# NATIONAL TECHNOLOGY INITIATIVE IN TRANSPORTATION: INTELLIGENT TRANSPORTATION SYSTEMS

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**Abstract**

One of the development indicators of a country is transportation infrastructure and investments in transportation. Especially in the last 20 years, Türkiye has made very significant investments in transportation infrastructure and supported these investments with domestic and national technologies. Our country, which has made very significant investments in highway, railway and airway transportation in the last 10 years, aims to develop this in seaway investments in the coming years. In this study, the investments made by the country in the 21st century in the fields of transportation in general and Intelligent Transportation Systems in particular and the domestic and national technologies used by Intelligent Transportation Systems have been examined. In other words, it is aimed to analyze Türkiye's domestic and national transportation technology move in detail, based on the domestic and national transportation technology products developed by the domestic supplier companies working here, not by the model of the investments and by whom.

In our country, which used imported technology more in Highways, Bridges, Tunnels, Urban Traffic Management and Control Systems, Rail Systems, Civil Aviation, Maritime Transportation, Micro Mobility, Web and Mobile and similar applications until the 2000s, after 2000s' domestic and national technologies in these areas were used more. Türkiye tries to reach a level that can compete with the leading countries of the sector such as Korea, Japan, Germany and the USA. Our country, which has made considerably large investments in the field of transportation in the world, will be among the first 20 countries in international competition. In the coming years if it continues this momentum for its Intelligent Transportation Systems investments which is pointed by all investment data and international foresight reports. The national technology initiative made in the defense industry can be given as a positive example in this sense.

***Keywords***

*Transportation, Transportation Technologies, Intelligent Transportation Systems (ITS), Domestic and National ITS Technologies, Türkiye Transportation Investments*

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# 1. Introduction

As a result of the investments made by the Ministry of Transport and Infrastructure in line with the 2023 strategic targets, our country has been equipped with rail networks, double roads, highways, bridges, airports, fiber infrastructure and logistics centers. Their integration with each other has provided. While the world experienced economic contraction due to the pandemic between the 2019-2021 period, our country announced its 2053 strategic plans in transportation and set strategic targets for the realization of these investments with national and domestic technologies. The Ministry of Transport and Infrastructure continues its domestic and national technology studies covering the whole country, together with universities, the private sector and other stakeholders, within the scope of its 2071 vision. These studies appear as highways where autonomous vehicles travel, roads where electric vehicles are widely used, cities with the least environmental pollution due to transportation, and a country with the least traffic accidents. However, international political and economic developments, bureaucratic and stability problems on a national basis, and the decrease in the contribution of stakeholders could hinder the achievement of these goals. Especially in terms of Intelligent Transportation Systems (ITS), the name of the future in transportation, our competitive power and market share with the world will decrease. Considering that this market was at the trillion-dollar level in 2021, it is clear that Intelligent Transportation Systems technologies will be a power factor like energy, agriculture and water that will change the global balance after 2030. It is clear that if our country makes the enormous national technology initiative in the field of transportation as it has made in the defense industry in recent years, it will be one of the strongest economies of the future. Our country has the brain power and young population to achieve this.

The important thing is to increase this power with R&D investments and support packages and bring it to public-private-university-industry cooperation. Sustainable policies and strategies should be developed and updated in order to maintain and improve this momentum gained today. With the power of audio and visual media, the public should be informed within the scope of national interests with common mind meetings across the country.

## *1.1. Basic Definitions*

**Transport:** It is the transportation of an object (person, cargo, etc.) from one place to another.

**Transportation:** It is the whole that includes all transportation systems (Railway, Seaway, Highway, Airway) and technological applications.

**Intelligent Transportation Systems (ITS):** ITS is developed for the purposes of reducing travel times, increasing traffic safety, optimum use of existing road capacities, increasing mobility, contributing to the country's economy by providing energy efficiency and reducing the damage to the environment systems that include monitoring, measurement, analysis and control the multipath data exchange between the user-vehicle-infrastructure-center (HGM, 2022).

**Domestic Technology:** It means that a product is physically made in Türkiye. That is, the product is produced by designers, engineers and workers who are citizens of the Republic of Türkiye.

**National Technology:** The owner is Türkiye, Türkiye comes to mind when looking at that product, the functionality of the goods is completely under the guarantee of Türkiye, the decision whether or not to produce the product belongs entirely to the Turks (such as UAV, Armed Drones) (Yılmaz O., 2018).

### *1.2. Intelligent Transportation Systems*

When examining the literature, there are many definitions of ITS. Some of these are as follows. ITS is the name of all systems that provide accessible and easy transportation, reduce traffic accidents, are human and environment friendly, reduce traffic congestion and increase mobility.ITS are systems that apply advanced electronic, communication, computer, control and sensing technologies in all types of transportation systems to improve safety, efficiency, service and traffic situation by transmitting real-time information (Fig.1).

