Smart transportation systems, which touch all the capillaries of cities, include signalized intersections as one of their most important applications. However, if not implemented properly, these systems can cause traffic jams.

Smart Transportation

REPUBLIC OF TURKEY
MINISTRY OF ENVIRONMENT, URBANIZATION AND CLIMATE CHANGE

DIRECTORATE GENERAL OF GEOGRAPHIC INFORMATION SYSTEMS

Smart Cities Capacity Building and Guidance Project

Training Manual

REPUBLIC OF TURKEY
MINISTRY OF ENVIRONMENT,
URBANIZATION AND CLIMATE CHANGE

SMART **TRANSPORTATION**

Smart Cities Capacity Building and Guidance Project

www.**akillisehirler**.gov.tr

DECEMBER **2020**

"We will broaden new horizons in urbanism with smart cities. We will support all Smart City applications that will expedite the daily life of our people, from access to municipal services to the management of transportation, energy, buildings and devices."

"We are pursuing for constructing smart cities."
"We are setting out the principles to meet the future needs of our cities, not the past or present needs."

"We will leave cities which have identities, to be proud of, to find traces of our civilization for our future generations."

"What is the main thing? The main thing is the human. We will provide opportunities for the human."

Recep Tayyip ERDOĞAN

President of the Republic of Turkey

REPUBLIC OF TURKEY
MINISTRY OF ENVIRONMENT,
URBANIZATION AND CLIMATE CHANGE

"The yields of technological developments are reflected in urban life with the concept of smart cities. One of the elements that makes up the city is culture and the other is happiness of the human. What needs to be considered is to build cities that preserve the cultural fabric and reflect their own identity. I believe that both history and culture should be strictly preserved while making cities smart."

Murat KURUM

Minister of Environment, Urbanization and Climate Change of the Republic of Turkey

SMART TRANSPORTATION

Smart Cities Capacity Building and Guidance Project

Ministry of Environment, Urbanization and Climate Change of the Republic of Turkey
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Preface

Urban populations are increasing day by day in our country and in the world, and as a result of this mobility, cities have to cope with new needs in many areas such as infrastructure, affordable housing, water, environmental cleaning, health services, transportation and security.

The concept of "smart city" comes to the fore in responding to these needs and even creating opportunities for urban development.

With its ability to transform the information it offers into social benefit, the smart city will create gains in the titles of sustainable development, competitiveness and environmental sustainability, increase the quality of life, contribute to economic development, and serve to prepare our cities in a way that reflects the perspective of history and civilization. However, the implementation of smart cities will contribute to the realization of many goals such as "Sustainable Cities and Communities", "Accessible and Clean Energy", "Industry, Innovation and Infrastructure" and "Climate Action" specified in the United Nations Sustainable Development Goals.

In our country, parallel to the whole world, smart city applications are becoming widespread day by day. Therefore, it is important that all public institutions, local administrations, universities, the private sector and non-governmental organizations act in a collective action in order to plan and direct smart city studies on a national scale.

With this motivation, it is to gain the ability to work together by bringing a holistic view at the national level to smart city policies in our country. At the same time, it is necessary to ensure that the investments are implemented with the right projects and activities by prioritizing the investments that are compatible with the determined policies. For this purpose, the 2020-2023 National Smart Cities Strategy and Action Plan, which was built with the common mind of ecosystem stakeholders, which considers national needs and priorities holistically, has been prepared. With the 2020-2023 National Smart Cities Strategy and Action Plan Circular No. 2019/29, it was published in the Official Gazette dated 24 December 2019 and numbered 30988 and entered into force.

The "Smart Cities Capacity Building and Guidance Project" was implemented by our Ministry in order to contribute to the realization of the actions, duties and responsibilities defined within the scope of the 2020-2023 National Smart Cities Strategy and Action Plan on a national scale and to increase the capacity of all stakeholders, especially our local governments.

This document you are reading is one of the guidance documents prepared within the scope of the aforementioned project, and all guidance documents can be accessed at www.akillisehirler.gov.tr.

Contents

1

INTRODUCTION

Transportation is a critical component of city life and frequently brings a slew of issues. The majority of people's daily time, particularly in large cities, is spent in traffic. This predicament, which resulted in traffic congestion as a result of the growth in vehicle ownership, is a result of both a lack of transportation infrastructure and inadequate solutions to transportation demands.

It is the goal of smart transportation (mobility) to properly build transportation infrastructures and to produce more sustainable solutions. Despite the perception that Turkey's cities are inaccessible to automobiles, vehicle ownership remains much lower than the European norm. While Europe has around 350 automobiles per 1,000 inhabitants, Turkey has approximately 150. With the country's economic progress, this figure is anticipated to reach the European average, aggravating the country's existing difficulties. As a result, there is a requirement for a paradigm change.

Transportation is fundamentally a function of supply and demand. Humans require movement in order to exist. They are regularly required to travel between locations in order to do their tasks. They are regularly required to travel between locations in order to do their tasks. As a result, transportation facilities throughout history began as paths. Today, as cities grow, their variety of activities expands, necessitating the expansion of transportation infrastructure. Highways have been widened and infrastructure for numerous means of transportation developed. It should be emphasized at this point that the infrastructures that will be built to meet travel demand will have an influence on human behavior and will govern how transportation wants will be satisfied. Establishing a comfortable walking path between two locations, for example, may encourage people to walk.

The primary factor that contributes to the creation of a journey in a city is a person's requirements. This debate begins with the topic

of whether an individual must travel for the duration of the day when he awakens in the morning (with the pandemic affecting the whole world in 2020, it is seen that the need for travel has decreased as some businesses have chosen to work remotely). Following that, these questions are followed by those of where to go, how to get there, and which path would be the most suited. Morning and evening rush hour traffic, which is one of a city's primary concerns, comes as a result of individual judgments about these issues. As a result, a paradigm change is required. In many cities, the separation of residential neighborhoods and commercial districts increases the demand for transportation and contributes to traffic congestion, particularly during morning and evening rush hours.

With the Covid-19 outbreak set to begin in 2020, remote working and flexible working techniques are options that have been considered in transportation planning for a long time but have yet to find implementation. Additionally, it has been demonstrated that relocation is not always essential to do an activity in the presence of this pandemic.

During peak hours, one of the major issues cities confront is that demand exceeds supply. Due to the fact that systems are not built around peak hours for economic reasons or because demand rises over time, demand exceeds capacity during peak hours.

As cities get larger and more distant, it becomes increasingly difficult to offer universal public transit. Travel times are growing and prices are increasing as a result of meeting basic demand.

Congestion is one of the primary issues confronting large cities worldwide. Congestion causes air pollution as a consequence of lost time and emissions, and economic loss as a result of fuel usage.

The automobile-oriented strategy is the one that traps cities' issues in an inextricable vicious spiral. When additional capacity is developed to meet automotive demand following a traffic congestion, there is some relief for a while, but demand is re-triggered, and after a brief respite, traffic jams recur (Elker, 2004).

Cities may address transportation challenges in two ways: by altering existing response techniques and policies and by implementing smart transportation systems (STS). In this context, the Ministry of Environment, Urbanization and Climate Change's 2020-2023 National Smart Cities Strategy and Action Plan study specifies all focus areas, from smart energy to smart health, from geographic information systems to disaster and emergency management, as well as goals for these focus areas. The action plan, which is targeted at smart transportation, comprises initiatives aimed at advancing the maturity of smart transportation in cities.

Additionally, the Ministry of Transport and Infrastructure, in its National Intelligent Transportation Systems Strategy Document and 2020-2023 Action Plan, outlined actions under five primary purposes aimed at increasing the country's transportation maturity; it also provided a roadmap covering all aspects of transportation maturity, from legal regulations to the implementation of innovative and technological applications.

In order to solve the transportation problems of our cities and to increase their maturity in the field of transportation, studies should be carried out in line with these strategies and goals.

In this study, smart transportation will be discussed in two basic frameworks:

- Meeting limited resources with innovative and sustainable solutions instead of the traditional understanding of solving transportation needs,
- Supporting innovative transportation solutions with information and communication technologies (ICT)

are listed as.

All kinds of application studies related to transportation in the city;

- It should be able to increase security,
- Should increase efficiency,
- Shorten travel times,
- It should be economical,
- It should be environmentally friendly and sustainable.

2

SITUATION DETERMINATION

2.1. TRANSPORTATION CHALLENGES OF CITIES

Cities are confronted with a variety of difficulties related to population expansion and migration. "Transportation" is the first of these stumbling blocks. Longer distances and hence longer travel times, traffic congestion, overcrowded public transit vehicles, and an increase in traffic accidents are only some of the major transportation issues that municipal administrations confront. Transportation is also a source of contention for city dwellers, who spend a substantial portion of their daily lives stuck in traffic as a result of urbanization. Transportation is significant in the first two of the main concerns identified in a persona analysis research done in Istanbul utilizing in-depth interviews with individuals (Figure 1).

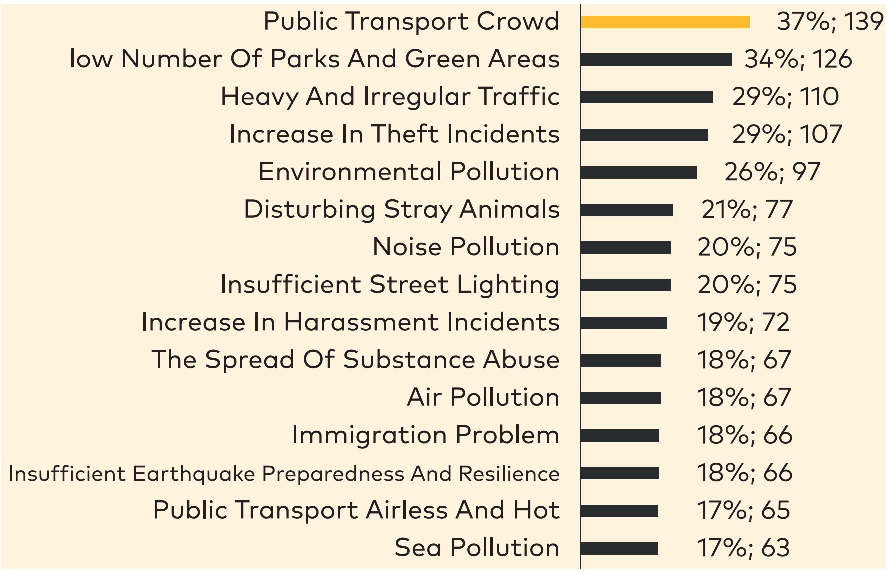


Figure 1: Istanbul Persona Analysis Results
Source: T.C. İstanbul Büyükşehir Belediyesi, 2018

Cities face infrastructure problems because infrastructures are not planned forward or because cities grow faster than anticipated. With population growth and economic development, the increase in automobile ownership emerges as traffic congestion. In addition, the following issues are among the transportation difficulties of cities:

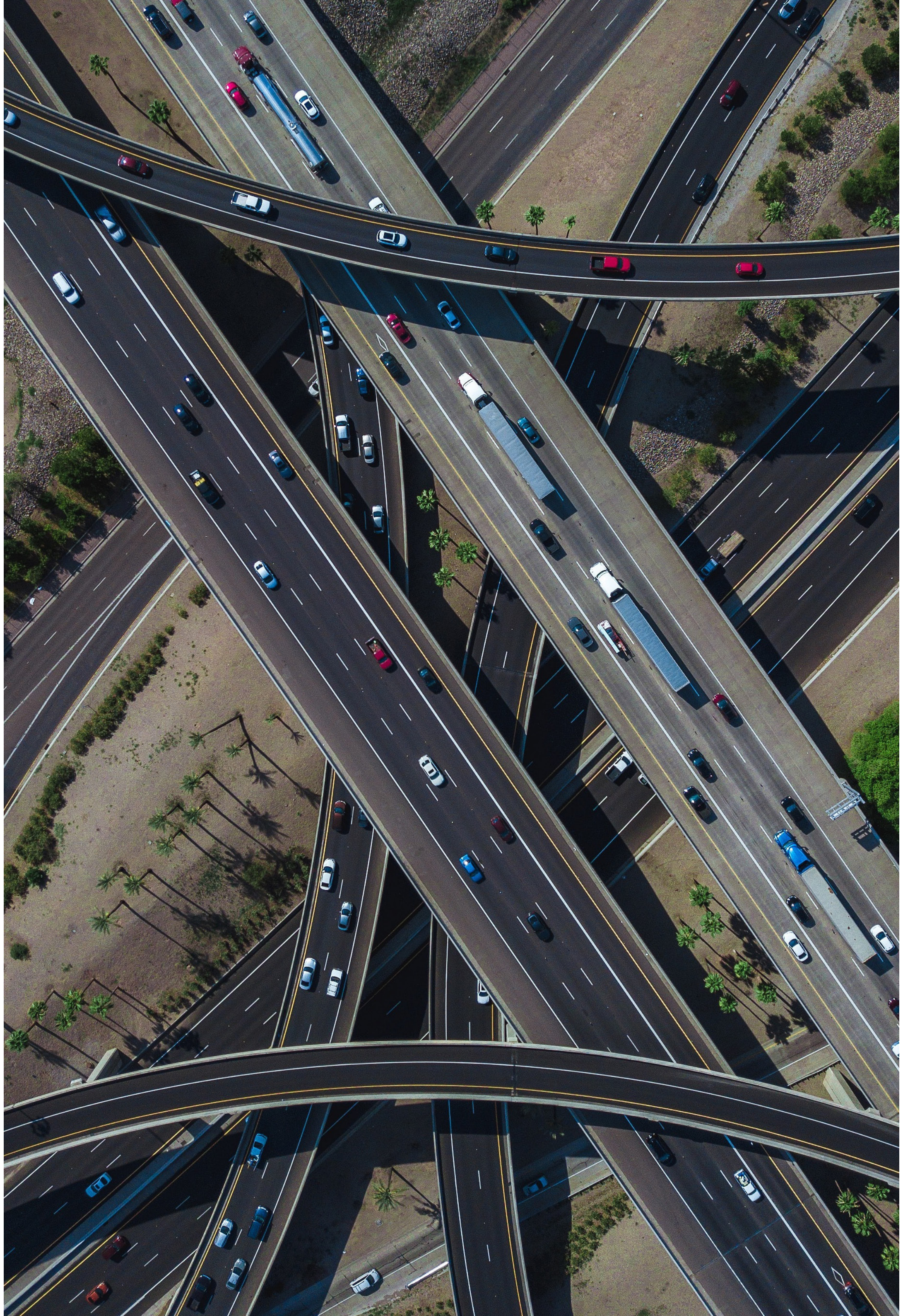
- Traffic jam,
- Traffic accidents,
- Accessibility,
- Parking problem,
- Noise pollution,
- Air pollution,
- Inefficiency.

