has caused an increase in the number of passenger cars, which resulted in insufficient capacity in the road network. One of the critical steps towards alleviating the traffic congestion problem is to increase the number of public transportation users. For effective implementation, it is necessary to present the benefits of public transportation effectively and promote its services sufficiently to influence the modal split in favor of public transportation usage. The government's strategy to accelerate urban transportation development then elaborated into the five pillars of urban transportation policies, one of which mentioned the improvement of public transport role as a priority.

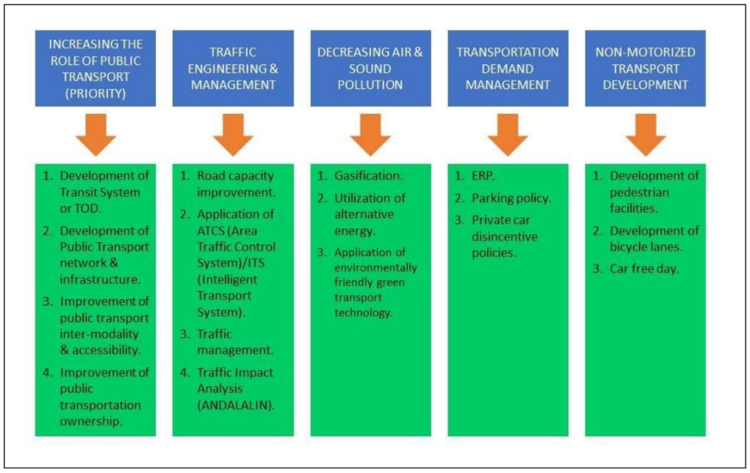

Figure 3.1 Five Pillars of The Urban Transportation Policy

3.3 User Behaviors

Present-day Jakarta and its metro area (GJMA) seem a massive and chaotic jumble of concrete, asphalt, vehicles, and people. Each day the streets carry more than 20 million vehicles; every year, approximately 11% more motorcycles, cars, buses, and trucks take to the streets (BPS Provinsi DKI Jakarta, 2020). On average, motorists spend more than half their daylight hours stuck in traffic, and when they can move, their speed is only about 5 km/h during a rush period (Tempo.com 2015). The current challenges of urban transportation include the high use of private vehicles, both motorcycles, and cars. The total number of people traveling inside Jakarta, Bogor, Tangerang, and Bekasi (Jabodetabek) increases from year to year. According to 2018 data, there are at least 49.5 million people traveling per day. Of that number, as many as 23.4 million people move within the city of Jakarta when the other 20.02 million are Bodetabek residents whose mobility is from outside the city into the city of Jakarta. Meanwhile, the number of users of public transport modes is still relatively small. Most of the mobility of Bodetabek residents still uses private vehicles as shown in figure below.

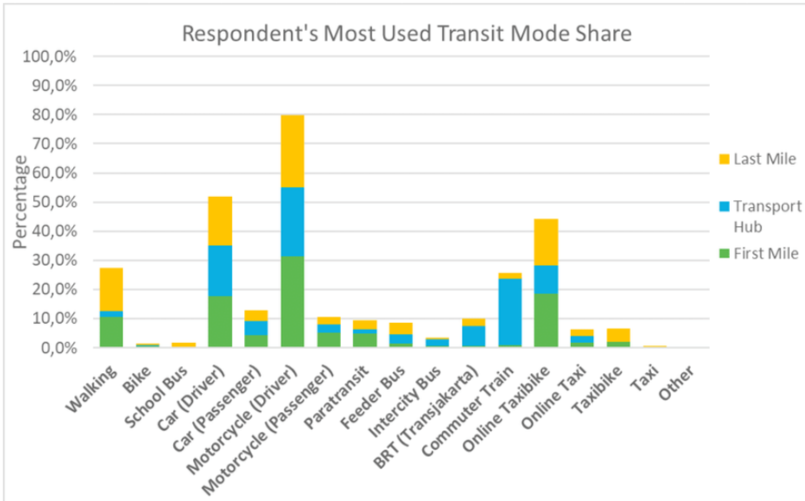

Figure 3.2 The Greater Jakarta Area Commuters Travelling
Source: Tjahjono, Tri & Kusuma, Andyka & Septiawan, Ahmad. (2020)

In addition to the traffic issues mentioned above, another issue worth noting is the continuously increasing number of vehicle purchases that impacted the travel pattern. It may have resulted from the growing number of automobile sales that offer an effortless and more attractive purchase scheme that has outnumbered the public transportation development. Such preferences may have also derived from demands for more convenience and security in the private vehicle than in public transport.

3.4 Access to Public Transport and Intermodal Integration Between Public Transport Modes

Of the 29 million residents of Jakarta Metropolitan Area (Jabodetabek), around 11% (3.2 million) are commuters (BPS, 2020). More than 70% of them are reluctant to use public transportation because of the long travel time, the impracticality of having to transfer or wait, unavailability of public transportation access, long waiting times, and uncomfortable conditions (BPS, 2020). Mass public transportation options currently available in Jabodetabek consist of commuter/line trains (CL), bus rapid transit (BRT), and the latest launches are mass rapid transit (MRT) and light rail transit (LRT). Other transportation options include regular buses, microtran (angkot), taxis, and ride-hailing. Given the target share of public transport of 60% by 2029 (Perpres, 2018), many efforts to develop public transport are needed to fill the gap from the current 30% share of public transport.

In Jabodetabek, mass transport users travel an average of over 25 km from their point of origin (e.g., home) to their final destinations (e.g., office) with an average travel time of 70 minutes one way. They have 3-6 trip segments using various transportation modes to reach their destinations. Therefore integration between public transport modes is essential to ease the journey.