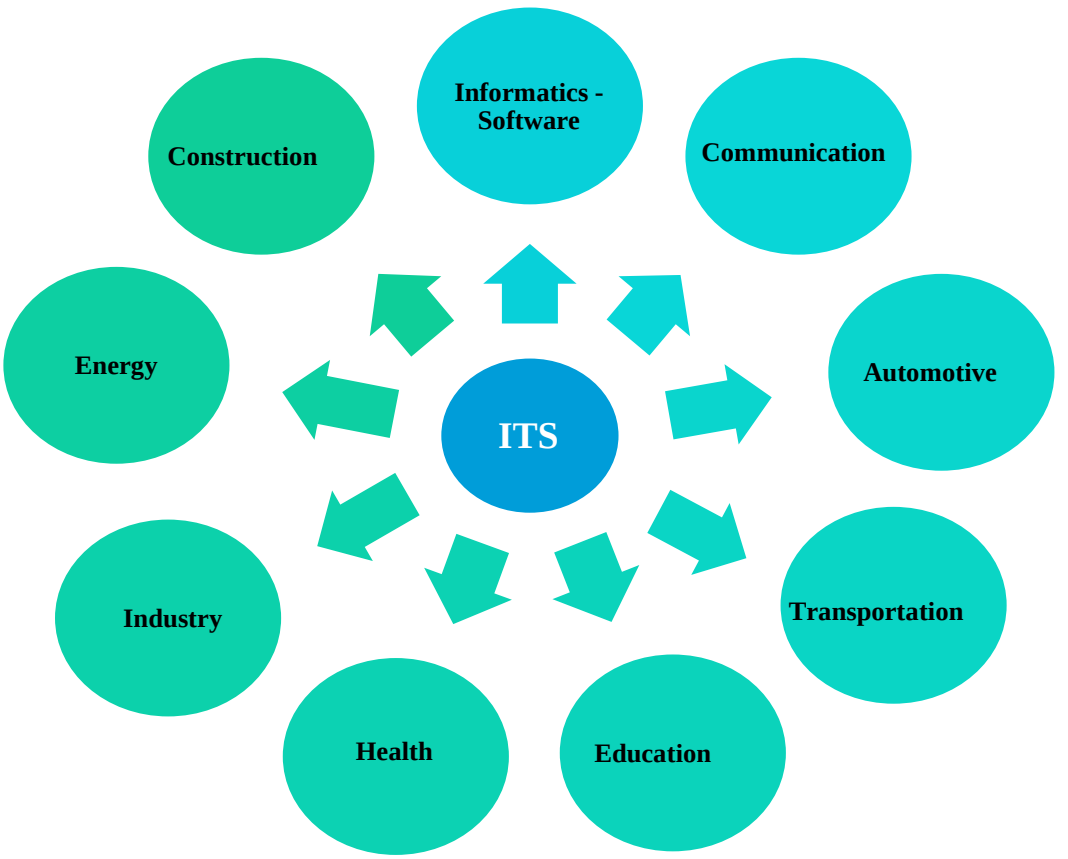



***Figure 1.*** *Intelligent transportation systems(hgm.uab, 2022)*

### *1.3. Scope of ITS*

ITS has a multidisciplinary and multisectoral structure. It includes fields such as social sciences, natural sciences, engineering sciences and health sciences. On the other hand, ITS is multi-sectoral and therefore requires a common bureaucratic vision and strategy with the automotive to the informatics sector, from the communication sector to the logistics sector, from the health sector to the construction sector, in this sense. It has a structure that concerns many ministries and general directorates, from the Ministry of Family and Social

Services to the Ministry of Transport, from the Ministry of Industry and Technology to the Ministry of Health, Environment and Interior (Fig. 2).


***Figure 2.*** *Multisector structure of ITS (Tektaş & Tektaş, 2019)*

### *1.4. Sectoral Contributions of ITS*

When local governments implement ITS applications in their regions with the contribution of central governments, it is seen that there is a decrease in traffic accidents and traffic congestion, the volume of emissions decreases, and road and driving safety increase and as a result of these, the increase in mobility has been proven by testing in many different parts of the world and shown in the literature (hgm.uab, 2022). In this sense, the benefits of ITS applications and ITS awareness should be promoted and disseminated by an organization from the local government to the central government, and it should be ensured that the whole country has an accessible, safe, comfortable, easy and environmentally friendly transportation. In this respect, ITS has become one of the most attractive areas of interest in recent years in terms of contributing to all sectors (Tektaş & Tektaş, 2019).

***Table 1.*** *Sectoral Breakdown of the Benefits of ITS Implementation*

| **Benefits of ITS implementation** | **Sectors** |
|---|---|
| Increasing mobility and contributing to social psychology | Transportation, Economy, Health |
| Reducing fatal and injury traffic accidents | Economy, Health |
| Saving fuel by reducing transportation time, reducing carbon emissions and shortening vehicle wear time | Transportation, Energy, Automotive, Environment |
| Reducing environmental pollution | Environment, Health |
| With the use of alternative energy sources, the number of electric vehicles will increase and oil consumption will decrease accordingly. The decrease in the budget deficit in our energy-importing country due to this decrease | Energy, Economy |
| Revitalizing the construction industry and increasing employment with smart roads, intersections and finally smart cities | Transportation, Energy, Automotive, Communication |
| Emergency Management Systems | Health, Transport, Communication |
| Providing ease of transportation by reducing travel time with vehicle-vehicle, vehicle-infrastructure, vehicle-driver communication systems | Transportation, IT-Software, Communication, Automotive |
| The need for Web-mobile applications that contribute to traffic safety and public transportation | Informatics-Software-Communication |
| Providing ease of access by analyzing big data obtained from vehicles, environment and infrastructure with the help of cameras, sensors and similar applications. | Transportation-IT-Software |
| Security of big data obtained from vehicles, environment and infrastructure with the help of cameras, sensors and similar applications (cybersecurity) | IT-Software |
| Forcing the transition to smart energy systems with the increase of electric and hybrid vehicles | Energy-Economy |
| Detection of criminals and crime with data obtained from cameras and similar applications | Security |

*Source: (Tektaş & Tektaş, 2019)*

In particular, ITS has a functional structure which has many applications in road transportation. (i.e. green wave, electronic control system, adaptive intersection control, public transportation and fleet management, smart stops, advanced traffic management systems, mobile applications, toll collection systems).

### *1.5. Benefits of ITS*

According to TUIK (Türkiye Statistical Institute) 2010-2020 data, the population growth rate in cities is 38,27% and the increase in the number of private cars is 73,66%. Increases in urbanization, automobile ownership and the number of drivers increase the demand for road transport and its density in traffic. The increase in traffic density and the increase in the amount of fuel consumption and carbon dioxide emissions accordingly make the use of information and communication technologies in the field of transportation obligatory. In this case, the best practices to use are ITS practices. Thanks to ITS, human-induced errors

are minimized. In addition, traffic-related time loss, fatal and injury accidents, material losses, air pollution and many other negative effects are reduced (Tektaş & Tektaş, 2019).

All these reasons mentioned above once again demonstrated the importance of ITS. Thanks to the widespread use of ITS, solutions to these problems will be possible. These solutions will also bring the following benefits:

- Increased mobility,
- Reduction in traffic congestion and contributions to public transportation,
- Reduction of traffic accidents and related deaths, number of injured and financial losses,
- Ensuring fuel savings by reducing the time spent in transportation,
- Reduction of carbon emission and environmental pollution,
- Saving in maintenance costs by delaying the wear time of vehicles,
- Increasing the efficiency and effectiveness of emergency management systems,
- Providing ease of transportation by reducing travel time with vehicle-vehicle, vehicle-infrastructure, vehicle-central communication systems,
- Ensuring widespread use of Web-mobile applications that contribute to traffic safety and public transportation,
- Ensuring ease of access by analyzing big data obtained from vehicles, environment and infrastructure with the help of cameras, sensors and similar applications,
- Ensuring energy savings by transitioning to smart energy systems due to the increase in electric and hybrid vehicles, contribution to the country's economy by reducing dependence on oil and natural gas,
- Ensuring public safety with data obtained from cameras and similar applications,
- Optimizing passenger and freight mobility with accurate and instant information to be obtained through mobile applications and services based on real-time data (hgm.uab, 2022).