A significant part of the environmental problems of cities are caused by transportation. According to the European Environment Agency, 23.8% of greenhouse gas emissions are caused by the transportation sector (European Environment Agency, 2020). However, city noise caused by transportation vehicles is also an important source of pollution. These problems can be solved with urban policies, planning and smart transportation applications as will be examined in the following sections.

2.2. SMART TRANSPORTATION IN THE WORLD AND IN TURKEY

Numerous worldwide and national applications within the context of Intelligent Transportation Systems (ITS) continue to be implemented now as they were in the past. One of them is the rising traffic congestion in London in 1896, which resulted in the introduction of gas-powered traffic signals to ensure the safety of pedestrians. In the 1920s, the United States of America deployed the first traffic-excited (dynamic) signaling systems that utilized both coordination (green wave) and sound waves in signaling systems. These dates might be regarded the earliest instances of ITS. Different methods and systems have been created over the years in response to technology advancements and developing demands.

In 1996, as ITS proliferated and the diversity of its deployed systems increased, ITS architectural studies began in the United States. Japan and other nations followed the European Union (EU) in conducting comparable research in the 2000s. The primary purpose is to standardize the application and architecture and to ensure compatibility across various systems. The ITS design is evaluated systemically in four areas: the center, the road, the vehicle, and the passenger.



Recently, systems for enhancing road network safety and reducing traffic congestion, such as lane management systems, road network management systems, and safety lane management, collectively referred to as "active traffic management" on urban or non-urban highways or divided highways, have gained popularity. Additionally, as communication technology advance, research is conducted on vehicle-to-vehicle (V2V) and vehicle-infrastructure (V2X) communication. These studies, also known as cooperative ITS, are carried out as test corridors, mostly in the United States and the European Union, and their outcomes are monitored. Vehicles participating in these programs, which aim to improve traffic safety and make better use of available road capacity, connect with one another and with the transportation infrastructure, exchanging "Traffic Status Information." However, the automobile industry is always in communication with its surroundings and, in an ideal world, does not require a driver;

it is continuing to develop autonomous cars that operate with the assistance of numerous sensors. When these studies are finished, benefits such as the reduction of traffic accidents caused by human error and improved utilization of road capacity are anticipated. Additionally, it is critical to incorporate cyber security risk into these assessments.

Another application that has been created recently within the context of ITS is "Mobility as a Service-MaaS." Its precursors were first observed in Scandinavian nations and subsequently extended around the world; It aspires to eliminate car ownership by providing all transportation services through a single channel via a mobile platform. MaaS is an application that will amplify the role of autonomous cars in cities in the next years. Numerous towns around Europe are now building their own MaaS applications in order to promote sustainable modes of mobility.

In contrast, Turkey, like the rest of the globe, pioneered ITS using signaling systems. Istanbul Municipality originally declared in 1929 the establishment of "Signaling Systems" (Milliyet Gazetesi, 1929). Following it, the expansion to Istanbul and Bursa proceeded. Murat & Gündoan, 2019). Murat & Gündoan (2019).

The 1988 implementation of the "Emergency Communication System" on the Istanbul-Ankara motorway might be regarded the first application of the system. The first "SCADA Control Center" was constructed in 1991 in the Korutepe-Gültepe (Istanbul) tunnels (T.C. Karayollar Genel Müdürlüü, 2014).

In 1995, the first electronic public transportation ticket, AKBİL (Smart Ticket), was launched by the Istanbul Metropolitan Municipality (IETT, 2021). In 1996, Turkey's first "Domestic Signaling System" was developed by Istanbul Metropolitan Municipality affiliate company ISBAK (ISBAK Istanbul Bilişim ve Smart Kent Teknolojileri A.Ş.). In 1998, the first "Traffic Control Center" to perform basic functions was established in Istanbul. The center continues to provide services with the addition of new functions, revised in 2004 and 2018 (ISBAK, 2021).

In 1999, the "Automatic Pass System (OGS)" was started to be implemented on the Fatih Sultan Mehmet Bridge. In addition, the “Card Entry System” was implemented. In 1999, “Bolu Mountain Traffic Information System” was put into practice. Again in this context, “Variable Message Systems (DMS)” was established. In 2000, the "Ankara Traffic Information System Project" was carried out (T.C. Karayolları Genel Müdürlüğü, 2014).

The first web-based "Traffic Information System Density Map" was implemented by the Istanbul Metropolitan Municipality in 2003, and "Mobile Traffic" was developed as a mobile application in 2006 (ISBAK, 2021).

In 2005, the "Red Light Violation Detection System", which is the first electronic monitoring system, was implemented (ISBAK, 2021).

In 2011, Okan University started studies on autonomous vehicles; In 2012, Istanbul Metropolitan Municipality completed the field work of the project in the field of vehicle-vehicle and vehicle-infrastructure for the first time with the EU Project (T.C. Karayolları Genel Müdürlüğü, 2014).

The first “National Transportation Portal” study was carried out by TÜRKSAT in 2012 (T.C. Karayolları Genel Müdürlüğü, 2014).

The "Adaptive Signaling System", which was implemented in a limited number of cities in the world in 2012, was developed locally (ISBAK, 2021).

In 2013, the "First Contactless Payment Project" was carried out on buses in Şanlıurfa with the cooperation of the public transport operator and the mobile operator.

In 2014, "Highway Network National Intelligent Transportation Systems Architecture" was completed (T.C. Karayolları Genel Müdürlüğü, 2014).

After 2014, "Camera Based Signaling Systems solutions" have become widespread especially in metropolitan cities. On the highways, the number of "Variable Message Systems (DMS)", "Traffic Control Centers" and "Electronic Control Systems (EDS)" has increased day by day. The last example of ITS applications was carried out in the Ankara-Niğde Highway Project, which was put into service in 2020. Therefore, the highway; It is known as Turkey's smartest highway (T.C. Ulaştırma ve Altyapı Bakanlığı, 2020b).

3

POLICY AND STRATEGIES

3.1. NATIONAL ACTION PLANS

Transportation, including its infrastructure, superstructure, and technology, is given precedence in governments' strategic goals and action programs. Mobility issues were addressed in our country's national strategy and action plan papers, and purposes were established to improve cities' maturity in smart transportation.

Because transportation is inextricably linked to a variety of fields of competence, including infrastructure, urbanism, energy, the environment, technology (communications), and security, transportation is unquestionably reserved for various organizational functions. The large proportion of energy consumed by transportation in overall energy consumption, the proportion of transportation vehicles in total air pollution in cities, and the influence of traffic accidents on fatalities from accidents all play a significant role.

In addition to the Smart Transport, 2020-2023 National Smart Cities Strategy and Action Plan, various strategies and action plans have found their place. These plans and documents;

- 11th Development Plan
- 2017-2020 National Broadband Strategy and Action Plan
- 2010-2023 Integrated Urban Development Strategy and Action Plan
- 2017-2023 National Energy Efficiency Action Plan
- 2012-2023 Energy Efficiency Strategy Document
- 2003-2023 National Science and Technology Policies Strategy Document
- 2014-2023 Regional Development National Strategy
- 2012-2023 National Earthquake Strategy and Action Plan

- 2011-2020 Road Traffic Safety Strategy and Action Plan
- 2010-2023 National Climate Change Strategy Document
- 2018-2022 Ministry of Environment, Urbanization and Climate Change Strategic Plan
- 2020-2023 National Smart Transportation Systems Strategy and Action Plan.
- Target 2023 Turkey Transportation and Communication Strategy

The National Smart Transportation Systems Strategy Document and the 2020-2023 Action Plan are important because of their direct relationship with the transportation sector. The strategy document prepared in line with the creation of "human and environment-oriented transportation system in Turkey with advanced information technologies" has 5 main purposes (Table 1).

Table 1: Purpose and Actions of the National Smart Transportation Systems Strategy Document and 2020-2023 Action Plan

Strategic Purposes	Actions
Strategic Purpose 1: **Development of STS Infrastructure**	• Meeting Legislation Needs on STS • Developing and Publishing STS Architecture • Identification and Classification of STS Standarts • Establishment of Provincial Traffic Control Centers • Establishment of Highway Traffic Control Centers • Expansion of ITS Communication Infrastructure

	• Smart Parking Application and Electric Vehicle Charging Station Establishment • Establishment of Test and Implementation Corridor for Cooperative Smart Transportation Systems (C - STS) • Establishment of Incentive Mechanisms for the Development of Domestic and National Technologies • Researching Disruptive and Innovative Technologies and Their Effects in the Field of ITS
Strategic Purpose 2: **Ensuring Sustainable Smart Mobility**	• STS for Persons with Disabilities and Mobility • Passenger Information System • Single Card Payment System • Expanding the Use of Drones for Logistics
Strategic Purpose 3: **Ensuring Road and Driving Safety**	• Completing the Highway Radio Installation • Creation of Traffic Accident Database • In-Vehicle Information and Communication System (VICS) • Creation of Smart Parking Areas for Vehicles Carrying out Dangerous Goods and Cargo • Smart Level Crossing Application

Strategic Purpose 4: **Creating a Livable Environment and Conscious Society**	• Building ITS Awareness and Consciousness • Updating the Curriculum on Smart Transportation and Traffic Safety • Establishment of the Unit Responsible for STS in Local Governments • Training of Qualified Human Resources in the Field of ITS • Use of Electric Vehicles in Public Transport Fleets and Service Vehicles and Promoting Public Transport • Reducing Fuel Consumption and Emissions • Expanding the Use of Bicycles • Evaluation of User Experiences in the Scope of STS Services • Disinfection and Social Distancing Warning with Autonomous Robots • Determination of Pedestrianization Projects General Concept and Implementation Steps
Strategic Purpose 5: **Data Sharing and Ensuring Security**	• STS Data Management Center Set-up • Ensuring Integration of STS Data Management Center with Traffic Control Centers

Source: (T.C. Ulaştırma ve Altyapı Bakanlığı, 2020a)

The above-mentioned strategic purposes and actions are necessary for legislative changes, the development of technological infrastructure (such as the establishment of control centers), the inclusion of individuals with disabilities in the community, the promotion of economic development, and the provision of effective and efficient services while protecting the environment. In this regard, it is aimed to:

- Ensuring the integration of all transportation modes in accordance with the developed STS architecture and determined standards,
- Developing the existing ITS infrastructure, ensuring integration with the established cooperative smart transportation systems (C - ITS) infrastructures and making it widespread throughout the country,
- Expanding the use of in-vehicle information and communication systems and carrying out studies for the domestic and national production of these systems,
- Carrying out preparatory work in order to make the existing infrastructure suitable for autonomous driving and developing fully autonomous vehicles and disseminating them in transportation modes,
- Carrying out the necessary system and infrastructure works for the conversion of the motion energy of the rail systems into green energy,
- Carrying out legislative studies on vehicle and ride sharing, micro mobility and similar alternative last kilometer transportation applications,
- Expanding the use of blockchain technologies in MaaS, data sharing, freight and logistics services and similar areas,
- Expanding the use of air taxi (VTOL-Vertical Take-Off and Landing), drone and similar vehicles within the scope of ITS by making legislative arrangements,
- Developing smart materials, surface coating, nanotechnology and biotechnology products, recyclable and similar materials, and promoting their use in the field of smart transportation for the purpose of sustainable environment,
- Establishing an Internet of Things (IoT) network containing STS components, storing the data collected from these components in the big data environment and making it suitable for analysis, optimizing the transportation infrastructure by using innovative technologies in artificial intelligence, deep learning, communication and similar fields,
- Anonymizing the collected transportation data and using it for the development of research and innovative applications,
- Developing congestion pricing, high-occupancy lanes, low-emission zones, flexible working hours applications to reduce traffic congestion,
- Dissemination of smart energy solutions in the field of ITS,
- Dissemination of accessibility practices in transportation modes,
- Facilitating transportation activities by integrating logistics centers with transportation modes,
- Functional and operational tests of autonomous vehicles are carried out, certification services are carried out,
- Establishment and dissemination of Autonomous Driving Test and Certification Centers,
- Dissemination of sustainable urban mobility plans

Within the framework of the document published in 2020, these activities are expected to be completed by 2023 (T.C. Ulaştırma ve Altyapı Bakanlığı, 2020a).

3.2. URBAN TRANSPORT POLICIES

As a result of the search for new methods to overcome the transportation difficulties of cities, the goal that people or objects move from one place to another is the goal, and vehicles are tool; and therefore it has been accepted that cities and transportation systems should be designed on the basis of this thought (Table 2).