Integration is very important in the use of public transportation. One of the main reasons is that many stations/stops in Jabodetabek cannot be reached on foot. On the other hand, the only option for first mile (FM) or last mile (LM) is micro-transit using a minibus service (JakLingko) which is not widely and reliably available. As ride-hailing has been introduced to the capital in recent years, some commuters are using it to help themselves, including the FM/LM mode of transportation. Others choose to leave their private vehicles at home and switch to ride-hailing services. Many rely on its on-demand nature and affordability, among many other things, to complement less integrated mass transit systems.

3.5 Environmental Condition

With the spreading of the CoronaVirus (COVID-19) globally, many countries are experiencing difficulties, including Indonesia. The World Health Organization (WHO) declared outbreaks as a global pandemic that spread so rapidly within a short amount of time has consequently put a limitation in the movements of public transport as enforced by government policies.

COVID-19 has hit all sectors in Indonesia, including transportation. Transporting passengers, goods, and logistics, either rental or charter, are directly affected, especially the Greater Jakarta Metropolitan Area. With the prolonged impacts of COVID-19, the number of passengers for all types of public transportation at GJMA has decreased. For MRT, the total number of passengers in January 2020 reached 85,000 thousand people per day before falling to 5,000 passengers per day or 94.11% in April 2020 compared to January 2020. Then the LRT also experienced conditions that were not much different. From January 2020, there were around 3,800 people per day. On 15 April 2020 it decreased by about 93.05% and there were only 264 people per day. The 3rd decline in passengers is the Commuter Line (KRL) in which the number of passengers was down by 78.69% equivalent to 1,830 thousand passengers per day on 15 April 2020. For Transjakarta services, on 15 April 2020, the number of users decreased by approximately 83,000 thousand passengers per day. Whereas in the air sector there was a decrease of 44% for domestic passengers and 45% for international passengers. The Government policy has caused a decline in passengers that stop public activities and restrict the public from going out of the house for activities like schooling, attending lectures, working, and worship. As the BPTJ limits the operational hours for public transportation during the restricted movement order (PSBB), in DKI Jakarta from 06.00-18.00 WIB, the Bodetabek area started their PSBB from 05.00-19.00 WIB. Meanwhile, the Jakarta LRT has started by changing its operating hours' policy from 06.00-20.00

WIB since 23 March 2020 and performed service restrictions by changing the headway from 10 minutes to 30 minutes starting on 1 March 2020 (Sahda, 2020).

Since the Indonesian government declared PSBB (semi lockdown) in 2020, urban mobility in GJMA decreased significantly, and no movement (stay at home) increased, as shown in the Figure below.

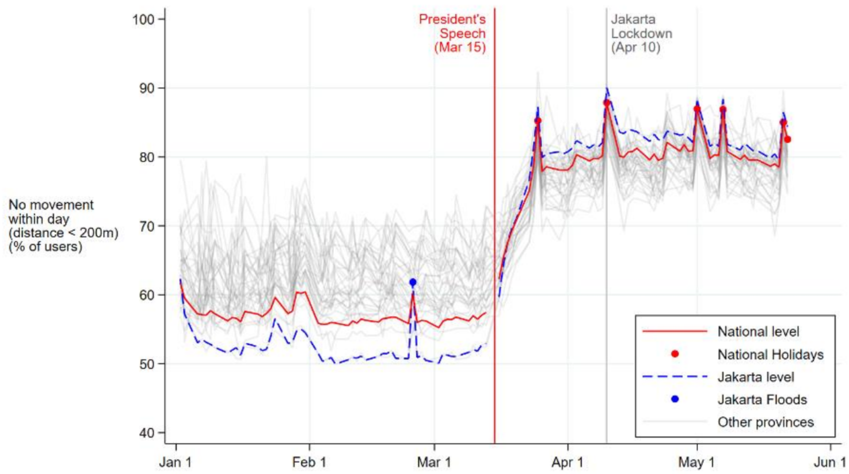

Figure 3.3 Daily fraction of users staying at home
Source: Arya Gaduh, 2021

Figure 3.3 shows the daily fraction of phone users who stay at home on a given day, defined as no travel beyond 200 meters away from their nighttime location. Before COVID-19, this fraction ranged from around 50% in Jakarta to 60% on average nationwide. After the president's speech on Sunday, March 15, and at the same time as many other countries were introducing formal lockdown restrictions, the fraction grows and reaches around 80% two weeks later, where it stays until late May at least. As a benchmark on public holidays, mobility decreases to almost 90% as users remain at home. By contrast, there was no noticeable jump in staying at home when the Government introduced the lockdown policies seen in Jakarta around the PSBB launch date on April 10.

On the other hand, the decrease in the number of movements in Jabodetabek has brought about an increase in air quality in Jabodetabek as seen in figure above (Sudirman Street). As example data below also shows the results of measuring the air quality in Jabodetabek

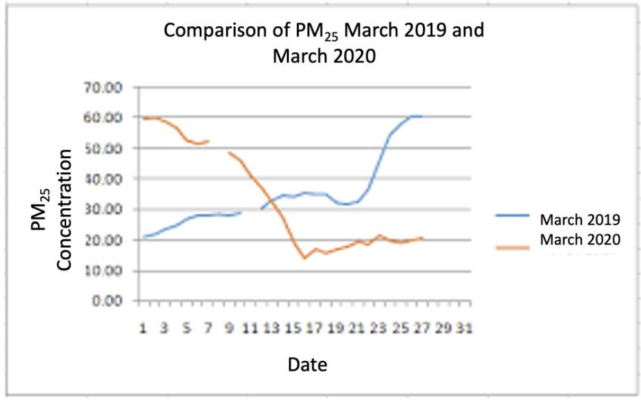

Figure 3.4 PM25 Measurement Before and After Pandemic in Greater Jakarta
Source: Umara Firman Rizi, 2019

3.6 Management

Despite the introduction of legal rules governing the implementation of ITS with the release of the Minister of Transportation Regulation 76 in 2021 concerning Intelligent Transportation Management Systems in the Road Traffic and Transportation Sector, there are still some obstacles affecting the implementation of ITS in Indonesia. They include low interoperability of the system making it difficult to integrate an ITS-based transportation system, the lack of involvement of relevant agencies to build long-term commitment and awareness of the benefits of the ITS project, and political problems (short-term politics or discontinuity due to political cycles). Another obstacle is the weak coordination between stakeholders, and also the clarity of responsibilities between the central and local government need to be improved. Law enforcement needs also to follow the adoption of technology, including how the fund collected from the penalties is managed and used.