### *1.6. Investments involving domestic and national ITS applications in Türkiye*

Various of the web-based, mobile, toll collection system, passenger and driver information systems, communication systems, control and automation applications that use domestic and national ITS technologies in Türkiye, which started in the 1990s, are listed below in chronological order.

| Year | Investments | ITS Technology |
|---|---|---|
| 1973 | Boğaziçi Bridge | Toll Collection System |
| 1988 | Fatih Sultan Mehmet Bridge | Toll Collection System |
| 1992 | KGM Highway Toll Collection System | Toll Collection System |
| | KGM Emergency Management System | Internet of Things (IoT) |
| 1994 | First Vehicle Tracking System | Camera and Sensors |
| 1995 | İstanbul Akbil | Toll Collection System |
| | Highway Cash Toll Collection System | Toll Collection System |
| 1998 | First Traffic Control Center | Communication Technologies |
| 1999 | Automatic Pass System (APS) | Toll Collection System |
| | İzmir Kentkart | Toll Collection System |
| 2000 | Bolu Mountain Pass Information System | VMS |
| 2002 | Mobile Variable Message Sign | VMS |
| 2003 | Istanbul Traffic Density Map | Web-Mobile Technologies |
| 2004 | Traffic Control Center | Communication Technologies |
| | Ankara Traffic Information System | Web-Mobile Technologies |
| | Card Pass System (CPS) | Toll Collection System |
| | Highway Traffic Management System | Web-Mobile Technologies |
| 2005 | EDS Red Light Violation Detection System | Camera and Sensors |
| 2006 | City Security System – MOBESE (2006) | Camera and Sensors |
| | The First Mobile Traffic Application | Web-Mobile Technologies |
| 2007 | Bolu Mountain Tunnel Management System | Communication Technologies |
| 2008 | Distance Based Pricing | Toll Collection System |
| 2009 | National Vehicle and License Plate Recognition System (PTS) | Camera and Sensors |
| | Istanbul Card Application | Toll Collection System |
| | First Smart Stop Application | Internet of Things (IoT) |
| 2012 | Fast Pass System – HGS | Toll Collection System |
| | National Transport Portal (2012) | Web-Mobile Technologies |
| | Türkiye Constabulary License Plate Recognition and Vehicle Tracking System | Camera and Sensors |
| | Adaptive Traffic Management System | Toll Collection System |
| | EGO Mobile Application | Web-Mobile Technologies |
| 2013 | Konya Intelligent Public Transportation System | Web-Mobile Technologies |
| | Marmaray Project | All applications |
| 2014 | Free Toll Collection System (SGS) | Toll Collection System |
| | Single Card Payment | Toll Collection System |
| | Istanbul MobİETT Passenger Information System | Web-Mobile Technologies |
| 2016 | Yavuz Sultan Selim bridge | All applications |
| | Osmangazi bridge | All applications |
| | Osmangazi Bridge SCADA and Automation System | Control Technologies |

| | Concept Smart Stop Application | Camera and Sensors |
|---|---|---|
| 2017 | Avrasya tunnel | All applications |
| | Public Transport Traffic Management Center | All applications |
| | İBB Yolgösteren | Web-Mobile Technologies |
| | First Driverless Subway | Web-Mobile Technologies |
| | i-Taksi | Internet of Things (IoT) |
| 2018 | Başkentray | All applications |
| | Istanbul Airport | All applications |
| | e-Call Application | Web-Mobile Technologies |
| | Durak Ankara | Web-Mobile Technologies |
| 2019 | 2019-Gebze-İzmir Highway ITS Systems | All applications |
| 2021 | Ankara-Niğde Highway | All applications |
| 2022 | 1915 Çanakkale Bridge | All applications |
| 2023 | Togg (Domestic Automobile) | All applications |

## 2. Türkiye's Transportation Investments

### *2.1. Türkiye Railway Investments*

Invested services; passenger and freight transportation, logistics services, ferry, freight and passenger transportation services, high-speed trains, conventional trains, urban suburban trains, Marmaray, Başkentray, these services are carried out by TCDD Taşımacılık (TCDD Taşımacılık, 2022).

Considering the investments in railways, an increase of 17% was achieved in the total length of the railway network in Türkiye, which reached to 12803 km in 2021, from a total of 10959 km in 2003 (Fig. 3).

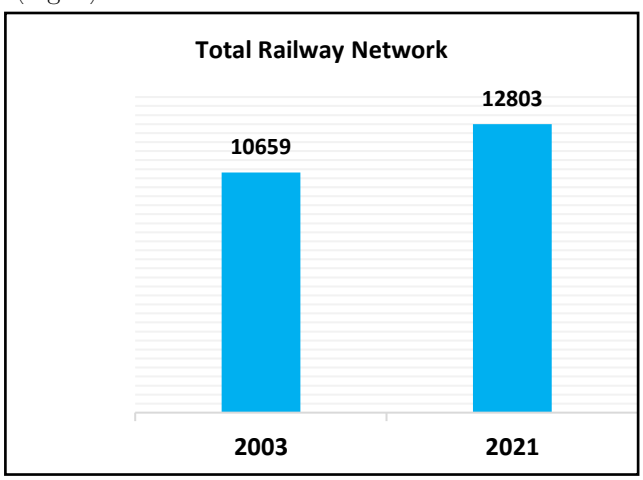



***Figure 3.*** *Total railway network in Türkiye (UAB, 2021)*

Comparison of the railway network line lengths between 2003 and 2021 is shown as follows (Fig. 4.)