Traditional Approaches	Contemporary Approaches
Planning the transport supply	Request forwarding
Priority to vehicles	Priority to people
Creating additional capacity	Efficient use of existing infrastructure
The current distribution of trips by species is taken as data	Journeys are shifted to higher capacity and fuller vehicles
For the problems of automobile users	Balancing the problems of various segments of society
Capital intensive investments	Small/feasible investments
Irreversible decisions	Flexible decisions
Physical solutions weighted	Managerial / legal / economic solutions
For Construction	Environment friendly

Table 2: Characteristics of Traditional and Contemporary Transportation Approaches Source: (Elker, 1999)

Rather than expanding supply to meet rising demand, it is used to regulate demand in traditional transportation demand management systems. Transportation demand may be controlled by more cost-effective, sustainable, and adaptable solutions. This new approach is primarily to reduce the demand for transportation with different methods such as working from home and online shopping, shifting the demand created temporally (such as flexible working hours), spatial (such as routing to empty roads) and generic (from automobile to public transportation), and the remaining traffic is dynamically (intelligently). such as intersections) is described as managing (Table 3), (Elker, 1999; Boltze, 2003).

Table 3: Short-Term Policies and Related Measures

Policies	Measures
Reducing Travel Demand	Reducing the total trip level, Reducing the travel demand in certain corridors, Reducing the travel demand during peak hours, Reducing the travel demand in motor vehicles
Public Transport Routing of Journeys	Physical improvements in public transport, Improving the public transport business, Arrangement of intermediate public transport, To reduce the user costs of public transportation, Public transport transfer possibilities from the car

Limitation of Individual Transportation	Prohibitions, Capacity constraints, Parking policies, Pricing, Vehicle sharing programs, Priority for high occupancy vehicles

Source: (Elker, Çağdaş Ulaşım Politikaları, 1999)

3.3. ENVIRONMENTAL IMPACTS OF SMART TRANSPORTATION APPLICATIONS AND DEVELOPED POLICIES AND PRACTICES

ITS, which is defined as an ICT supported and integrated transportation system; It is related to the concepts of reducing travel times, increasing traffic safety, efficient use of existing road capacities, increasing mobility, efficient use of energy and reducing damage to the environment (T.C. Ulaştırma ve Altyapı Bakanlığı, 2020a). In essence, the system, which encourages the use of public transportation vehicles and organizations instead of individual vehicle use, provides services that increase user satisfaction and quality of life in terms of time, safety and efficiency by feeding on today's technological developments. In addition to all these services, STS also contributes to the environmental sector with its sustainability dimension. Indeed, the fossil fuel vehicle density, traffic congestion, vehicles, stop frequency, atmospheric conditions, number of vehicles and old-source air pollutants (carbon monoxide, carbon dioxide, particulate matter, nitrogen oxides, and volatile organic carbons such as environmental issues, climate change, and is known to cause adverse effects on human health. (Öztürk, 2017). STS is used effectively as an international and national policy tool in the

fight against such negativities. As part of STS's contribution to the livable environment and sustainability goals, many developed countries have taken decisions such as gradually increasing the number of electric vehicles and stopping the production of fossil fuel-consuming vehicles by 2030-2035 in order to reduce fuel consumption and emission values. Among these cities are New York, Toronto, Hamburg, and Stockholm. Along with these cities, there is a smart city application called "Green Fleet Application" that is used in the field of smart transportation in Amsterdam and whose primary purpose is to monitor driver performance in real time and improve conditions; it also includes environmental and sustainable goals such as fuel savings and carbon dioxide emission reduction (Deloitte; Vodafone, 2016).

In our country, environmental stewardship is reflected in the vision, purpose, strategic goals, long-term goals, and action plans established as part of the "National Intelligent Transportation Systems Strategy Document and 2020-2023 Action Plan." Specifically, within the framework of the "Improving ITS Infrastructure" and "Creating a Livable Environment and Conscious Society" strategies, "reducing accidents and traffic congestion, ensuring traffic safety, reducing fuel consumption and negative environmental impacts," and "disseminating smart pedestrianized areas and bicycle transportation, clean urban transportation," the goal is to disseminate fuel and energy efficient vehicle technologies, as well as more environmentally friendly modes of transportation (T.C. Ulaştırma ve Altyapı Bakanlığı, 2020a). In this direction, the following actions have been taken:

- ITS Awareness and Consciousness Building,
- Updating the Curriculum on Smart Transportation and Traffic Safety,
- Establishment of the Unit Responsible for ITS in Local Governments,

- Training of Qualified Human Resources in the Field of ITS,
- Use of Electric Vehicles in Public Transport Fleets and Service Vehicles and Promoting Public Transport,
- Reducing Fuel Consumption and Emissions,
- Expanding the Use of Bicycles,
- Disinfection and Social Distance Warning with Autonomous Robots,
- Determination of the General Concept and Implementation Steps of Pedestrianization Projects,
- Establishment of Test and Implementation Corridor for C - STS

"Creation of a transportation corridor where basic services such as stopped vehicle warning, emergency vehicle priority, road works, weather, road condition and traffic information will be provided" and "Smart materials, surface coating, nanotechnology and biotechnology product, recyclable and similar materials to be developed and used in the field of smart transportation for the purpose of sustainable environment" appears as a different indicator of environmental sensitivity (T.C. Ulaştırma ve Altyapı Bakanlığı, 2020a). It is also possible to talk about "environmentally friendly" practices developed by some local governments in line with the strategies and actions developed within the scope of ITS.

The smart city application "BİSİM", which is implemented in the field of smart transportation in İzmir, aims to popularize the use of bicycles, which is a healthy and environmentally friendly transportation vehicle, in the city (Aslan, 2018).

With the smart city application called "Bicycle Taxi", which is implemented in the field of smart transportation in Lüleburgaz (Kırklareli), it is to increase the use of bicycles, which is an environmentally friendly transportation method, as well as to reduce carbon emissions in the district. The operation of the smart city application called Bicycle Taxi includes processes such as providing training to citizens who do not know how to use bicycles, and making carbon footprint measurements (T.C. Lüleburgaz Belediyesi, 2020).

Environmentally friendly electric buses are now being tested by the Manisa Metropolitan Municipality in order to alleviate urban traffic and contribute to the environment. After this phase is completed and the buses are commissioned, Manisa Metropolitan Municipality will have Turkey's largest electric bus fleet. (Figure 2), (Büyükşehir Belediyesi T.C. Manisa, 2021).

Figure 2: Manisa Metropolitan Municipality Electric Bus Fleet
Source: (T.C. Manisa Büyükşehir Belediyesi, 2021)

4

METHODS AND TECHNIQUES IN SMART TRANSPORTATION

4.1. DATA MANAGEMENT

Smart cities are fundamentally based on data-driven administration. Smart transportation (mobility) management is guided by short, medium, and long-term strategies informed by data collected from sensors installed across the city. According to the method of obtaining the data used in transportation management, it can be classified as follows:

- Local data (such as loop sensors, infrared, magnetic sensors),
- Distance-based data (such as camera, radar, laser),
- Data obtained from mobile (such as vehicle tracking devices, mobile phone data),
- Parking data (such as parking areas, data from parkomat devices),
- Notification data (notifications, police, driver, passenger notifications),
- Environmental data (such as weather, icing),
- Basic traffic parameters (information such as volume, availability, occupation, speed).

Numerous sensors are employed to collect this data. These sensors can be installed in a road cut or along the side of the road. The most well-known and oldest type of sensor is the loop sensor, which is embedded in asphalt. Loop sensors can be used to determine volume, presence (presence/absence information), occupancy, and speed (Figure 3). Simultaneously, these sensors may be used to classify vehicles. The sensor has drawbacks such as asphalt cutting and resulting disturbance of traffic flow. Wireless magnetometer sensors are another sort of sensor that is employed in the road section. These sensors, which are 10-15 cm in diameter, are wireless and run on a battery that lasts 5-10 years. During asphalt work, the sensors may be removed and reused. Cutting the asphalt and requiring the sensor's installation skill might be noted as drawbacks for these sensors.

Figure 3: Loop and Camera Based Sensors

With the use of video sensors and image processing techniques, it is possible to collect information about volume, presence, and occupation. When mounted on the roadside or on a road tag, it does not require road excavation. Recent research on this area has shown extremely positive findings. However, the loss of picture quality or susceptibility to weather conditions that may occur when cameras are mounted at a high location might be regarded the system's primary drawback in terms of data gathering health.

On the other hand, Bluetooth sensors are put along the roadside and are mostly used to estimate journey time. Sensors such as laser, infrared, radar, and radio-frequency identification (RFID) are also employed. Along with these sensors, data from moving vehicles in traffic is used, referred to as floating car data (FCD), whose use has risen dramatically in recent years. These sensors may be used to determine the position of an object, its journey duration, and its density. Several downsides might be listed, including the expense of communication and lack of privacy. Additionally, in-car sensors (such as a rain sensor or a fog sensor) can provide a wealth of data about the environment in which the vehicle is positioned.

Real-time data is also critical for making long-term transportation choices, since it is utilized to solve local and regional transportation problems and boost efficiency. This massive volume of fast flowing data from a variety of sources may be used in real-time analysis for transportation projects utilizing big data methodologies. This generated data is also shared with citizens, so increasing the data's added value and adhering to the ideal of transparency. Nowadays, the notion that data should be accessible by default is widely recognized. To do this, transportation data should be made available to people and entrepreneurs via open data platforms in order to educate them and bring value to the economy. In this context, the National Smart Transportation Systems Strategy Document and Action Plan research placed a premium on big data and open data, and established data management centers as a strategic purpose.

4.2. SIGNALING METHOD

Signaling management is an application of ITS that is most frequently used in cities. In 1868, London deployed a semaphore-operated model to improve the safety of pedestrian-car interactions at crossings; in 1926, demand-sensitive uses of signaling systems were also implemented, for which electrical models were created in the United States. Signaling systems are critical for boosting both the capacity of intersections and the safety of drivers.

Before the signaling system is installed, analysis must be performed. The signaling system can be installed for reasons such as security, capacity or routing.

Signaling Installation Criteria:

- Number and level of accidents,

- Visibility at the entrance to intersections,
- Safety of pedestrians and cyclists,
- Density of motor vehicle traffic on the main and secondary roads,
- Orientation of public transport vehicles,
- Traffic administrations of pedestrians and cyclists,
- Directing motor vehicles in traffic,
- Preventing agglomeration in certain parts of the road network,
- Environmental pollution

reasons such as signaling are among the installation criteria (FGSV, 2015). Before installing a signaling system at any intersection, traffic studies (such as traffic counts, speed measurements, accident analysis) must be done. As a result of these studies, the most appropriate solution can be put forward within the framework of traffic safety and capacity criteria (Figure 4).

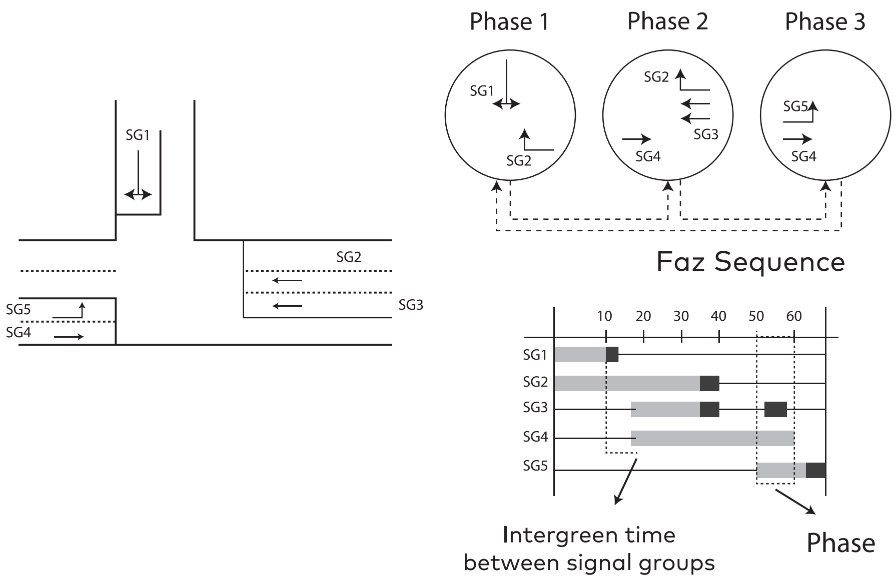


Figure 4: Key Components of Traffic Signal Control
Source: (FGSV, 2015)

Numerous studies worldwide assess signal management using a three-tier system. For instance, in Friedrich's (2000) three-level architecture, policies and plans at the strategy level envision reacting to short-term needs at the tactical level and to immediate requests (e.g., bus priority requests) at the operational level (Figure 5), (Friedrich, 2000).

Thus, signalized intersections can react instantly to changes in the local area that occur within the framework of pre-prepared framework plans, and they can give priority to vehicles that must

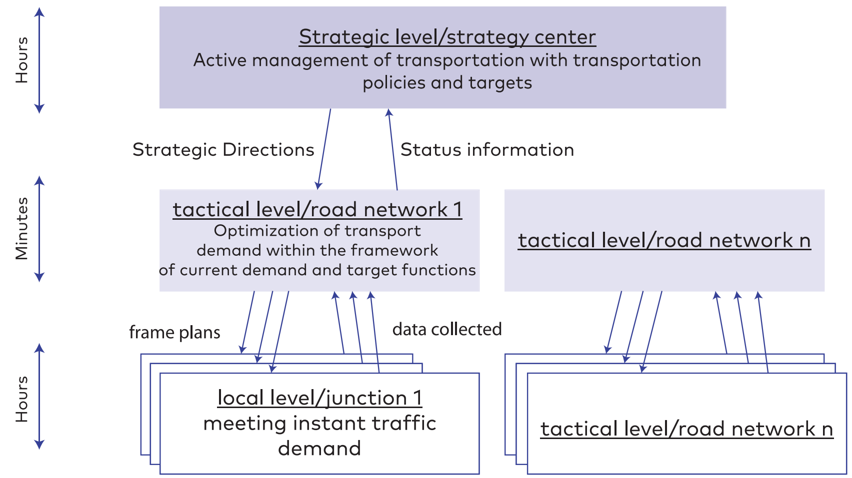


Figure 5: Three Level Traffic Control System Architecture
Source: (Friedrich, 2000)

pass through intersections without stopping, such as ambulances, police vehicles, and public transportation vehicles. Junctions with similar traffic characteristics should be grouped together, and tactical plans should be conducted in conjunction with one another. At the strategic level, choices must be made about the implementation of long-term plans, the implementation of scenarios or contingency plans for social events or major events.