3.7 Financial Aspect

With many projects depending on the budget of the central government, sustainability of funding is still a problem. Local governments need to take an active role in ensuring the sustainability of transport services, for example in the implementation of buy-the-service bus services in several cities in Indonesia. Governance needs to be set up to manage the services and receive revenue from farebox and non-farebox services.

Chapter 4. Transportation and ITS Project List

4.1 Arterial – ITS (North and South Coast of Java Arterial Network) – Ministry of Transport

In the last few years before the pandemic, the movement of transportation in major cities and on major arterial roads during peak hours created congestion and delays in both streets and intersections, resulting in decreased segment performance caused by an increase in the number of vehicles and side barriers. Given these problems, it is necessary to think of a solution for the next few years. The solution that needs to be done is to increase road capacity and be encouraged to implement an integrated transportation system, one of which is implementing an Advanced Transport Management System (ATMS) by utilizing communication and information technology infrastructure.

Advanced Transport Management System (ATMS) is a major sub-field in the Intelligent Transportation System (ITS) domain, mainly known as Arterial ITS. The ATMS view is a top-down management perspective that significantly integrates technology to improve vehicle traffic flow and safety on protocol roads, national roads, and arterial roads. Real-time traffic data can be obtained from smart cameras, speed sensors, detections, etc. (front-end). The data is connected to the Transport Management Center (Transport/Traffic Management Center). It will be integrated and processed at the back-end. For example, incident detection, traffic volume, and vehicle classification, which can be forwarded in actions such as traffic routing messages to users via Dynamic Message Sign (DMS) to increase the smooth flow of traffic. From all the working principles and components of ATMS, it can be seen the active pattern of AtMS in the form of a general architectural topology as below.

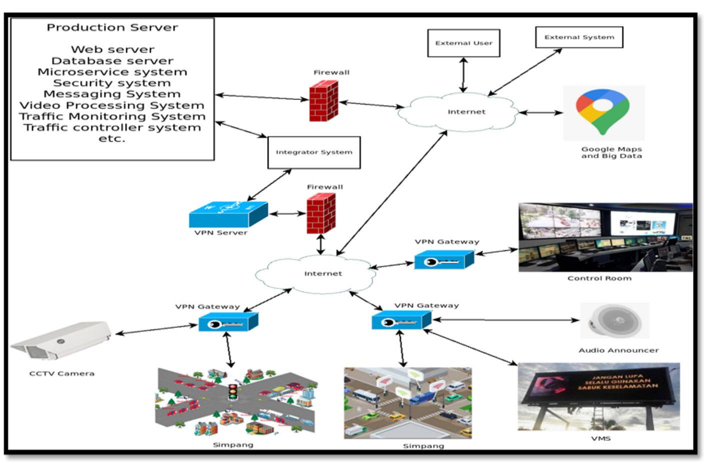

Figure 4.1 General Topology and ATMS Working Principles and Patterns

In its implementation, all the features of the ATMS component must be integrated. The integration needs to be done at the back-end through a dashboard management system in the control room. The entire process of integrating components and features of AtMS can be seen in the following figure.

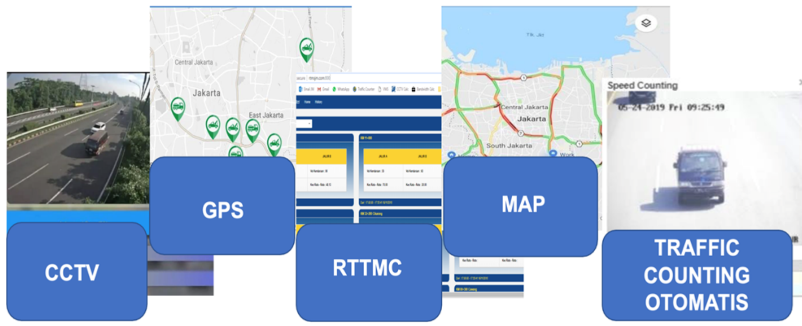

Figure 4.2 ATMS Integration Features in the Dashboard Management System
Source: Directorate General of Traffic, Ministry of Transportation, 2021

In the process of integrating information systems in the control center, the data stored in the traffic processing system server is the input and output of the parties related to the road transportation management process in the command center.

The stored data will be used by the traffic monitoring computer to display the condition of the highway in the form of graphical displays and numbers as below.

4.2 Multi Lane Free Flow (MLFF) with GNSS (Global Navigation Satellite System) Technology for Toll Road- Ministry of Public Work

The increase in the number of vehicles is not in line with the growth of road construction in Indonesia. Traffic is often encountered, especially in urban areas. Toll roads are made to reduce the level of congestion that occurs. Even though payment by electronic card has been implemented, in fact, queues of vehicles still occur at toll gates. A technology update is needed, namely using Multi Lane Free Flow. That is a non-stop payment method where users don't have to stop their vehicles to transact. Based on data from the Central Statistics Agency (BPS) in 2018, the number of passenger cars in Indonesia reached 16.44 million units. In the next few years, the length of the toll road will reach 6,000 km.