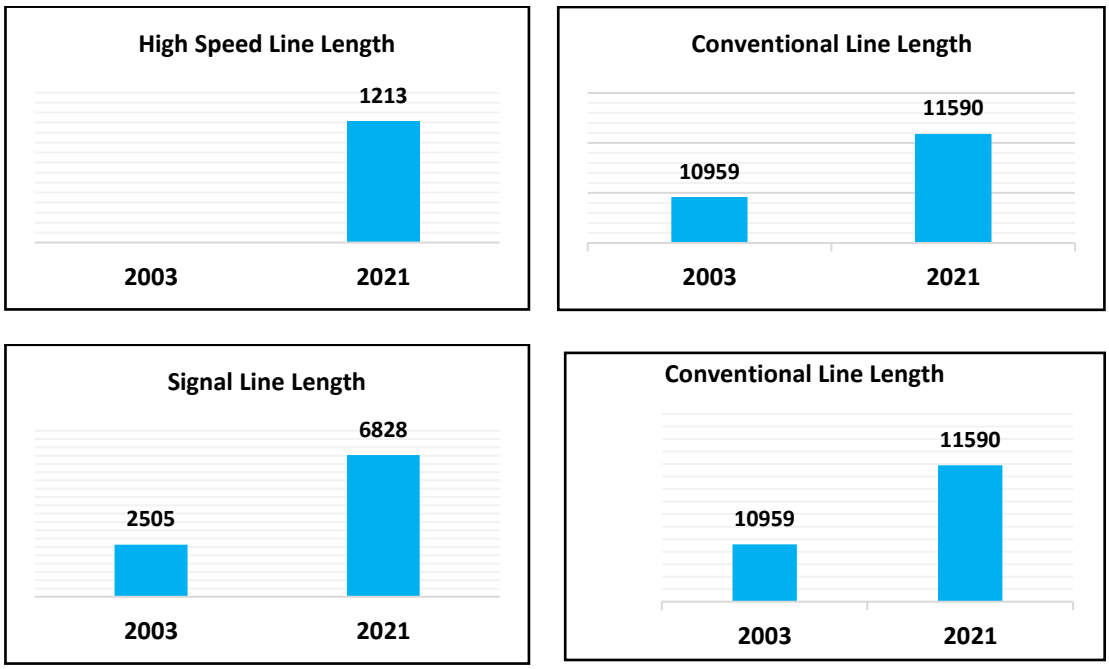



***Figure 4.*** *Turkish railway line lengths (UAB, 2021)*

- ***Seamless Rail Corridor Between Asia and Europe***

The demand for transit transportation between China and Europe via Türkiye is increasing day by day, in addition to the freight transport between Türkiye and China by block trains, over the Middle Corridor called *the Iron Silk Road*. Silk road is considered as the shortest, safest, most economical and most suitable railway corridor between the continents of Asia and Europe. Global trade volume is 12 billion tons in 2020, 25 billion tons in 2030 and it is estimated that it will reach 95 billion tons by 2050 (TCDD Taşımacılık, 2022) (Fig. 5).

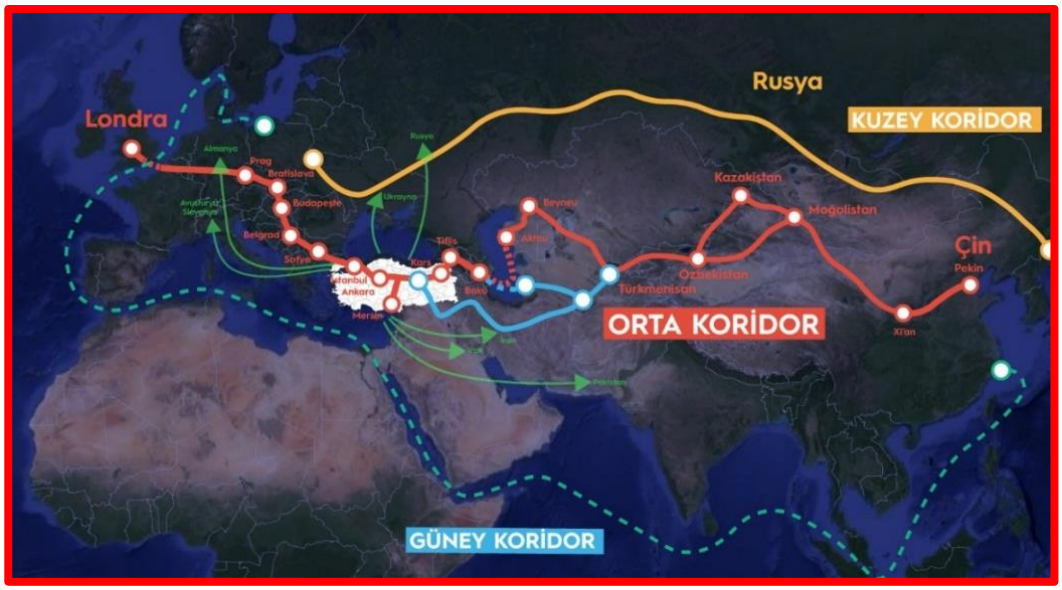



***Figure 5.*** *Continuous rail corridor between Asia and Europe (UAB, 2021)*

Transportation is carried out on eight different routes that are starting in Mersin (Kazakhstan-Kars-Mersin, Mersin-Turkmenistan, Izmit-Kazakhstan, Izmit-Uzbekistan, Izmit-Azerbaijan, Russia-Iskenderun, China-Türkiye-China and China-Europe-China) and line lengths are from Mersin to Kokhshetau 4700 km, Kostenai 4300 km, Aktobe 4000 km and Baku 2098 km. The summary of the existing, ongoing, project completed, and project prepared lines of the Turkish railway network could be seen in Figure 6.


***Figure 6.*** *Türkiye rail network map (UAB, 2021)*

- ***Ankara-İzmir High Speed Train Project***

Ankara-İzmir High Speed Train Line Project (AIYHT) is an important project that will connect Türkiye's Capital Ankara to İzmir, Türkiye's third largest city in terms of population density, under the Ministry of Transport and Infrastructure, General

Directorate of Infrastructure Investments. The main line of the high-speed train line, which is 503.3 kilometers long, passes through the provincial borders of Ankara Eskişehir, Afyonkarahisar, Kütahya, Uşak, Manisa and İzmir. When the project is completed, there will be additional stations and stations in Emirdağ, Afyonkarahisar, Uşak, Salihli, Turgutlu and Manisa (UAB, 2021) (Fig.7).


***Figure 7.*** *Ankara-İzmir high-speed train route (UAB, 2021)*

- ***Bursa-Yenişehir-Osmaneli High Speed Train Project***

The section of Bandırma-Bursa-Yenişehir-Osmaneli High Standard Railway Line that is from Bursa to Osmaneli is planned to be completed by 2023. The line, which will then be extended to Bandırma with connections to the port, is planned to be used for freight and passenger transportation (Fig. 8).


***Figure 8.*** *Bursa-Yenişehir-Osmaneli high-speed train route map (UAB, 2021)*

- ***Konya-Karaman-Ulukışla High Speed Line (237 Km)***

76% of the work in the Karaman-Ulukışla section of the 237 kilometers long Konya-Karaman-Ulukışla High Speed Line Project has been completed and the Ulukışla-Yenice Railway line project has been included in the investment program of the General Directorate of Infrastructure Investments as the Aksaray-Ulukışla-Yenice high-speed train line. Efforts are being made to provide the opportunity to travel at 200 kilometers per hour on this line, when the construction of all sections between Konya-Karaman-Mersin-Adana is completed (Fig. 9) (RAY HABER, 2022).