Signaling systems are examined under the headings of fixed-time, time-based control and traffic demand-based control, depending on whether their duration is predetermined or the duration changes according to instantaneous demands. In addition to these:

Fixed time control:

It is a type of signal control in which traffic demand is mostly neglected and the same control timings are used throughout the day and year.

Time-based control:

It is a technique of signal control in which the same durations operate at the times (morning peak, evening peak, etc.) specified by past traffic studies. Because times do not vary over the given time periods, the time-based control approach is frequently employed as a fixed-time control.

Control based on traffic demand:

The traffic demand-based control approach produces fresh time by taking into account changes in the traffic condition throughout the day. The control mechanism can be determined by the number and position of sensors at the signalized intersection, depending on the traffic demand.

Semi-traffic-stimulated control:

Sensors are located at signalized intersections for secondary or left turns exclusively in this control approach. For certain signal groups with low demand, right of way is not granted until and until there is demand. When a demand occurs, the green time is allocated proportionately to the requirement. This procedure is also employed at campus entrances when emergency vehicles such as firemen and hospitals are required to evacuate. Only a few sensors are required.

Full traffic alert control:

Sensors are installed on all approach arms and/or stop lines of a signalized junction in the complete traffic alert control technique. The data from these sensors is used to regulate the junction by performing immediate inquiries on demand (is there a vehicle wishing to pass through?), duration (how long is required?) and status (querying the general condition of the traffic with a threshold value).

Plan selection based on traffic demand :

In this method, predetermined signal plans are uploaded to the traffic signal controller and with various queries, if the traffic situation matches the situation in the predetermined plan, that plan is activated.

Adaptive traffic signals management:

Signal timings at intersections are computed in real time using data from sensors in adaptive traffic signal management. The distinction between this approach and others based on traffic demand is that it employs a traffic flow model and does real-time optimization. It optimizes important performance metrics such as the frequency of vehicle stops and delays. SCOOT, SCATS, MOTION, BALANCE, OPAC AND UTOPIA/SPOT and RHODES are the world's most well-known adaptive systems.

Table 4: Traffic Signaling Control Methods, Advantages and Disadvantages

Control Method	Advantages	Disadvantages
Fixed time control	Low installation and operating costs	Can't respond to traffic fluctuations
Time-based control	Low installation and operating costs	It partially responds to daily routine traffic variations. It cannot respond to sudden changes.
Semi-traffic-stimulated control	Installation and operating costs are moderate	It cannot respond to traffic fluctuations. Only slightly better use of capacity.

Full traffic alert control	It can respond to traffic changes instantly. It can provide public transport priority for vehicles from all directions.	High installation and operating costs
Plan selection based on traffic demand	It can respond to traffic variations on a macro scale.	Installation and operating costs are medium. It cannot respond to instant, lane-based changes.
Adaptive traffic signals management	It can respond to traffic changes instantly. With real-time optimization, the most suitable plan is selected.	Very high installation and operating costs

Isolated and coordinated systems:

The isolated system is responsible for the operation of a signalized intersection in isolation from other intersections. The coordinated system is formed by the interplay of at least two adjacent junctions' signal designs. The coordinated system's most well-known use is the so-called "green wave." Intersections can be parallel or create a network in a coordinated system. If junctions are located within 700 meters of one another, they must be coordinated. Coordination is predicated on the utilization of same cycle times (Figure 6).

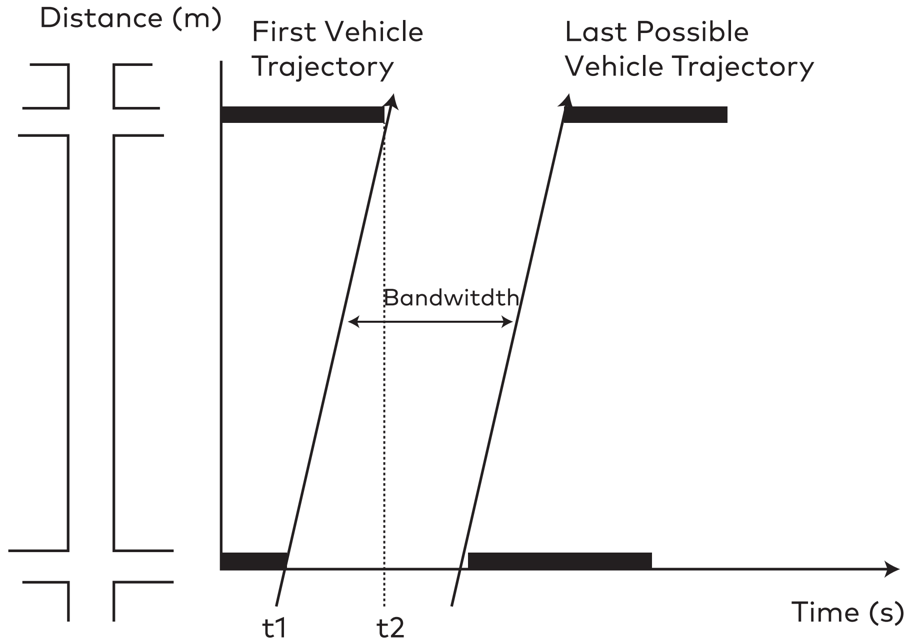


Figure 6: Isolated and Coordinated Systems
Source: (FGSV, 2015)

Sensors:

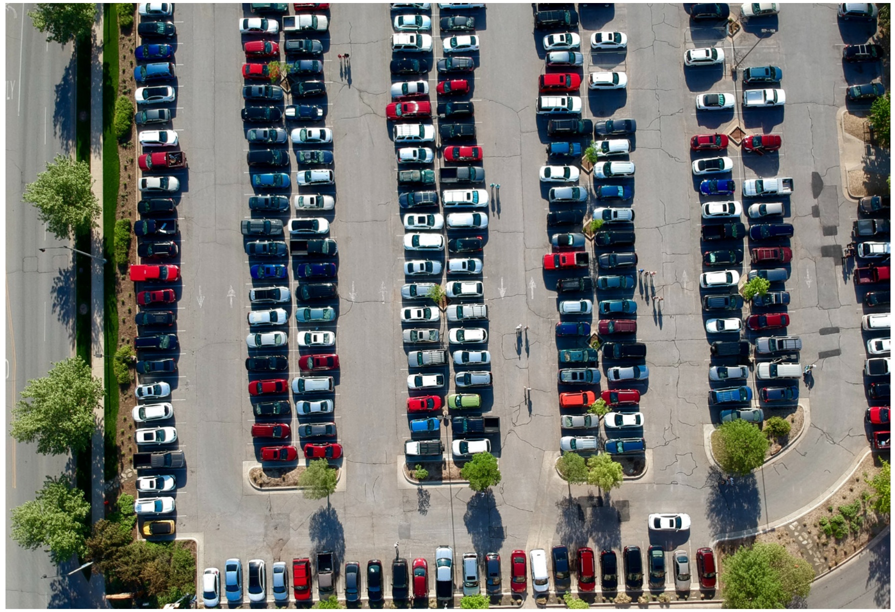
Sensors are primarily used on roadways as part of signalization systems. Loop detectors are first, as they are a wired system. Magnetometers, which are wireless sensors, have been used recently. These sensors, which operate with battery support, have a battery life of between five and ten years, and some models also include a battery replacement. Additionally, signaling is accomplished through the use of camera-based sensors. These systems detect each intersection approach by utilizing image processing techniques, a fisheye camera to a central point, or multiple cameras.

It is the sensor loop of choice, particularly in developed countries. It is reliable and has a high rate of accuracy. It is not preferred in our country because it cannot be operated reliably due to the asphalt situation. As a result, various searches were conducted. As a result, magnetometer- or camera-based systems are preferable.

Points to be considered in signaling systems:

In summary, the preceding sections discussed the definitions and methods used in signaling systems. Signalized intersections are critical applications of ITS because they touch every capillary of a city. However, if not implemented properly, these systems can result in gridlock. If signalized intersections are not thoroughly analyzed and their durations are not properly adjusted, they can create traffic jams and necessitate solutions such as multi-story intersections, which are both costly and detrimental to the city's structure.

Signalized intersections can be used in areas with a low vehicle population for traffic safety reasons, primarily to allow pedestrians to cross the street. Due to the high number of waiting times at unsignalized intersections, using a fixed-time control method at signalized intersections or a time-dependent control method that uses only different signal plans for morning and evening peak hours is insufficient as the number of vehicles increases. If pedestrian demand is not very high, demand buttons should be installed at pedestrian crossings; if secondary roads exist and demand is low, a semi-traffic alert solution should be implemented through the installation of sensors. If demand is equivalent in all directions and fluctuates throughout the day, full traffic stimulation or adaptive control should be used. However, these methods are both costly and time consuming to implement.



4.3. PARKING MANAGEMENT

Parking is a requirement for all vehicles that provide mobility in a city, including automobiles, bicycles, taxis, and pickup trucks. A comprehensive parking management policy should primarily serve as a backbone for basic transportation policies. In city centers, there are essentially two types of parking areas: roadside and open/closed. These spheres of influence should be evaluated and managed holistically.

Reducing the parking lot supply and pricing together with pedestrianization in city centers serve to reduce travel by automobile and to support sustainable modes of transportation. Parking management can be basically examined under three headings:

1. Planning and Implementation,

2. Charges,

3. Guidance.

In a city's transportation plans, parking areas with a high capacity should be identified in the zoning plans and arranged on the road. Loading-unloading zones, taxi stops, kiss-and-ride zones, disabled parking areas, and other paid and/or free parking areas should all be planned and marked in advance, as should bus stops throughout the road network. In this context, IMM designed the parking areas in the 2017 Parking Lot Master Plan study, taking the aforementioned criteria into account (Figure 7), (T.C. İstanbul Büyükşehir Belediyesi, 2016).

Figure 7: Parking Lot Planning Example
Source: (T.C. İstanbul Büyükşehir Belediyesi, 2016)

Charge work should be planned so that it is concentrated in city centers, diminishes toward the city's periphery, and eventually covers the entire city. In city centers, pricing some streets and excluding others from the scope erodes the effectiveness of the demand management policy. Pricing is critical because it both promotes and subsidizes public transportation (Figure 8).

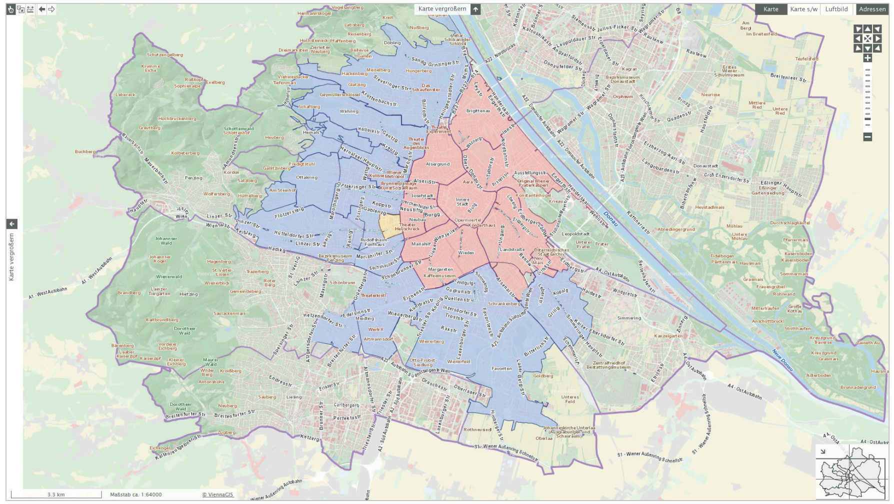


Figure 8: City of Vienna Progressive Parking Zones
Source: (City of Vienna, 2021

Figure 9: Parking Guidance System in Istanbul

Parking directions are also an important policy. Because these directions can both reduce the parking lot search traffic and contribute to the selection of different transportation types before starting the journey by car (Figure 9).

These directions provide important point information to drivers coming from outside the city, and the occupancy of the car parks can be balanced by reflecting the occupancy information of the car parks.

On the outskirts of cities, particularly near public transportation stations, "park and ride" applications are deployed. Thus, it is hoped that car owners will leave their vehicles in these free or low-cost parking lots and travel to the city center via public transportation or service vehicles. Europe's major metropolises, such as Vienna and Berlin, are attempting to reduce car trips to the city center by establishing these parking lots in neighboring towns. According to research, pedestrian journeys can be extended to up to 1 km with the improvement of walking routes. "Kiss and Ride" parking lots are specifically designated for passenger drop-off at locations such as public transportation stations and airports. The time limit for using these areas is 2-3 minutes, and you must wait in or near your vehicle during that time. Download and continue parking areas are also critical in terms of applications that make public transportation more convenient. As innovative parking policies; issues such as separating the sale of home and residential car parks, eliminating companies' free parking, and limiting the supply of parking lots. Parking supply and pricing restrictions in city centers will increase turnovers as the duration of a vehicle in the same parking lot will decrease. As a result, more people will be able to use the same parking space. Through pricing, transportation demand will be directed toward more environmentally friendly modes of transportation, such as public transportation and bicycles, resulting in a reduction in urban air pollution. Additionally,

guidance systems are critical components of smart city solutions for reducing unnecessary fuel consumption and pollution.

4.4. TRANSPORTATION MANAGEMENT CENTERS

A transportation system is divided into four distinct categories: human, vehicle, field, and center. Established transportation management centers are responsible for the system's operation. Transportation management centers serve as the focal point for strategy development, operations, and maintenance activities in this context.