This cashless transaction system based on Multi Lane Free Flow (MLFF) is one of the new innovations through the contactless payment system by creating an efficiency, effectiveness, security, and convenience in the implementation of the toll road payment system in Indonesia. The MLFF system that will be implemented by the Government of Indonesia is to use Global

Navigation Satellite System (GNSS) technology and make transactions through special toll road applications on smartphones or smartphones.

The government's plan to implement a contactless cashless toll transaction system based on Multi Lane Free Flow (MLFF) with Global Navigation Satellite System (GNSS) technology will begin in December 2022. And of course, the implementation of this MLFF requires a fairly massive socialization, so that a pilot project will be carried out as a pilot project in the third quarter of 2022 in stages and will be carried out in full in September 2023.

Through the Letter of the Minister of PUPR Number PB.02.01-Mn/132, it has been determined that Roatex Ltd. as the initiator of the project. Roatex Ltd. Zrt has now formed a company as a Business Entity Implementing the MLFF-Based Non-Cash Toll Transaction System, under the name PT Roatex Indonesia Toll System (RITS).

The MLFF to be implemented is the result of bilateral cooperation between Indonesia and Hungary with the aim of improving the toll transaction system in Indonesia. This project was initiated during the visit of the Prime Minister of Hungary, Mr. Victor Orbán, to Indonesia in 2016. The Hungarian government invests 100 percent of this project with a value of IDR 4.5 trillion in the form of government and business cooperation (PPP).

Furthermore, GPS will determine the location determined by the satellite and the map-matching process will run in the central system. When the vehicle exits the toll road and the map-matching process ends, the system will calculate the fare. Global Navigation Satellite System (GNSS) technology, is a system that allows transactions to be made via an application on a smartphone and read via satellite. The use of electronic money has reduced the transaction time to 4 seconds compared to manual transactions of 10 seconds.

GNSS technology makes the reader do not need to be in every place because it uses satellites, in contrast to radio frequency identification or RFID. GNSS uses a tool that is installed in the car. When the vehicle is at the toll road substation, the device will be read through the system on the satellite.

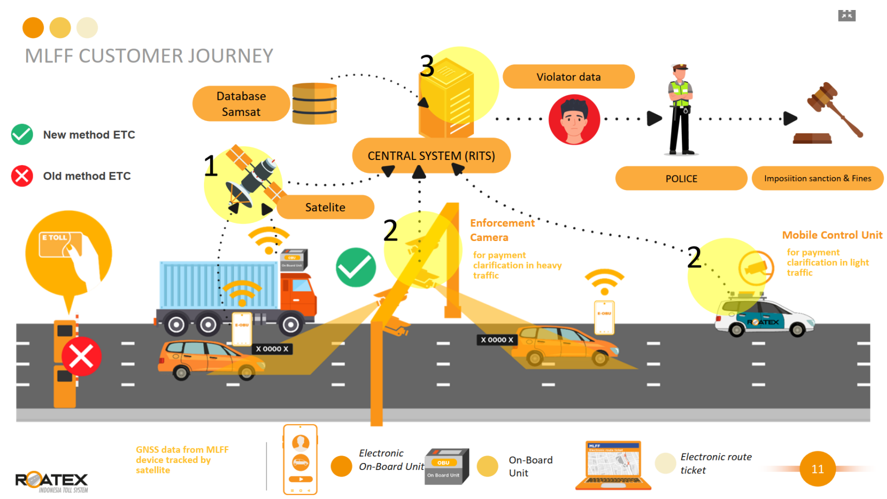

Figure 4.3 MLFF Customer Journey by Roatex

4.3 Intelligent Traffic Control System (ITCS) for DKI Jakarta- Jakarta Transport Authority

Area Traffic Control System (ATCS) is an information technology-based traffic control system that aims to optimize road network performance by optimizing and coordinating traffic light settings at every intersection. With ATCS, it is hoped that problems related to accidents, violations, or traffic jams can be avoided or followed up objectively. The nature of this system is about monitoring. Thus, it is necessary to have a more optimal follow-up in the form of policies by determining service and performance indicators and advanced supporting technology to change its function from supervision to control through development and improvement to ITS Traffic Light in ITCS (Intelligent Traffic Control System).

The development and improvement of ITS Traffic Light in DKI for the entire intersection (321) requires an increase towards an intelligent traffic control system (ITCS) that uses an artificial intelligence (AI) network and can be controlled in real-time and coordinated for all 321 intersections through the control center. The development and improvement of ITS Traffic Light in real-time requires control in the control center through the Interactive Dashboard Management System (IDMS). The IDMS needs AI-based technology, a solution to replicate real conditions (physical world) into the digital world, and optimization with predictive modeling is carried out to return to the real world of traffic through effective and efficient signaling phase control.

The architectural development of ITCS Development and Improvement in DKI Jakarta must refer to the ITS national architecture, especially the ATMS (Advanced Traffic Management System) which the Ministry of Transportation compiled in 2020.