***Figure 9.*** *Konya-Karaman-Ulukışla route map (UAB, 2021)*

- ***Ankara (Kayas)-Sivas YHT (393 Km)***

With the Ankara-Sivas High Speed Train (YHT) Line coming into service, the travel time between Ankara-Sivas will decrease from 12 hours to 2 hours. Thus, many cities that are integrated with other high-speed railway lines will get closer on the west-east axis (TCDD Taşımacılık, 2022) (Fig. 10).


***Figure 8.*** *Ankara-Sivas high speed train (HST) route (UAB, 2021)*

- ***HST (High Speed Train) Passenger Transportation***

From 2009 to 2019, passengers were transported by HST with an increase of 337%. However, while 2.8 million passengers were carried with a decrease of 66% in 2020 due to the pandemic, 4 million passengers were transported with an increase of 43% in 2021, and a total of 58 million passengers were carried from 2009 to 2021 on HST (TCDD Tasimacilik, 2022). The view of passenger number data between 2009-2021 is as follows (Fig. 11).

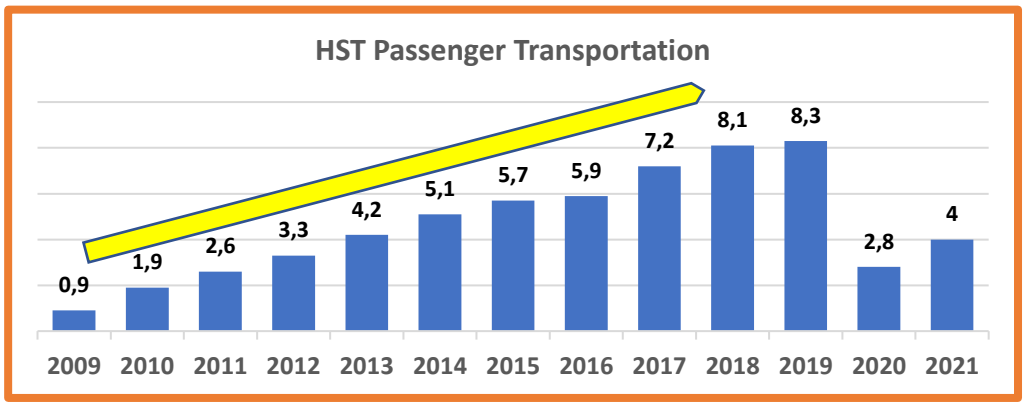



***Figure 9.*** *HST passenger transportation (TCDD Taşımacılık, 2022)*

- ***Türkiye Railway investments Maps***

Türkiye railway investment map is shown in Figure 2.12. Accordingly, it shows the lines that have been put into operation and completed, under construction, at the stage of construction tender, and at the survey and planning stage (Fig.12).


***Figure 10****. Türkiye railway investment map (UAB, 2021)*

- ***Urban Rail Systems***

The map of the urban rail systems completed or under construction within the scope of the National ITS Strategy Document and the 2020-2023 Action Plan is as follows (Fig.13).

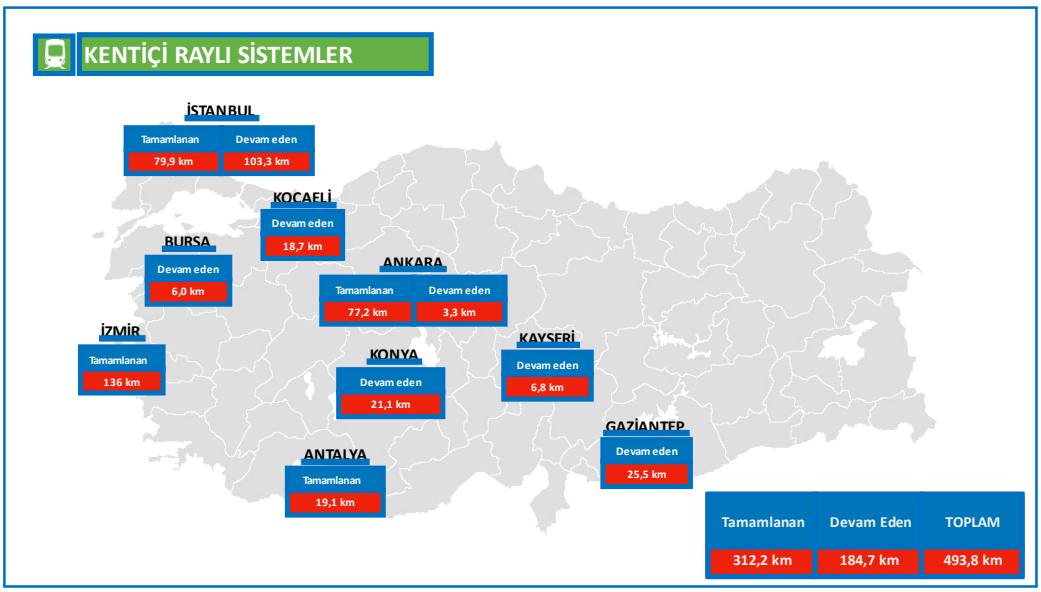



***Figure 13.*** *Map of the urban rail systems of the 500 km line completed or under construction within the scope of the National ITS Strategy Document and the 2020-2023 action plan (UAB, 2021)*

### *2.2. Türkiye Highway Investments*

In Figure 14, the data of the Ministry of Transport and Infrastructure for the year 2003-2021 and Türkiye's road network are shown.

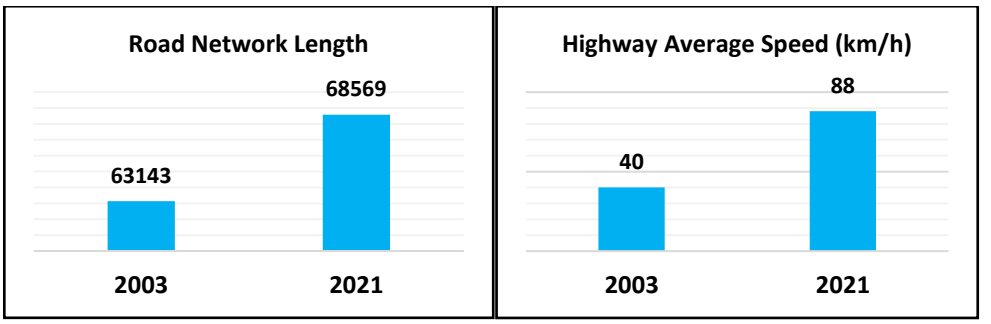



***Figure 14.*** *Türkiye road network length and average speed (UAB, 2021)*

In Table 2, The data of the Ministry of Transport and Infrastructure for the year 2021 are included and information about the sections that are completed, in progress and to be tendered.