Depending on the size and function of the control center, it can have several purposes:

- Making the best use of existing capacity,
- Reducing the effects of planned and unplanned events,,
- Management of devices in the field.

In addition to the above-mentioned purposes of innovative and integrated transportation management centers;

- Managing transportation demand,
- Ensuring integration between transportation types and systems,
- Routing of emergency vehicles

has purposes as well. If there is dynamic pricing in the city, parking pricing; If there are lane or bridge charges and these charges are made dynamically, these calculations are made according to the traffic situation in the center. For example, air pollution data from environmental sensors installed on highways in Austria are evaluated and speed limits are set in that highway section.

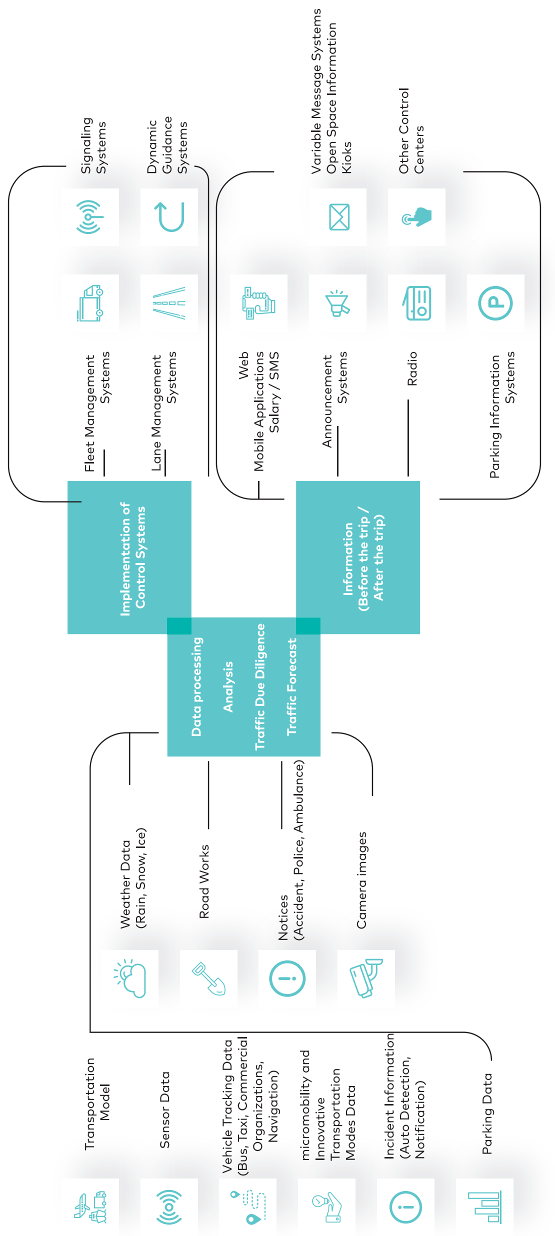


Figure 10: Transportation Management System Architecture

City transportation management centers are frequently established as road network monitoring and signaling management centers and gradually expand in scope. As the number of systems in the field grows, it is necessary to establish connectivity between these systems and the center. If a city has multiple control centers, it is critical for efficiency, communication, and coordination that these centers be housed under the same roof. If this is not possible, the affected centers should exchange data and integrate with the primary management center. Additionally, transportation management centers should work closely with security and emergency response personnel.

Transportation management centers also serve as the focal point for city transportation decisions. These centers are tasked with the responsibility of implementing and supervising strategic, tactical, and operational decisions. Transportation management centers are responsible for data collection, data transfer, data processing, analysis, and control, as well as information (Figure 10),

Transportation management centers are also centers that monitor, operate, manage, and inform citizens about the ITS that has been installed in the field. Its primary function is to collect data in areas related to city transportation, to process that data, and to perform management, control, and information functions. The Istanbul Transportation Management Center, which was renovated in 2018, is depicted in Figure 11. All data pertaining to Istanbul's traffic are consolidated and transportation strategies are determined accordingly using the smart city management software housed in this center.

Transportation management centers are responsible for the management of activities such as planned and unplanned events, traffic accidents, and road construction that may occur in a city. Organizations such as the General Directorate of Highways, which is responsible for only the ring roads and the road network, may have control centers that are limited to their respective jurisdictions. Likewise, for Rail Systems. However, because cities have a variety of modes of transportation, including a road network, a rail system, and a bus system, management centers should cover all of them.

Figure 11: Istanbul Transportation Management Center

A comprehensive transportation management center performs the following tasks:

- Incident management,
- Traffic jam for road traffic,
- Traffic control centers,
- Individual transportation,
- Signaling management,
- Highway lane management,
- Highway network management,

- Park management systems,
- Tunnel Management Systems,
- Variable message systems management,
- Online information services management,
- Public transport,
- Fleet management,
- Passenger information.

Transportation Management Centers Benefits:

- Transport Management Centers provide advanced communication in all areas if stakeholders share the same center,
- When all sub-center are gathered at one point, costs such as personnel and infrastructure are reduced.

While highway control centers are generally established and operated by the General Directorate of Highways, urban highways in major cities such as Istanbul are also managed by traffic control centers. These centers ensure that data collection, monitoring, and incident management strategies are implemented, particularly on the road network. By implementing active traffic management strategies that take into account data from sensors and/or notifications from other communication channels, the efficient use of available traffic capacity, as well as preventive measures and notifications in adverse weather conditions (rain, icing, etc.), accidents can be avoided. Control centers for highways (highways) and tunnels collaborate.

The control centers established to manage the city's road network are primarily concerned with signal management. It is responsible for tasks such as updating signal plans, transmitting new plans to the field, ensuring intersection coordination, and tracking faults. If the city installs a central parking lot management system, it must be connected to the transportation management center.

The primary responsibility of public transportation management centers is to monitor and manage buses and trams. The functions of these centers, which are responsible for monitoring public transportation vehicles and drivers, as well as activities such as job assignment, driver tracking, and event management, are strengthened by the addition of devices that can communicate with the field and collect data. With direct access to all devices, especially in today's technology, devices should be able to be updated and monitored centrally. Additionally, the fact that public transportation vehicles are equipped with camera systems enables local governments and law enforcement to work more efficiently in the event of a social event.

4.5. TRAFFIC SAFETY AND TRAFFIC CALMING

Safe transportation is a critical component of smart transportation applications in cities. Cities are the most congested areas for pedestrians and vehicles. This is why it is not and should not be permitted for vehicles to travel above specified speed limits in city centers. While there are occasional discussions in this direction, the linear relationship between accident risk, its consequences, and speed is self-evident. Throughout history, traffic signaling systems have been developed in order to safely organize pedestrian-car encounters.

In cities where people and vehicles often meet, traffic safety is affected by the following factors:

- Design of transportation infrastructure, physical condition of roads and junctions,
- The type, number, technical condition and speed of the transportation vehicle,
- Behavior of the traffic participant (pedestrian, driver), perception of the situation,
- Traffic or pedestrian density,
- Environmental factors (such as rain, snow, icing).

With improvements to each of the factors mentioned previously, traffic safety in the city can be improved and the number of accidents, fatalities, and injuries reduced. The creation of a planning framework is the starting point here. Special consideration should be given to users who are less powerful than vehicles in traffic, such as children, the disabled, pedestrians, and cyclists.

Vision Zero:

Projects called "vision zero" are becoming widespread all over the world in order to reduce fatal accidents. Vision zero studies, which started in Sweden in 1997, are today one of the most important initiatives in the field of traffic safety all over the world.

Legal regulations and supervision:

Since traffic safety is an issue that concerns people's life safety, it is seen that the number of legal regulations and inspections to increase traffic safety is increasing day by day. In addition, inspections are important in terms of making it a habit to follow the rules.

Education:

The proper way to behave in traffic, both as a pedestrian and as a vehicle user, should be taught at a young age through consistent training and exemplary behavior. Traffic safety education is currently included in the primary school curriculum. Additionally, it is critical to demonstrate these trainings practically in traffic training parks to ensure that the training is retained. However, it is critical for parents to model appropriate traffic behavior through personal experience. Certain regulations and engineering studies, on the other hand, are areas in which local governments should work. It is critical to establish the current state of affairs prior to conducting these studies. It is necessary to identify accident hotspots and high-risk areas throughout the city and to develop a plan for implementation.

Figure 12: Bern Municipality Traffic Calming Application

Physical changes to increase traffic safety:

The term "traffic calming" refers to physical restrictions that improve traffic safety, particularly in urban areas. This technique, which is particularly well-suited for residential areas, enables vehicle drivers to slow down by adding physical obstacles and/or altering the road geometry (Figure 12). Vertical and horizontal applications, as well as point or street-wide applications, can be considered for such traffic calming measures.

Speed bumps:

Speed bumps are implemented in two ways. Narrow and generally made with plastic material, the other is wide and usually made with permanent material such as asphalt or stone.

Raising the intersection or sidewalk:

It is the practice of raising pedestrian crossings, which can also be seen as speed bumps. It increases safety for both pedestrians and vehicles, but can often generate noise from the material used.

Coloring of the road surface:

Coloring to be made on the road surface and using different materials will also reduce the traffic speed.

Lane narrowing:

One of the effective traffic calming methods is lane narrowing. It can be made safe for pedestrians to cross the street by narrowing the lane partially at a single point or along a longer corridor.

Roundabouts and strips:

By making mini roundabouts, especially at street intersections, both speed reduction and side-impact accidents can be reduced.

Surprising lane narrowing along the road:

It is the method used to reduce speeds along the street, especially in residential areas. The creation of narrow street areas where two vehicles cannot cross each other is an example.

Speed warning systems:

Systems where vehicles are reported with a dynamic plate by measuring their current speed.

Electronic Supervision Systems:

Speed violation and red light violation detection systems are among the most effective systems for changing aggressive driving style and reducing speeds.

Signaling systems:

Signaling systems should be designed with pedestrian priority. Pedestrian signaling systems should be installed in school crossings and in areas where the elderly live densely in order to make pedestrian crossings safe.

4.6. ACCESSIBILITY

Access to food, services, activities, and destinations is defined as the ease with which one can obtain food, services, activities, and destinations. Information is available through markets, food, libraries, and the Internet. Access to information is provided by markets, food, libraries, and the internet; routes, roads, and airports provide access to destinations and, thus, activities. Even if individuals do not currently use any form of access, it should be considered that they may require it in the future. For instance, drivers may place a premium on the availability of public transportation in the event that they are unable to drive in the future. Except for exceptional journeys such as jogging or recreational trips, the primary goal of most transportation activities is access. Even a weekend trip is covered, as the destination is included (Victoria Transport Policy Institute, 2019).

Accessibility is a critical aspect of city life in the modern era. Accessibility is evaluated on social, economic, and environmental grounds and is assigned varying degrees of importance. When it comes to accessibility, the disabled or mobility-impaired may be prioritized. Accessibility, on the other hand, is a holistic concept that encompasses all of its dimensions.

Social dimension:

It is critical for all city stakeholders to have easy access to activities and services. This requires physical and/or technological adaptations, particularly for the disabled who have difficulty accessing.

Perimeter Size:

Neither the energy consumed for access nor the environmental impact are significant. From this vantage point, cities with dispersed settlements have a greater negative impact on the environment due to their automobile-centric nature. In this type of urbanization, pedestrian, bicycle, and public transportation access is restricted, and automobile access is preferred.

Economic Size:

The access issue may be a result of the city's existing transportation infrastructure or may arise as demand increases over time. The economy is impacted in both cases. In a city with access issues, commerce either stagnates or the city's commercial appeal dwindles. As a result, large business centers throughout the country prefer cities, easy-access regions, or regions within cities that are more attractive to them economically. If we consider automobile traffic to be a subset of mobility, we can also consider mobility to be a subset of accessibility. Because accessibility provides a more comprehensive view of and solutions to transportation problems. For instance, it prioritizes broad solutions such as enhanced communication infrastructure or in-home service over more accessible land use structures or mobility (Victoria Transport Policy Institute, 2020).

Accessibility, which seems advantageous for land use and one mode of transportation, may not be equally advantageous for another mode of transportation. In conclusion;

1. Motorways are designed for automobile mobility and are generally described as access-controlled roads (with few intersections and access roads). Highways, on the other hand, are designed for maximum accessibility (with lots of connections and intersections), but in this case cars cannot speed safely.

2. The land use structure that maximizes automobile access provides low access for public transportation and non-motorized journeys, while the development focused on public transportation can create traffic and parking problems (due to limited parking and strong pedestrian access).

3. Wide roads and high speeds become barriers to pedestrian travel. Therefore, cars and pedestrians clash in street design (Victoria Transport Policy Institute, 2011).

There is an accessibility issue if a person without a car or a disabled person has difficulty reaching a destination. Thus, starting with the premise that "the city is for everyone," an accessible city should be designed with all individuals in mind, in accordance with the governance and decision-making principles of smart urbanism.

In a city, the most important factor affecting accessibility is the land use structure. Cities, of course, have a history. For example, the cities of the United States of America (USA) have a heritage built around automobiles, whereas the centers of Italian cities are built around pedestrians. After the 1960s, transportation policies shifted paradigms to emphasize the movement and access of people, not vehicles. As a result, the recommendation of mixed land use structures (residential and commercial in the same region) facilitates accessibility while also demonstrating positive economic and environmental outcomes.

4.7. SMART TRANSPORTATION SYSTEMS ARCHITECTURE

Numerous systems are being developed to improve road transportation's safety and performance, as well as to reduce travel times and environmental impact. STS Architecture, in its simplest form, refers to these systems' interoperability. STS Architecture is a "system of systems" in this sense. The STS architecture serves as a common framework for planning, defining, and integrating field-implemented smart transportation systems. It is a collection of systems that have been developed through the collaboration of all STS stakeholders. It encompasses not just technical integration but also organizational and legal concerns.