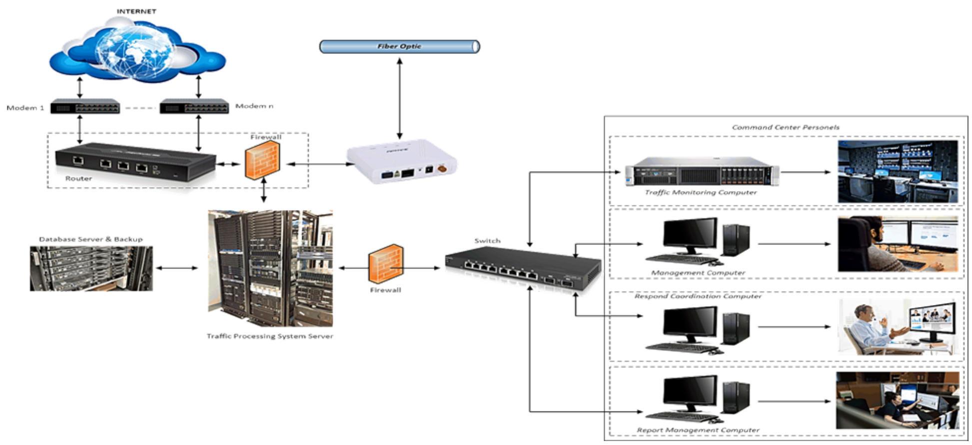

Figure 4.4 The Basis for the Architectural Development of ITCS DKI Jakarta
Source: Masterplan ITS Jabodetabek, 2019

As the picture above, both systems—Traffic processing system and traffic command center—will be connected to the internet, specifically for synchronizing data with the website server and web service server through several modem devices (modem 1 to modem n) and modem devices connected to fiber-optic communication lines. The data stored in the traffic processing system server is the input and output of the drivers related to the command center's road transportation management process. The traffic monitoring computer will use the stored data to display the condition of the highway in the form of a graphical display and numbers (Dashboard).

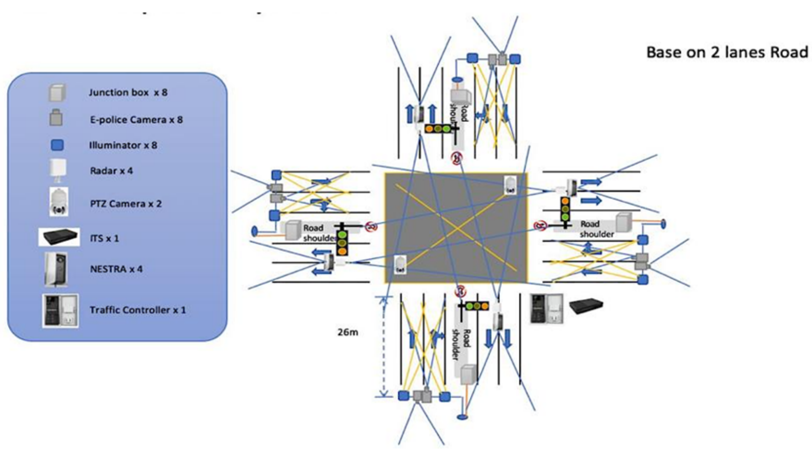

Figure 4.5 ITCS Topography Architecture (Implementation)

In this ITCS planning, architectural topology scenarios are also carried out for each intersection to calculate the number of hardware requirements in the field and show the installation layout and topology in the ideal front-end hardware working mechanism. The architectural topology of the ITCS implementation above is the most perfect layout. It can take advantage of all the features (intelligent traffic control (real-time), illegal parking detection, automatic pedestrian crossing arrangements coordinated with traffic lights, green wave settings, VIP green waves, priority buses, coordination with ITS on the roadside and others in the digital twin-based ITCS system. In contrast, it is possible to regulate which features will be implemented in stages in actual implementation.

The implementation architecture topology is on the roadside where the scenario above is with two two-way lanes with a median where each lane has two main lanes. Installation of ITS on roads is placed between two intersections to get the amount of traffic generated (generation) and distributed (distribution) along with its classification. This data will be integrated with the ITCS system at the intersection and automatically predict the signaling in real time to control the intersection very effectively. The hardware used includes two Nestra cameras which are installed on the side of the road in each lane and are equipped with an AI-based system

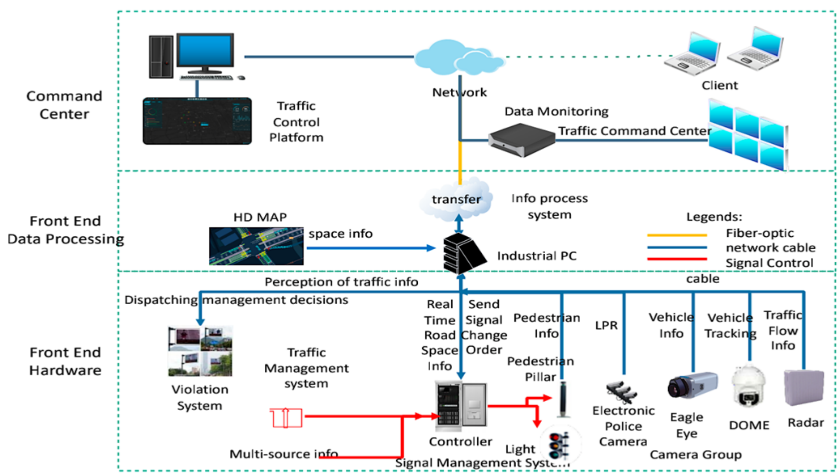

Figure 4.6 ITCS DKI Jakarta Architectural Development

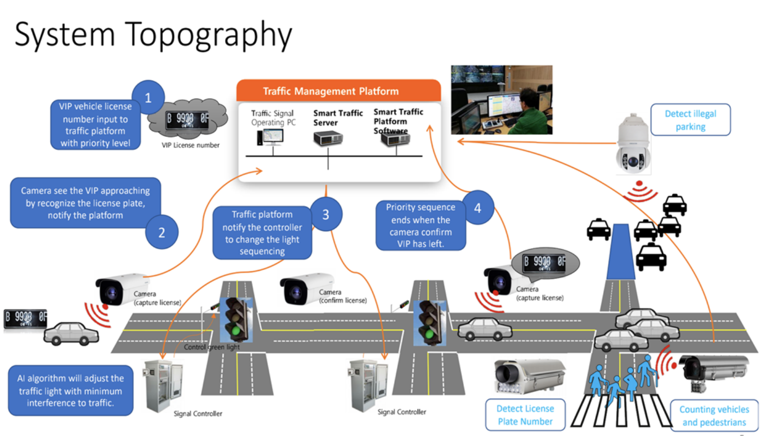

Figure 4.7 VIP Green Wave Architecture in ITCS DKI Jakarta

4.4 ITS Design Platform for Toll Road (Jasa Marga) - Toll Road Operator

JMTC (Jasa Marga Toll Road Command Center) is equipped with an Advanced Traffic Management System (ATMS) and an Advanced Traveler Information System (ATIS). There is also an initial Incident Management System (IMS), an early detection tool for traffic disturbances.