***Table 2.*** *Information on Highways of the Ministry of Transport and Infrastructure for 2021*

| | **Divided Road** | **One Way** | **Total** |
|---|---|---|---|
| Completed Sections | 7382 Km | 375 Km | 7757 Km |
| Sections in Progress | 279 Km | 3 Km | 282 Km |
| Sections to be Tendered | 424 Km | 61 Km | 485 Km |
| **Total** | **8085 Km** | **439 Km** | **8542 Km** |

*Source: (UAB, 2021)*

Contributions of 28284 km divided roads to our country; 1 billion 921 million liters of fuel savings, 315 million hours of labor savings, total annual savings (September 2021) 20 billion 688 million TL. It will contribute to the environment with 3 million 957 thousand tons less CO2 emissions annually (UAB, 2021).

***Table 3.*** *2021 Divided Road Network of the Ministry of Transport and Infrastructure*

| **Divided Road Network** | **2003** | **2021** |
|---|---|---|
| Highway | 1714 km | 3532 km |
| Divided State and Provincial Roads | 4387 km | 24752 km |
| **Total** | **6101 km** | **28284 km** |

*Source: (UAB, 2021)*

The 177% increase in vehicle ownership in the last seventeen years in our country has brought along significant increases in passenger and freight transportation. These data require new investments in infrastructure (Road, Bridge, Tunnel, Viaduct etc.). These investments and their details are as follows.

- ***1915 Çanakkale Bridge and Highway***

1915 Çanakkale Bridge; It is the world's largest central span suspension bridge that will connect Istanbul to Çanakkale and later to the North Aegean (Fig.15).


***Figure 15.*** *1915 Çanakkale Bridge (UAB, 2021)*

The Malkara-Çanakkale section of the highway is 101 km long. With the commissioning of the Malkara-Çanakkale Highway, the transportation between Istanbul and Çanakkale decreased to 2 hours and 20 minutes, and the transportation between Malkara and Gallipoli to 1 hour or 75 km (40 km shortening). Thus, the Çanakkale Strait can be crossed in only 6 minutes (UAB,2021) (Fig. 16).


***Figure 16.*** *1915 Çanakkale Bridge highway and route information (UAB, 2021)*

- ***Istanbul-Bursa-Izmir Highway and Osmangazi Bridge***

With the opening of the Istanbul-Bursa-Izmir Highway road transportation between Istanbul and Izmir was reduced to 3,5 hours and with the opening of Osmangazi bridge, the gulf crossing was reduced to 6 minutes and 4 thousand 85 people were employed during the project process (Fig.17.)


***Figure 17.*** *Istanbul-Bursa-Izmir Highway and Osmangazi Bridge route map (UAB, 2021)*

The opening of the Istanbul-Izmir highway has contributed to the prolongation of Izmir's tourism season and the increase in the number of visitors to tourism centers. This has led to the creation of new investment areas. Integration has been achieved with port, railway, airway and road transportation projects in the region, and transportation costs have decreased in the Aegean Region's exports to Europe. A total of 4,12 billion liras were saved, including an annual reduction of 451,141 in emissions, 3 billion liras of fuel and 1,12 billion of annual time (UAB, 2021).

- ***Ankara-Niğde Highway (330 Km)***

Ankara-Niğde Highway, which provides uninterrupted service from Edirne to Şanlıurfa, has the feature of being the smartest road in Türkiye with the following features. These features are; It is produced with domestic and national means, the Incident Detection System is integrated with the cameras on the highway and it warns operators and drivers in cases such as dangerous accidents and traffic density on the highway. In addition, the fact that 317 kilometers of road, which took 4 hours and 14 minutes, decreased to 2 hours and 22 minutes, reveals the importance of this highway (Ankara Niğde Highway, 2022) (Fig.18).


***Figure 18.*** *Ankara-Niğde highway route map (UAB, 2021)*

With the commissioning of the highway, 36 million 220 thousand person/hour time savings, 127 million 551 thousand liters of fuel will be saved annually, will contribute 1 billion 628 million liras to the country's economy and carbon emissions will decrease by 318 million 240 thousand kilograms annually (UAB, 2021).

- ***Northern Marmara Motorway(KMO)-(Including Yavuz Sultan Selim Bridge) (443,4 Km)***

The Northern Marmara Highway has the feature of being the widest tunnels in the world with its four-lane tunnels, providing high standard, safe, quality and uninterrupted transportation connecting the Asian and European continents in order to ease the transportation of the Marmara region. The highway route between Tekirdağ and Sakarya, which combines the Yavuz Sultan Selim Bridge and Istanbul Airport connection roads, significantly reduces the traffic load in the existing transportation networks and especially in the Bosphorus crossings. In addition to being the first with its aesthetic and technical features, Yavuz sultan Selim Bridge is the widest and longest suspension bridge in the world which is a rail system with an eight-lane highway and two-lane railway. Yavuz sultan Selim Bridge has also the feature of being the suspension bridge with the highest towers in the world (North Marmara Highway Administration, 2022) (Fig. 19).