ITS architecture first began in the USA in 1993 with the definition of user services in transportation. The STS architecture, which was used only in the USA for many years, started to be used in different countries in the following years. The EU, on the other hand, published the first version of its architectural studies in 2000, with the EU Project called KAREN, which it started in 1997. Later on, the FRAME project and today the FRAME NEXT, FRAME-S and E-FRAME projects and the STS Architecture projects continued within the EU. Some EU countries, especially France (ACTIF), Italy (ARTIST), have developed their own national architectures by taking the FRAME architecture as a reference. In some countries such as Germany, STS Architecture is not yet available.

Countries develop new versions of STS architectures by leveraging one another's experience. Because novel suggestions regarding user requirements and solution methods may emerge. The STS architecture is composed of three layers: enterprise, transportation, and communication. Architectural planning studies begin with the definition of user services or requirements and conclude with the presentation of application packages (Figure 13).

The STS architectural development process should first start with the definition of user needs together with the stakeholders. This development process applies when you do not have any reference architectures. In the case of using reference architectures put forward by institutions such as the EU, new needs and services can be defined based on the basic user needs generally accepted by smart transportation experts.

Data flows and processes are defined in the logical architecture layer. What the STS should do is described in this layer. In the physical architecture layer, architectural flows, physical units and equipment packages are defined. The main components that will manage the STS are defined in this layer. Application packages are the definitions of services that should be used to solve transportation problems directly in the field.

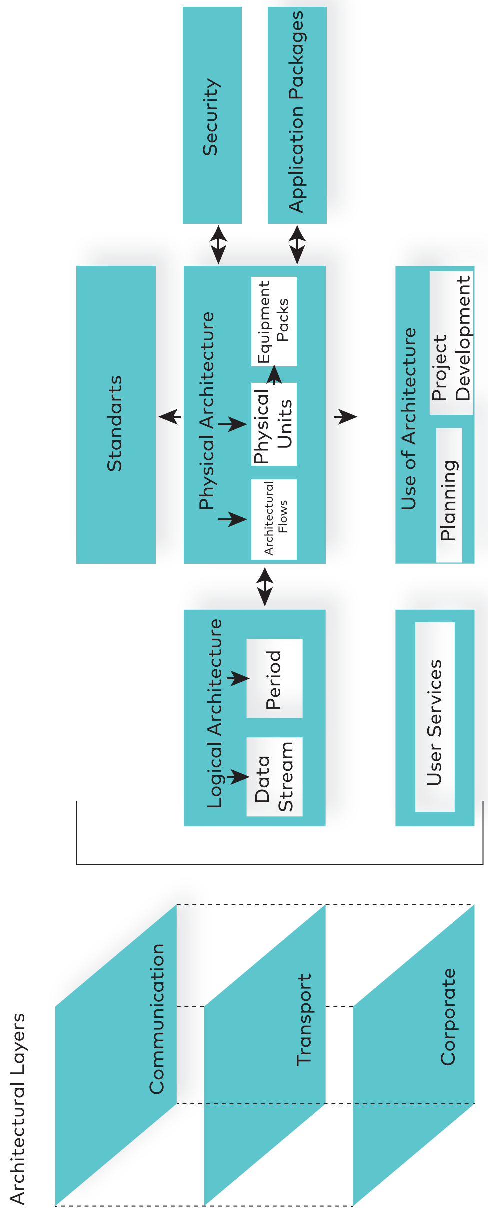


Figure 13: US Smart Transportation Systems Architecture Topology
Source: (United States Department of Transportation, 2020)

The process of developing an STS architectural design should begin with a collaborative effort to define user requirements with stakeholders. This process is used when no reference architectures are available. By referring to reference architectures developed by institutions such as the EU, new needs and services can be defined in accordance with widely accepted user requirements for smart transportation.

The logical architecture layer establishes the data flows and processes. This layer defines what the STS should accomplish. Architectural flows, physical units, and equipment packages are all defined at the physical architecture layer. This layer defines the fundamental components that will manage the STS. Application packages define the services that should be used to resolve transportation issues in the field.

The following service groups were used in the STS Architecture study conducted by the General Directorate of Highways:

- Traffic Management,
- Passenger Information,
- Public Transport Management,
- Vehicle Security and Control,
- Cargo and Fleet Management,
- Disaster and Emergency Management,
- Road Maintenance and Construction Management,
- Data Archive Management,
- Electronic Fee Collection Management,
- Pedestrian and Traffic Safety.

In previous versions, the STS architecture implemented by the USA was grouped under four headings: center, field, passenger and vehicle. Support systems have also been added with the new version. Centers refer to centers such as traffic control center, emergency management center, public transportation management center. The field represents systems such as variable message systems, traffic signaling systems. Passengers, or passenger devices with its new name, consist of devices such as smartphones. Non-operational STS data can be considered as support systems (Figure 14).

Studies for the development of STS in Turkey started in 2014 with the project carried out by the General Directorate of Highways. In this context, world examples were examined and as a result of the workshops held with public and private sector stakeholders, the National Highways Intelligent Transportation Systems architecture was prepared and a pilot application was carried out for the Antalya region.

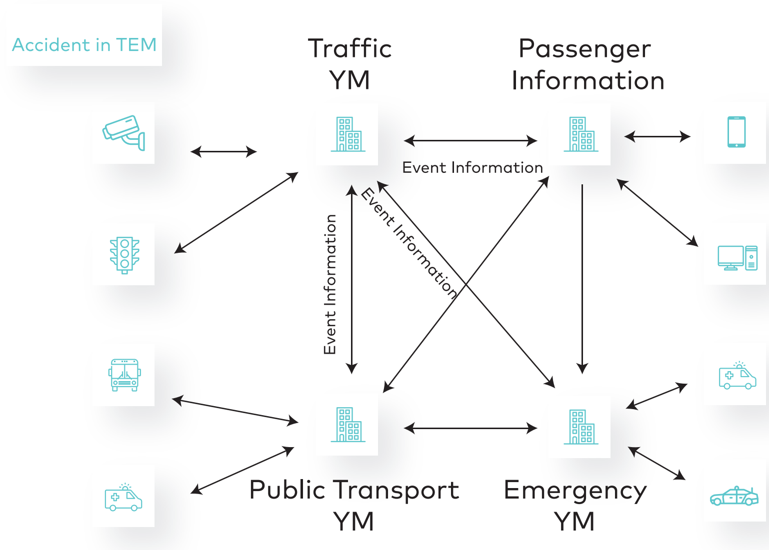


Figure 14: Application Package Example
Source: (United States Department of Transportation, 2020)

The issues that should be considered in the application of the STS Architecture, which is framed on a national scale, that is, covering all possible systems, to regions, such as the agreement of institutions on duties and authorities, and the determination of who will carry out the maintenance and support works of the architecture come to the fore.

HARTS (Harmonized Architecture Reference for Technical Standards) came together with the USA, EU, Japan, Australia, which aims to enable the architectures developed by the EU and the USA

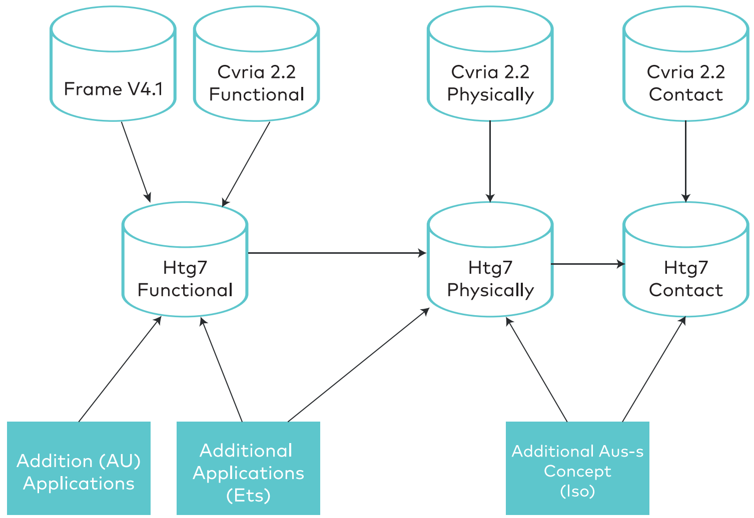


Figure 15: HARTS Architectural Structure
Source: (T.C. Ulaştırma ve Altyapı Bakanlığı, 2020a)

to work together, after the STS architectures developed for the integration of the systems that countries have implemented. A working group called) was formed. The HARTS architecture basically consists of the integration of the US CVRIA (Connected Vehicle Reference Implementation Architecture) architecture and the EU's FRAME architectures (Figure15; Figure 16).

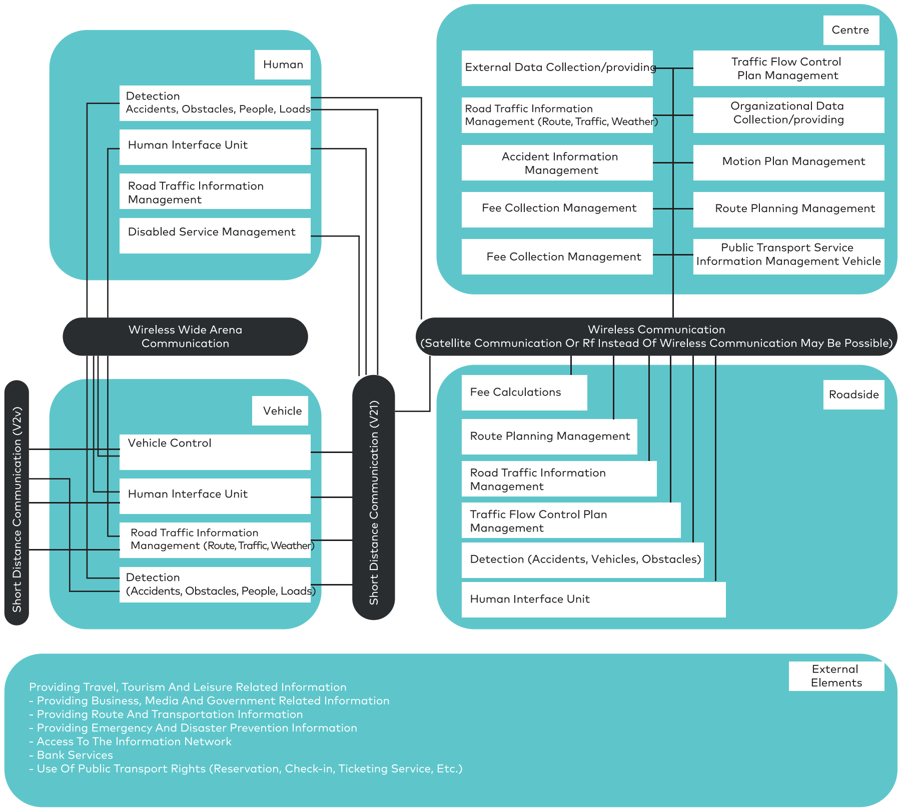


Figure16: Japan STS Architecture
Source: (T.C. Ulaştırma ve Altyapı Bakanlığı, 2020a

1. MaaS (Mobility as a Service)

MaaS is an integrated system that unifies all modes of transportation on a single platform. Its emergence is based on the philosophy of meeting people's transportation needs via a platform rather than through ownership of a vehicle. MaaS is defined by the EU project MAASiFiE as "multimodal and sustainable mobility

services that meet customers' transportation needs by integrating planning and payment into a one-stop shopping model." (Conference of European Directors of Roads, 2017), (Figure 17).

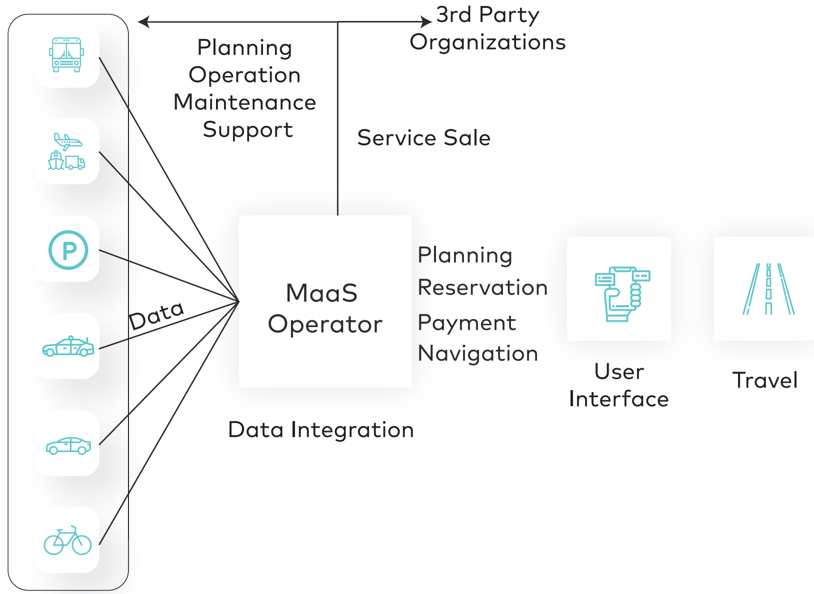


Figure 17: Bir Mobility As a Service
Source: (T.C. Ulaştırma ve Altyapı Bakanlığı, 2020a)

MaaS brings a new perspective while using the existing traditional public transportation. People can use all means of transport without owning any means of transport. A MaaS platform should include the following modes of transport and include a payment system:

- All modes of public transport (train, metro, tram, bus, minibus, ferry),
- Taxi,
- Rent a car,

- Car sharing,
- Micromobility (bike, scooter rental).

In order for the MaaS application to be successful, the following conditions must be met:

- City governments should support the MaaS application,
- Public-private partnership should be established,
- It should be agreed on how the technology architecture will be,
- Public public transport should be included.