There is an ITS ecosystem with six systems, namely ATMS, ATIS, IMS, ETC, ITMS, and WIM ODOL (not yet integrated with ITS) which are integrated into one ITS platform. For ATMS, ATIS and IMS are coordinated with traffic law enforcement related to road safety, such as implementing detection of violations such as speed violations of overload (not yet for over dimensions). At the same time, for ETC it is divided into two parts of the system, namely the electronic financial transaction system and service integration electronic payment. For ITMS the system is divided into 3 parts, namely the toll road maintenance system, maintenance of supporting equipment and prevention maintenance (preventive maintenance).

1) ATMS (Advanced Traffic Management System)

Current Condition: traffic monitoring system along with ramp metering, which is connected to the data center or control center at the back end (JMTC) and then distributed to information systems through applications, VMS, through call centers, and radio communications. Traffic control is available but it is still monitoring. The back office still is monitoring (Control Room) and all roads cannot be processed into predictive modeling.

Adaptation: Building a higher generation ATMS (gen 4 or 5) can perform predictive modeling to prevent traffic management. Other than that, the development of Traffic Operation Center (level up to NoC-Network Operation Center), and the development of ATMS with Interactive Dashboard Management System and using digital twin solution predictive modeling will also be done.

2) ATIS (Advanced Traveler Information System)

Current Situation: There is information management which is also equipped with the Advanced Traveler Information System (ATIS), which can provide information to toll road users both before and during the trip. This information is obtained through several data inputs, such as One Call Center 24 Hours. at 14080, Variable Message Sign (VMS) through the Travoy 3.0 application.

Adaptation: Development of ATIS enhancements by constructing container systems (containerize system) that connects JMTC to the Transport Information System Container before connecting to ATIS applications such as Travoy, VMS, etc.

3) ITMS (Intelligent Toll Maintenance System)

Current condition: Jasa Marga has two subsystems within the ITMS that are being developed, namely the development of road damage monitoring using the Hawkeye tool and an integrated asset management and maintenance system

Adaptation: Developing an integrated system where the two systems that have been developed become input subsystems (pavement management, road inventory, monitoring, maintenance including asset management) and connected to the development of the sub-system within JMTC to be processed into information and databases for technical analysis in the Pavement Management System. Thus, the digital output reports on maintenance budget programs and action plans can be produced. The development of the ITMS ecosystem through technical analysis of PMS to produce a digital report related to the budget and action plan for toll road maintenance.

4) IMS (Incident Management System)

Current condition: JMTC has a system that adapts Electronic Traffic Law Enforcement (ETLE), which can accurately provide data on traffic violations on toll roads (such as speed and load violations) with the help of speed camera equipment that has vehicle number plate detectors and weigh in motion to the Police for further legal proceedings.

Adaptation: IMS implementation based on Emergency Management Response where all data collection from surveillance cameras and all devices traffic monitoring will be connected to JMTC. The data will be processed analytically and distributed to emergency response services (police, firefighters, ambulances, hospital hospitals, etc.) appropriate procedural action in an incident. This process goes through improving and is distributed informationally through various information tools to users (onboard/mobile, VMS, web port, etc.)

5) ETC (Electronic Toll Collection)

Current condition: Currently using the ETC method with a barrier using the tap cash method (cashless) in the form of e-money.

Adaptation: Building an MLFF-based ETC system with Global Navigation Satellite System (GNSS) technology that uses e-OBU as an intermediary device to a touchless system. Build a GNSS-based MLFF System in stages at all Jasa Marga toll gates

6) Over Dimension-OverLoad System (WIM and Sensor OD)

Current condition: Currently, the use of the WIM method has been adopted at Jasa Marga through the installation of WIM on several bridges known as WIM Bridges but there is no use of installed OD sensor technology. In addition, Jasa Marga has initiated collaboration with the police to apply ETLE as a process of prosecution for the ODOL system on toll roads.

Adaptation: Building a WIM technology system based on High Speed WIM and OD Sensors in collaboration with BPTJ in meeting the installation standards of WIM and OD Sensors. Development of High Speed WIM System for main roads and implementation of OD sensor based on dimension scanner/LIDAR

4.5 Over Dimension-Over Load System with WIM and Scanner Technology for Toll and Arterial Road - Ministry of Public Work

The existing issues that Indonesia face related to big vehicles are vehicle overload, road surface destruction, reduced road capacity, increase in potential negative consequences of road accidents, and over-dimensional vehicles. One of the companies that is now collaborating with Indonesia Toll Road Authority, NTS Group, is currently in the trial phase of ODOL implementation in one of the toll roads in Indonesia. In the picture below, the NTS Group has shared the equipment Specifications and the data architecture of the proposed ODOL system.