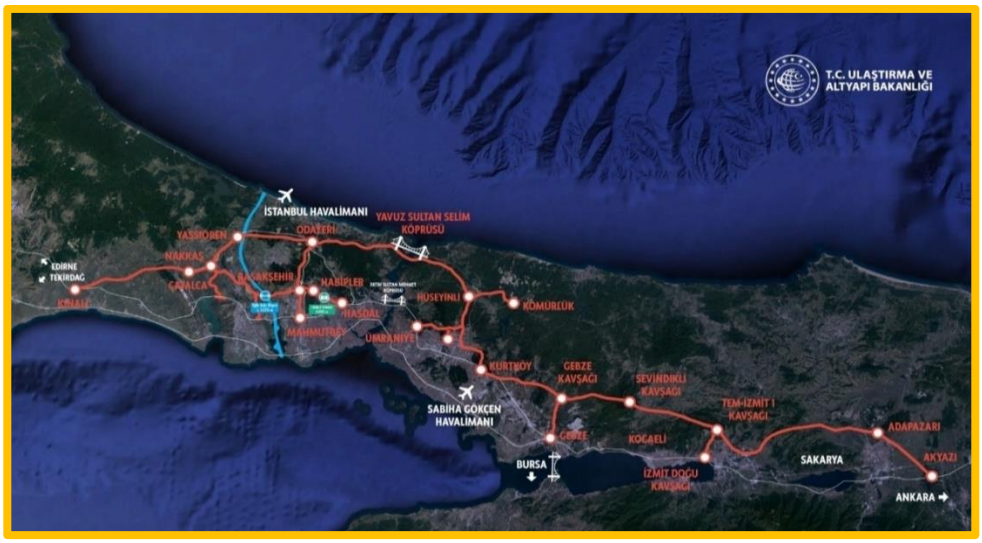
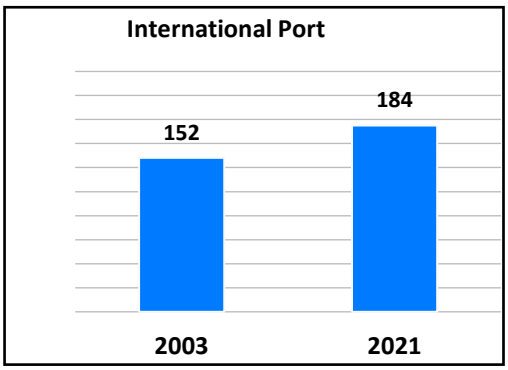


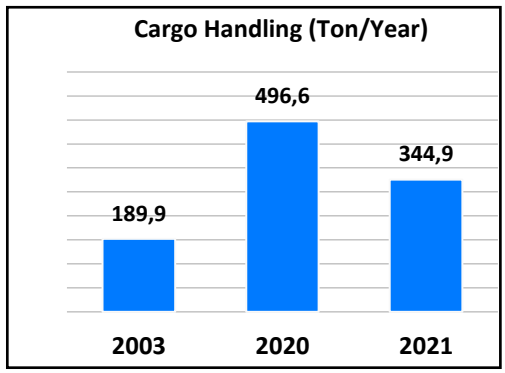

***Figure 11.*** *Northern Marmara Highway route map (UAB, 2021)*

Northern Marmara Highway provides an uninterrupted and controlled transit pass by connecting Europe to Asia in the Marmara Region, which has the busiest traffic in Türkiye, thus saving 3 billion TL per year from time. Hence, 198 thousand tons of $CO_2$ is emitted less, and a total of 3,5 billion TL savings is achieved annually (UAB, 2021).

### *2.3. Türkiye Maritime Investments*

Investments continue at an accelerating pace in order to utilize Türkiye's potential in the seas. In today's world, it is clear that the maritime transportaion and trade have become very important due to the epidemic and economic, social and logistics problems have arisen. The Ministry of Transport and Infrastructure continues to grow and strengthen its investments in the maritime sector in line with Türkiye's National Development Move and the Logistics Master Plan of the Ministry (UAB, 2020) (Fig. 20).



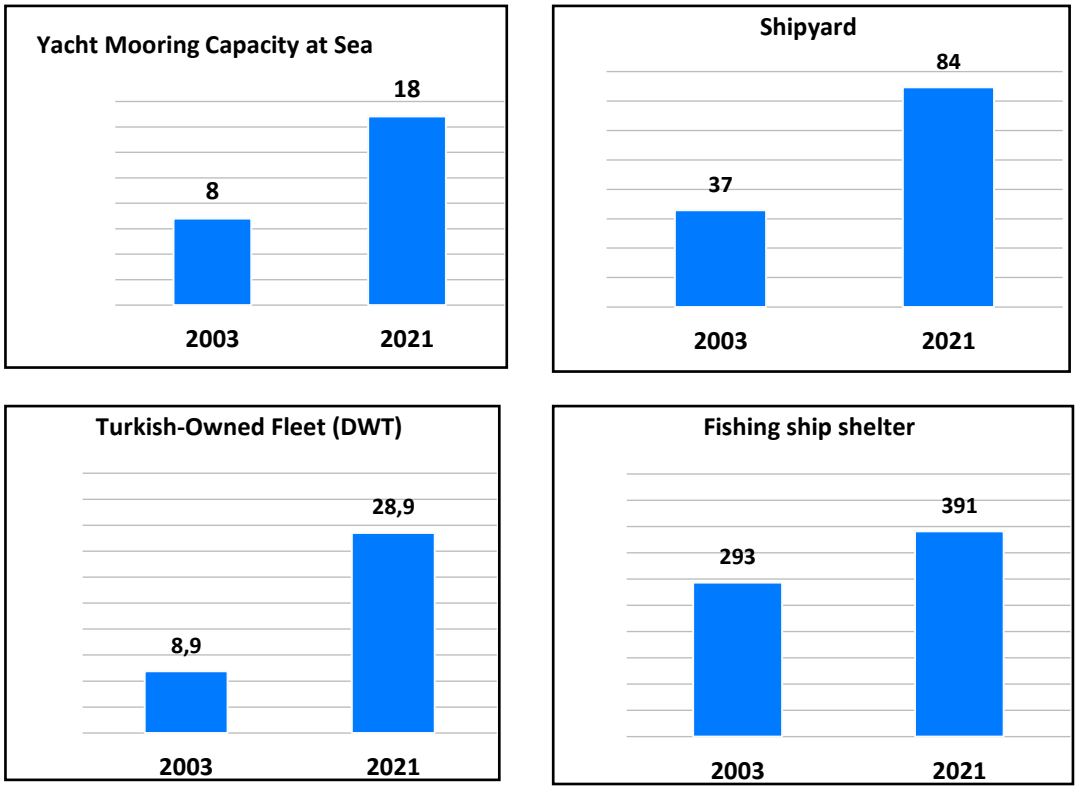



***Figure 12.*** *Investments made in maritime lines between 2003 and 2021 (UAB, 2021)*

- ***Development of Port Facilities***

While there were 149 port facilities in Türkiye in 2000, this number increased by 46% to 217 port facilities as of 2021.In 2000,186 million tons of cargo handled at 149 port facilities. In 2021, 496,6 million tons of cargo handled with an increase of 167% (UAB, 2021) (Fig. 21).