However, MaaS is an issue that can and should be addressed by the public sector on its own, but only with the help of the private sector and the public sector. A number of cities across the country have begun implementing MaaS applications of various forms, particularly in the Scandinavian countries. Mobility-as-a-service applications are shown in Figure 18. Depending on the monthly fee, a mobile app subscriber can choose from a variety of transportation options.

Figure 18: MaaS Practice Example
Source: (WhimApp, 2021)

MaaS will also play a significant role in the development of autonomous vehicles, which will be integral components of future smart cities. When MaaS and autonomous vehicles are combined, car ownership in cities is expected to decline significantly.

4.9. CONGESTION CHARGE

To reduce the environmental impact of travel per capita, to make city centers more livable, and to limit individual automobile journeys, some cities and regions have implemented pricing policies, though some cities have imposed restrictions. Thus, both automobile use and resources for alternatives such as public transportation and bicycles are reduced. Behind this practice is the belief that automobiles cause more environmental damage and that the user should bear the cost. Particularly in the United States, toll lanes known as HOT, which are applied to ring roads, can be used for a fee in instances of traffic congestion. In some instances, cars carrying two or more passengers may use these lanes for free (Figure 19).

Lane and road pricing:

Road pricing applies to ring roads, lanes on highways connecting two major metropolitan cities, and bottlenecks such as bridges, tunnels, and roads that experience congestion. Additionally, tunnel, bridge, and highway pricing is a critical financial resource for covering the cost of the state-of-the-art structure.

Field pricing:

While area pricing accomplishes the same thing as road pricing, it is more effective. There are drawbacks, such as the fact that all streets entering the city center must be controlled, but the presence of natural and artificial thresholds throughout the city can help with control by reducing the number of control points (Elker, 2002). Area pricing can have an effect on the decision to drive prior to the trip, as it covers an entire area and is frequently limited to a specific section of the city center. Area pricing will also incur infrastructure costs, as it will necessitate the establishment of a system at the control points of all streets and streets entering the area.

Dynamic pricing:

Pricing can be applied dynamically based on time of day or traffic conditions, whether it is for an area, lane, or road. Thus, demand can be spread throughout the day, reducing traffic congestion. For instance, the fact that the Istanbul 15 July Martyrs Bridge is paid for today contributes to the reduction of automobile use. By charging more for bridges during morning rush hour, less during other hours, and significantly less at night, traffic congestion can be reduced and travel demand distributed throughout the day. With today's payment technologies, dynamic pricing is a breeze

to implement.

Due to the fact that applications such as space pricing can be linked to a person's financial situation, it has sparked global debate. The urban pricing study in London and Stockholm generated considerable controversy. These cities' superior public transportation infrastructures have been significant advantages. Despite the heated debates, subsequent interviews in these two cities revealed an increase in support for the practice. This debate continues in a number of German cities, with the general policy being to create "environment zones (regions)" that are only accessible to vehicles with low emission rates. To avoid such political debates, a well-designed parking fee can serve the same purpose as space pricing.

Concerning the direct effect of remuneration on demand, it is necessary to emphasize the following: Along with purchasing power, it is critical to familiarize oneself with the effect of charge on demand. Due to the fees collected automatically and typically monthly by toll collection systems, the effect of this policy on traffic reduction is diminished. Additionally, the fact that these expenditures are recorded as expenses on public and company vehicles mitigates this effect.

Examples from the world:

The most well-known form of road toll is the Singapore Electronic Tolling System (ERP), which was implemented in 1975 during morning and evening rush hours. The system was revised in 1998, and an entirely automated fare collection system with on-board units was implemented. Singapore has also implemented a fee structure that is subject to change. Traffic congestion has been reduced by 13% as a result of the application (United States Department of Transportation, The Federal Highway Administration, 2008).

Stockholm began charging for congestion in 2006. After seeing the benefits of the system, which previously lacked support, the rate of support increased. It has resulted in a reduction in the travel times of alternative modes of transportation such as buses and taxis. The system became permanent in 2007 following a referendum (United States Department of Transportation, The Federal Highway Administration, 2008). Another well-known instance occurs in London. Today, those traveling by car to the London city center must pay an 8-pound daily fee. This application resulted in a 15% reduction in London's traffic congestion.

Figure 19: World Examples of Congestion Pricing

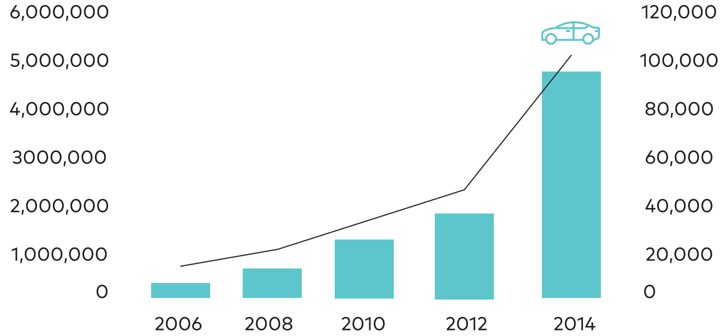
4.10. RIDE SHARING, CARPOOLING AND CAR POOL APPLICATIONS

Today, the average number of people in cars in Turkey, as in the rest of the world, ranges between 1 and 1.5. This demonstrates that, despite their large size, automobiles carry a small number of people. As a result, promoting public transportation and prioritizing vehicles that take up less space over automobiles becomes critical in resolving cities' traffic problems. In this context, three approaches are comparable: ride sharing, vehicle sharing, and vehicle pool applications.

It is an instant or planned transportation method that allows drivers with empty seats in the ridesharing vehicle to travel together with passengers going in the same direction and save on travel costs (T.C. Ulaştırma ve Altyapı Bakanlığı, 2020a). This application, which has been applied for a long time in Europe and continued through internet browsers with the spread of the internet, and later with mobile applications, still continues to be used as a cost-effective method for both the vehicle owner and the passenger.

Car sharing is a type of rental model in which vehicles are rented for a limited period of time and then used for short distance trips. Thus, the purpose is to maximize the efficiency of road and parking space use (T.C. Ulaştırma ve Altyapı Bakanlığı, 2020a). Car sharing demand is growing globally on a daily basis. This is interpreted as a sign of the sharing economy's growing attractiveness in smart cities, as well as a sign that people are becoming more frugal with their assets. According to Deloitte's (2017) Market Analysis report, between 2006 and 2014, the market increased approximately tenfold (Figure 20).

On the other hand, vehicle pooling is the organized sharing of one or more private vehicles with other users. Sharing a person's private vehicle on a continuous and regular basis (for example, with coworkers) for a fee (T.C. Ulaştırma ve Altyapı Bakanlığı, 2020a).



	2006	2008	2010	2012	2014
Members	346,619	670,822	1,163,645	1,788,027	4,842,616
Membership Growth Rate		%39	%32	%24	%65
Vehicles	11,501	19,403	31,967	43,554	104,125
Fleet Growth Rate		%30	%28	%17	%55
Member Vehicle Ratio	30.1	34.6	36.4	41.1	46.5

Figure 20: Global Car Share Size

Source: (Deloitte, 2017)

With all of these practices and methods, it provides significant benefits to both the environment and citizens' budgets, such as fuel savings, emission reduction, effective asset utilization, and affordable travel. For instance, if a person who owns a car solely for weekend use rents it on a regular basis during the week, this results in significant gains for both the lessor and the lessor. These applications are expected to become more prevalent as mobile applications become more prevalent. Along with these applications, on-demand public transportation is an innovative study that improves citizen satisfaction and makes better use of scarce resources in rural areas with low demand.

4.11. MICROMOBILITY APPLICATIONS

Micromobility is defined by the International Transport Forum (ITF) as "Personal transport via devices and vehicles weighing up to 350 kg, whose power supply, if any, is gradually reduced and cut off at speeds below 45 kilometers per hour." Micromobility refers solely to the use of bicycles, skateboards, roller skates, and scooters. This definition encompasses both human-powered and electric-assisted vehicles, including bicycles, e-bikes, and foot-push scooters.

The ITF examines micromobility tools in four classes. Type A and Type B small vehicles include human-powered vehicles or vehicles with a maximum speed of 25 km/h. Many bicycles, e-bikes, e-scooters fall into this class. Type C and D cover vehicles speeding between 25 and 45 km.

Due to the lack of adequate regulation of electric scooters globally, some countries classify them as bicycles. Legal regulation studies continue in our country.

Micromobility continues to benefit from pedestrian trips as well as other modes of transport (Mayor of London, 2020). Micromobility vehicles are gaining popularity daily due to the benefits they provide (Figure 22).

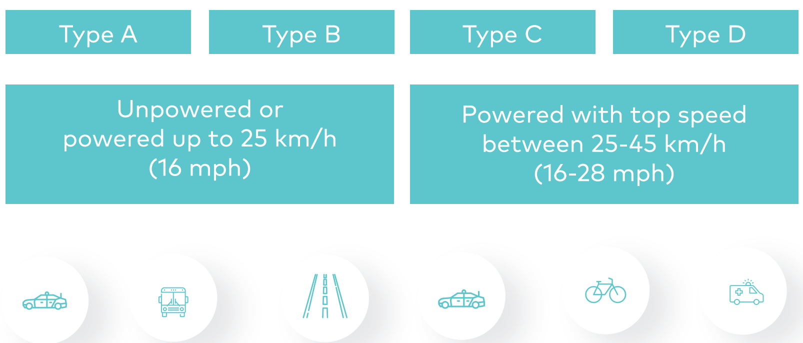


Figure 22: Electric Micromobility Vehicle (Scooter)

In recent years, both in our country and throughout the world, the use of shared electric scooters has increased. Today, approximately 35,000 shared electric scooters are available. This figure is expected to rapidly increase. Additionally, cities' infrastructures must be made micromobility-friendly. Automobile journeys will decrease if cities are made micromobility-friendly. This entails both structural changes to land use and physical improvements such as special lanes.

4.12. COOPERATIVE SMART TRANSPORTATION SYSTEMS (C – STS)

The management of highways, ring roads, and the highway network using smart transportation system software and hardware is also referred to as "active traffic management" or, more recently, cooperative ITS, which incorporates vehicle-vehicle and vehicle-infrastructure communications (Figure 23).

With active traffic management systems, it is aimed to increase traffic safety against sudden danger situations. The following are required for this:

- Accident and congestion notification,
- Weather conditions information (fog, slippery, precipitation),
- Road works need to be informed;

In order to increase efficiency and capacity in traffic flow;

- Harmonization of speeds (speed limiting),
- Preventing heavy vehicles from using the left lane with the prohibition of overtaking,
- Managing workspaces.

Active Traffic Management Systems consist of the following sub-systems:

- Data collection with fixed sensors,
- Data collection and communication of vehicles over vehicles,
- Speed and lane management,
- Road network management,
- Police Martyrs Management,
- Attendance control (ramp metering).

EU member states collaborate on C - STS testing to create C-Roads, a platform for testing STS, vehicle-vehicle, and vehicle-infrastructure applications across borders. Germany, Austria, Belgium, Czechia, Denmark, Finland, France, the Netherlands, England, Spain, Sweden, Italy, Hungary, Norway, and Portugal all participate in the platform. Numerous institutions and organiza-

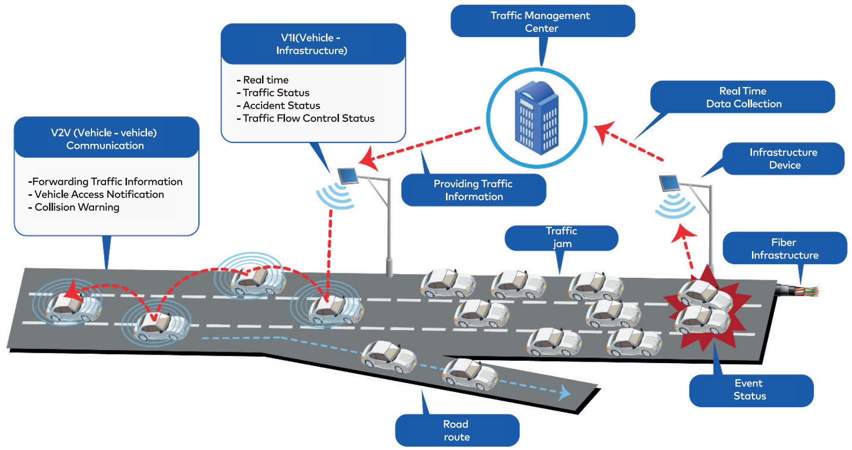


Figure 23: Cooperative Smart Transportation Systems (C-STS)
Source: (T.C. Ulaştırma ve Altyapı Bakanlığı, 2020a)

tions from both the public and private sectors that work in the field of STS are also involved in the project, which requires each country to develop and implement its own pilot applications. For urban and intercity roads, a variety of applications are being evaluated, including accident information, reverse direction warning, shock wave, public transportation signal priority, and malfunctioning vehicle warning (C-Roads, 2021).

4.13. PUBLIC TRANSPORT MANAGEMENT

Public transportation systems are one of the most important modes of urban transportation in terms of efficiency and sustainability. The fact that more people can be transported in fewer vehicles that take up less space emphasizes the importance of public transportation. Figure 24 illustrates public transportation campaigns in a variety of cities.

Figure 24: Mass Transportation Systems and Automobile Difference
Source: (The Bullet, 2018)

While traditional definitions included criteria such as the public transportation system being open to all, a fixed route, and predetermined stops, all types of "Public Transportation" applications that increase passenger capacity are critical today. Public transportation systems also incorporate innovative applications such as on-demand public transportation and routes and stops that can be reserved in advance.