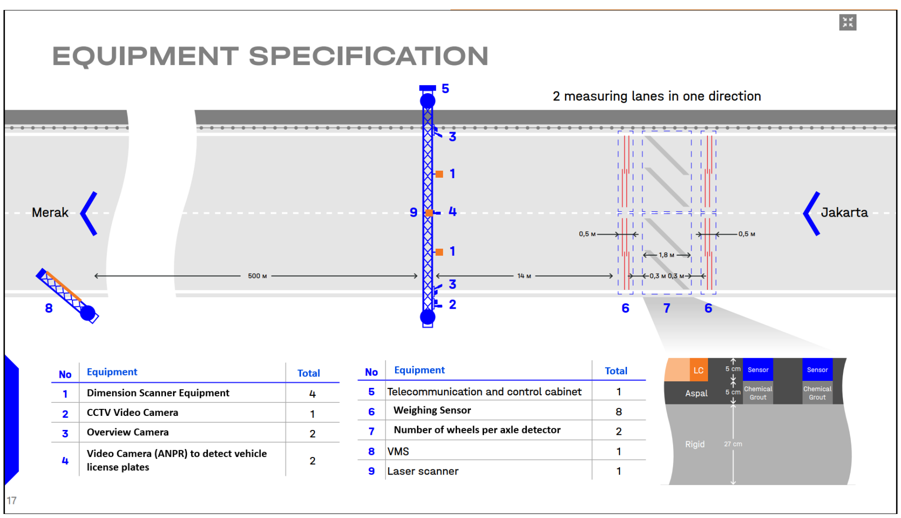

Figure 4.8 Equipment Specification

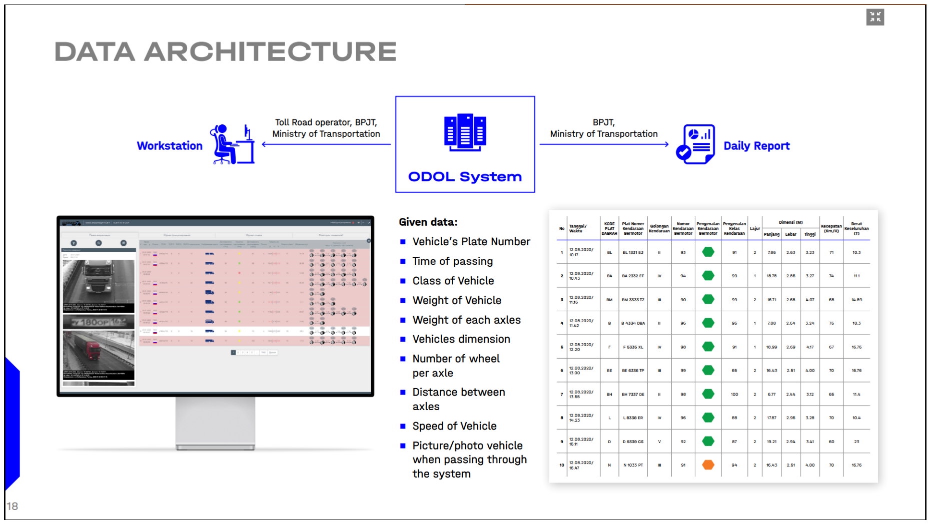

Figure 4.9 Data Architecture

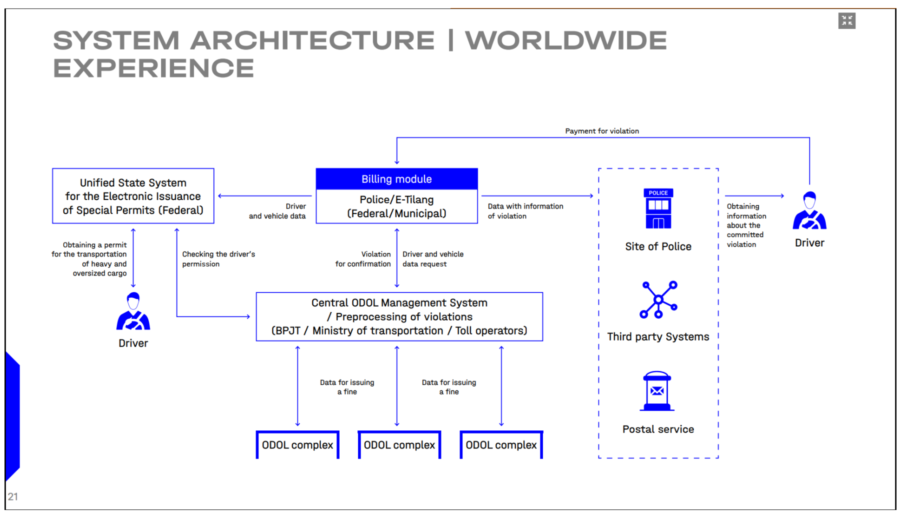

Figure 4.10 System Architecture I Worldwide Experience

Weigh In Motion (WIM) technology in order to control Over Load Vehicles on Toll Roads to support the national program Indonesia Free from Over Dimension Overload (ODOL) in 2023. The use of WIM technology is planned to be integrated with the Electronic Traffic Law Enforcement (ETLE) system. So that the number of ODOL vehicle violations can be reduced

The Ministry of Public Works and Housing will continue to encourage the modernization of the toll road operating system through surveillance technology for vehicles with more dimensions (over-dimension) and those with overloads.

Over-dimension – overload or ODOL vehicles are not allowed to operate on Toll Roads starting January 1, 2023. All Toll Road Business Entities must install the Weigh in Motion (WIM) and Over Dimension Detection technology which is targeted to be completed by the end of 2022.

4.6 Electronic Traffic Law Enforcement (ETLE)- Indonesia Traffic Police Department

Electronic Traffic Law Enforcement (ETLE) is a traffic law enforcement system based on information technology using the camera to detect various types of traffic violations and present motorized vehicle data automatically (Automatic Number Plate Recognition). ETLE camera footage can be used as evidence in traffic violation cases. The legal basis for the implementation of ETLE is Law No. 11 of 2008 concerning Information and Electronic Transactions, Law No. 22 of 2009 concerning Traffic and Road Transportation, Government Regulation No. 80 of 2012 concerning Procedures for Inspection of Motorized Vehicles on the Road and Enforcement of Traffic Violations. Road Traffic and Transportation, Regulation of the head of the Indonesian National Police No. 5 of 2012 concerning Registration and Identification of Motorized Vehicles.

Since ETLE was implemented in March 2021, there has been a change in behavior in April-May. At that time traffic violations decreased by about 47 percent which were recorded by cameras. Until December 2021, the decrease in violations ranged from 10-20 percent. The picture below explain the mechanism of E-TLE:

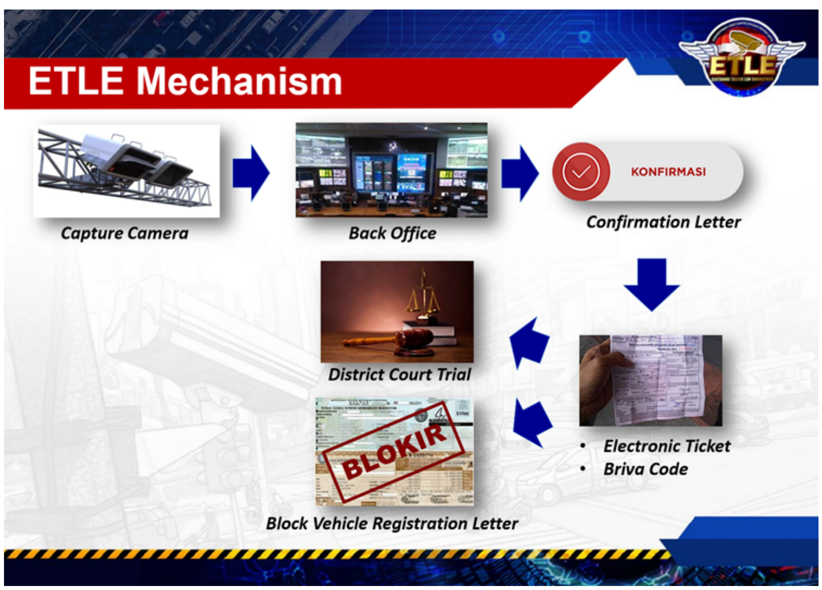

Figure 4.11 ETLE Mechanism

The development of ETLE in 2022 is a collaborative implementation of ETLE on Toll Roads in collaboration with the National Police Traffic Corps and Jasa Marga and the application of National ETLE to 10 Polda. National ETLE aims to achieve road safety effectively and efficiently, namely realizing and maintaining safe, orderly and smooth traffic. Then improve the quality of safety, reduce the fatality rate of accident victims, and build a culture of orderly traffic.

The National Police Traffic Corps has only implemented the first stage of CCTV ETLE at 12 Regional Police with 244 cameras. Most of them are in the Regional Police Metro Jaya area with 98 camera points. It is planned that ETLE will be implemented throughout Indonesia through three stages, of which the second phase will be launched at 13 Polda in February or early March 2022.

Currently, ETLE is able to detect violations:

1. Detecting Odd and Even Violations
2. Detecting seat belt violations by driver
3. Detecting over speed violations
4. Detecting cell phone violations
5. Detecting violations by motorcycle (not wearing helmet/against the road flow)
6. Capable to detect multiple vehicles in infraction at the same time
7. Illegal lane crossing detection
8. Capable to detect multiple types of offense for a single vehicle
9. Classification between trucks and light vehicles
10. Capability to set speed limit for trucks and light vehicles independently
11. Capability to set speed limit for each lane independently
12. Capability to track vehicles in both directions (approaching and receding) at the same time
13. Capability to detect Forbidden U-Turn
14. Capability to detect vehicles that stopped on a yellow box (middle of the road intersection)

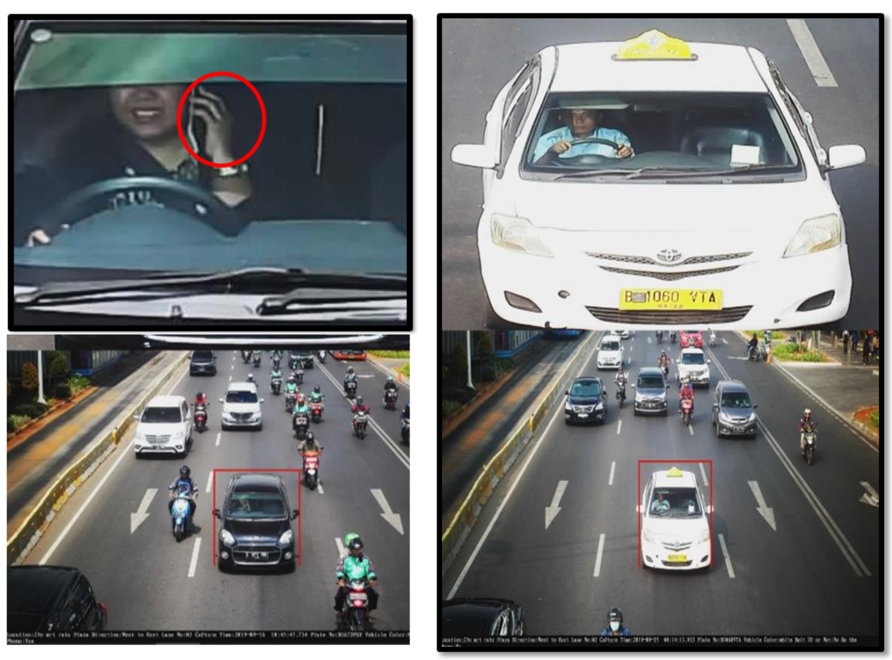

Figure 4.12 Cell phone and seat belt violations that is captured by E-TLE camera

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