While public transportation systems in rural areas are required to provide a basic level of service to those in need, they must now compete with automobiles for a sustainable city life in urban areas, and even prioritize automobiles. This can be accomplished by providing a rapid and comfortable public transportation system. Prioritizing public transportation in developed countries can be demonstrated by prioritizing trams and buses at signalized intersections, abandoning the "pocket" application at bus stops,

and implementing bus lanes. In transportation, the term "door to door" is used to refer to the access time. A city's public transportation system should be faster and more cost effective than a door-to-door automobile, if possible. As a result, researchers have suggested setting up parking lots further away from bus stops in recent years. Congestion pricing is also necessary because public transportation is more cost effective than driving a car.

The quality of a public transport system can be measured by the following parameters (Babalık-Sutcliffe , 2017):

- Speed,
- Service frequency,
- Punctuality,
- Reliability,
- Security,
- Comfort,
- Accessibility,
- Intelligibility,
- The fee is payable.

Additionally, comfort is a factor in deciding to take public transportation rather than driving a car. It includes features that increase demand, such as the ability for passengers to travel in comfort, air conditioning, lighting, and phone charging. Furthermore, public transportation stops should be easily accessible via foot, bicycle, or scooter. The rate of use of public transportation systems that are inaccessible or difficult to find is decreasing.

The use of technology in public transportation systems should also support transportation authorities in all these parameters. For this, public transport systems;

- Ticketing Systems such as Contactless Smart Cards, Ticket (Card) Receiving and Loading Machines, POS Filling Devices, Online Banking,
- Payment Systems such as Validators, QR Readers,
- In-Vehicle, Station, Web or Mobile Passenger Information Systems,
- Driver Control Systems that Communicate with the Driver,
- Public Transport Navigation Systems,
- In-Vehicle Passenger Announcement Systems,
- In-Vehicle Camera Security Systems,
- Phone Chargers,
- In-Vehicle Wi-Fi

must accommodate passenger-facing systems as above (Figure 25). In addition:

- Inventory management can be provided by defining and tracking information such as lines, stops, routes, drivers, vehicles, etc., which are components of the public transportation network, on the system,

- Violations such as line, stop, speed can be tracked,
- In-vehicle cameras can be monitored,
- Expedition plans, driver assignments can be made,
- Fee tariffs can be determined and calculations can be made,
- Expedition and driver optimizations can be made,
- Driver scoring can be done,
- Control center systems should be established in order to increase the service quality and efficiency, where the features such as fuel consumption and performance of the vehicles can be monitored and reported.

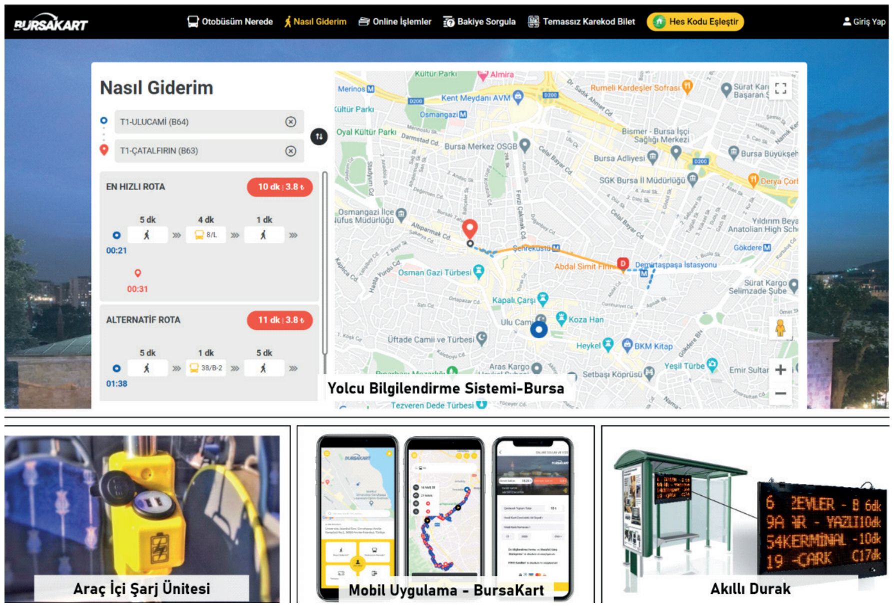


Figure 25: Smart Systems and Applications in Public Transport

The utilization rate of a city's public transportation system indicates its quality. The most blatant example of this is found in Western European countries and the United States of America. While the daily use of automobiles is lower in Western European countries with developed public transportation systems, it is higher in America.

With the development of mobile phones, NFC (Near Field Communication) and QR (Quick Response-Karekod) payment methods are becoming more common day by day. Many municipalities in Turkey are renewing both their software and hardware in this direction.

Along with parameters such as the system's prevalence and comfort, improvements to monitoring, control, and optimization systems will ensure that these systems are preferred as the primary mode of daily transportation, particularly in metropolitan areas.

4.14. VEHICLE TECHNOLOGIES OF THE FUTURE: ELECTRIC AND AUTONOMOUS VEHICLES

4.14.1. Electric Vehicles

Electric vehicles have a long history, dating all the way back to the automobile's invention. The first electric vehicle was invented in 1834 by an American named Thomas Davenport. Later that year, in 1886, Mercedes-Benz, a German automobile manufacturer, began manufacturing electric vehicles. Porsche created the first hybrid automobile in 1900. Henry Ford achieved mass production for the first time in 1908. (Helmers & Marx, 2012). Fossil fuel engines were invested in the subsequent years and have remained popular, particularly in automobiles, to the present day. However, other than automobiles, electricity was still used in transportation systems (eg trolleybus, train, cable car).

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4.14.2. Autonomous Vehicles

Although studies on autonomous vehicles have come to the fore a lot in recent years, they are actually a result of technological adventure. As a result of the development of driving support systems, machine learning, artificial intelligence and radar technologies, autonomous vehicles have now reached the stage of conducting tests and showing their applications in the field. There are many software and hardware needs in an autonomous vehicle. The software and hardware in autonomous vehicles are listed below (Figure 26), (Deloitte, 2019);

- **On-board equipment:** Camera/Optics, Radar, Communication equipment, Lidar, Actuators, GPS, Ultrasonic sensors, odometry sensors, on-board computer,
- **On-board software:** High resolution in-vehicle map, data fusion and mapping, object analysis algorithm, forecasting software, decision making, vehicle operation system, supervisor platform,
- **Other:** Data center and cloud software and hardware.

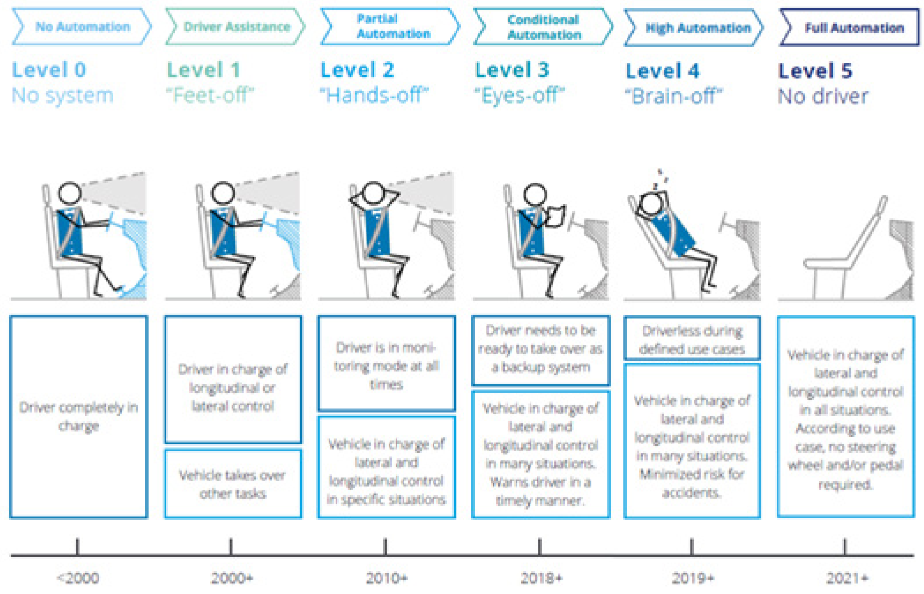


Figure 26: Autonomous Vehicle Levels
Source: (Deloitte, 2019)

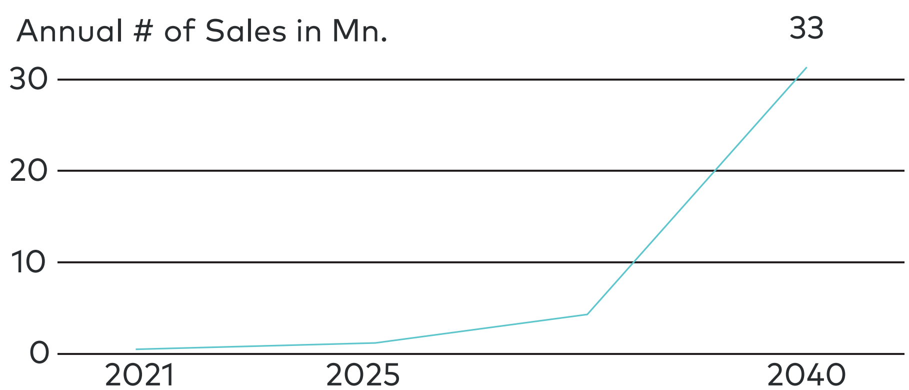


Figure 27: Autonomous Vehicle Sales
Source: (Deloitte, 2019)

Today, large automotive companies, universities and newly established technology companies (start-ups) are working on autonomous vehicles in the world. While studies on autonomous vehicles continue at full speed, it is predicted that 1 million vehicles will be sold in 2025 and 33 million autonomous vehicles will be sold by 2040 regarding the autonomous vehicle market (Figure 27).

As a result of these studies, with the spread of 5th level autonomous vehicles all over the world, various legislative arrangements are also needed. In addition, in order to reduce the number of vehicles in cities and to use resources efficiently, it will be important to put autonomous vehicles into service shared and to call them in case of need with the help of mobile applications (MaaS).

Figure 28: Transport with Drone
Source: (Amazon, 2021

4.14.3. CITY AIR TRANSPORTATION: AIR TAXI AND DRONE

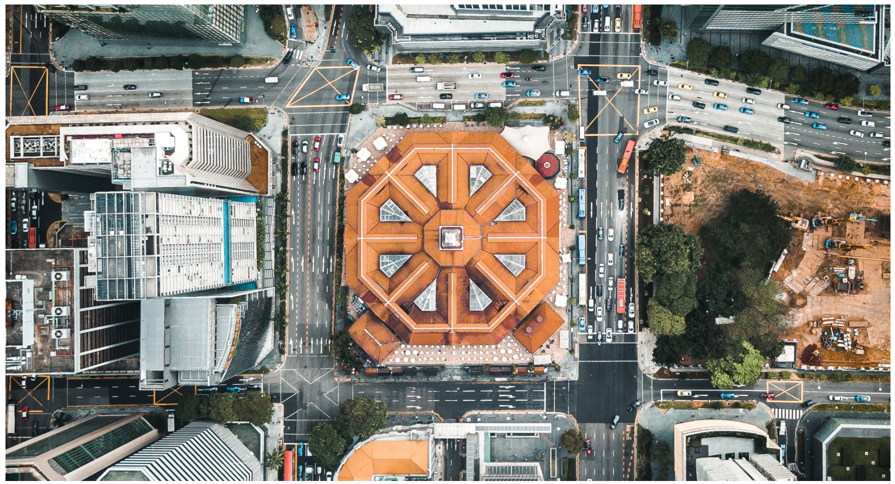
Additionally, technology companies are collaborating with some aircraft manufacturers on flying vehicles known as air taxis or drone taxis, which are envisioned as future modes of transportation. As of today, there are concerns that it will serve only a small segment of the population, particularly in megacities, rather than providing a mode of transportation for everyone living in the city.

As a result, it is predicted that demand will increase in Asia's major cities by the 2030s. Additionally, these vehicles are expected to address transportation needs such as emergency response and cargo transport. The National Intelligent Transportation Systems Strategy Document and the 2020-2023 Action Plan both contain recommendations in this direction.

4.15. SMART CITY LOGISTICS

City logistics, which must run continuously in order to sustain city life, is a critical area of research for smart cities, due to the environmental impacts and traffic congestion. Customers, vendors, shippers, purchasers, distributors, and policymakers are all stakeholders in urban logistics (Figure 28).

Cities have been establishing a fast and environmentally friendly distribution mechanism in recent years. Inter-species transportation, nighttime use of metro and tram lines, electric vehicles, and transportation and distribution services utilizing small electric vehicles in pedestrian areas are all examples of different models.



5

CONCLUSION AND EVALUATION

Transportation is a fundamental need of every city, one that grows in importance as cities grow. While pedestrian travel can meet demand in small cities, motor vehicles are more necessary in large cities. Land uses and urban planning structures are two of the primary factors affecting journey lengths and durations. As a result, when developing city plans, special attention should be paid to increasing the attractiveness of sustainable modes of transportation that reduce travel times. Because, in addition to economic factors such as time and fuel spent on city transportation, the design of transportation infrastructures directly affects the reduction of environmental effects such as air, noise, and climate change. Thus, in order to improve city dwellers' quality of life, transportation demand should be planned and implemented using the appropriate methods and techniques.

Transportation needs can be met more economically and innovatively through the use of smart transportation, which is supported by information and communication systems. To begin, it is necessary to accurately define the need, to determine which methods and techniques will be most effective in meeting that need, and to implement those methods and techniques. Additionally, it is critical to control and supervise implementations to ensure they are consistent with the purposes.

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With the support of information and communication systems, in order for smart transportation applications to be successful, which enable the transportation need to be solved with more economical and innovative methods, the need must be correctly identified and appropriate methods and techniques must be determined in order to meet this need. In addition, it is essential to control and supervise the compliance of the practices with the targets. This work touches on the problems of transportation, one of the important areas of daily city life, and innovative solutions. Examples of the contribution of many types of transportation to city life, from public transportation to road transportation, from bicycles to drones, are presented.

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