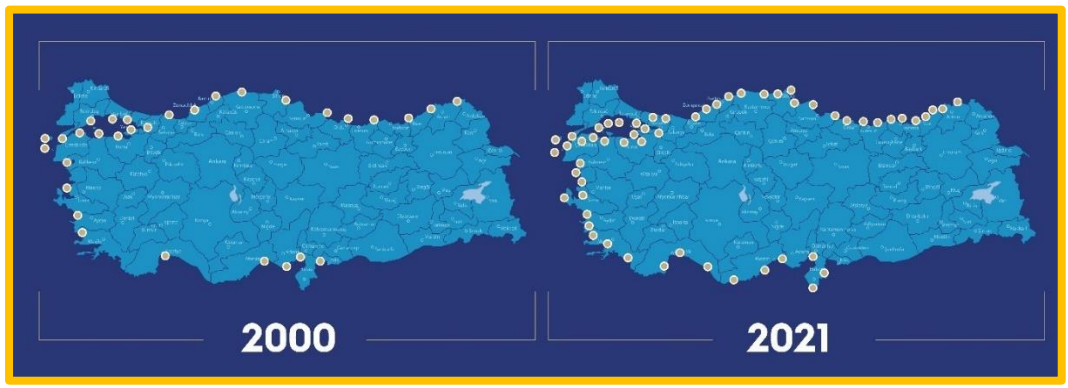


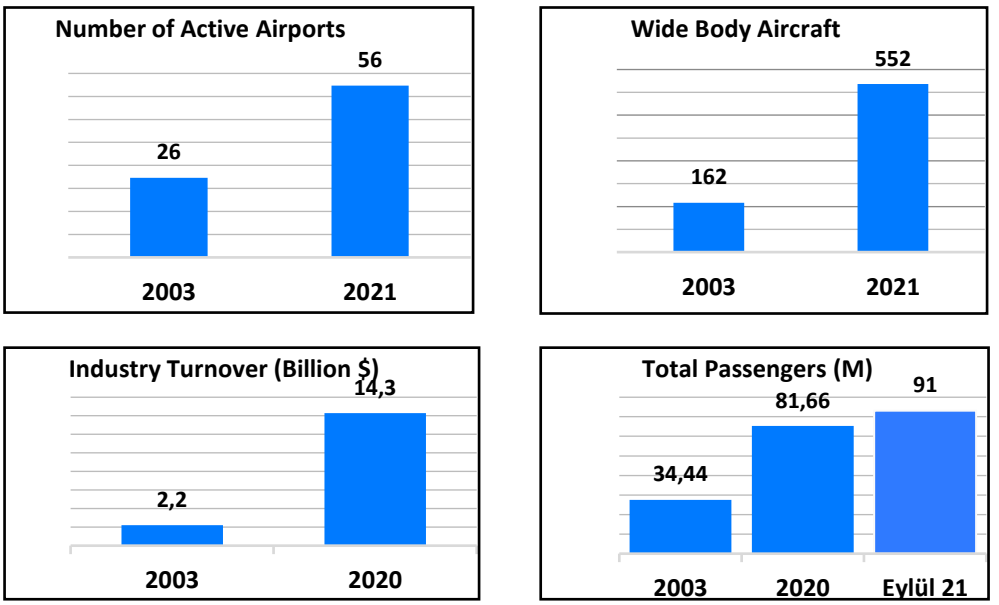

***Figure 13.*** *Development of Ports from 2000 to 2021 (UAB, 2021)*

### *2.4. Türkiye Airline Investments*

In our country, the number of passengers in air transport, which was less than 1 million in the 1960s, exceeded 10 million in 1988, 50 million in 2005, and 100 million in 2010. In 2018, more than 210 million passengers were served at Türkiye airports (Fig. 22).

***Figure 14.*** *Airport status map for the years 2003-202 (UAB, 2021)*

While Türkiye had 26 airports before 2003, 30 more airports were put into service and 5 airports are under construction. The situation, which was 2 centers and 26 locations in 2003, increased to 7 centers and 56 locations in 2021, resulting in an increase of 115% in 18 years (UAB, 2021) (Fig. 23).



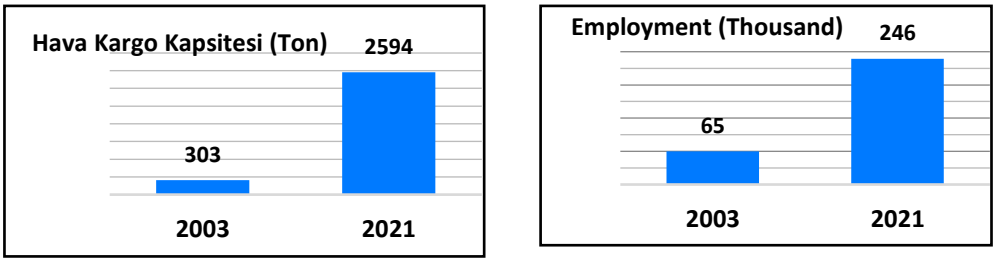



***Figure 23.****Investments made in airlines between 2003 and 2021 (UAB, 2021)*

### *2.5. Türkiye Communication Investments*

- ***Türkiye's Space Studies (1990-2022)***

Space studies in Türkiye failed with the first satellite TÜRKSAT 1A in 1994 and TÜRKSAT 1B became the first communication satellite in the same year and served for 12 years. TÜRKSAT 1C in 1996, TÜRKSAT 2A in 2001, BİLSAT in 2003, TÜRKSAT 3A in 2008, RASAT in 2011, GÖKTÜRK 2 in 2012, TÜRKSAT 4A in 2014, TÜRKSAT 4B (KA band internet service 3 Gigabit) in 2016, GÖKTÜRK 1 in 2016, in 2021, TÜRKSAT 5A (310 east longitude rights) and TÜRKSAT 5B, finally, our 2022 domestic and national satellite TÜRKSAT 6A commissioned (HGM, 2022) (Fig. 24).


***Figure 24.*** *Türkiye space studies (1990-2022) (UAB, 2021)*

- ***Fare Collection System and Fiber Infrastructure***

**Single Card Payment System:** With the design of the Türkiye Cards to be printed within the scope of the Türkiye Card Project, new logos and visuals with the theme of "TRKart, Türkiye Card" were prepared. Thus, the trademarks "TRKART" and "TÜRKİYE KART" were registered. It is planned to issue Türkiye Card-enabled PTT cards, which will be commissioned shortly within the scope of the cooperation between PTT Corp. and the Interbank Card Center, with a payment scheme with the TROY (Türkiye's Payment Method) logo (UAB, 2021)."

**Fiber Infrastructure:** The sector size of the Ministry of Transport and Infrastructure increased by 21% in 2021 compared to the previous year and reached approximately 186,3 billion TL. The number of mobile subscribers increased from 27,9 million in 2003 to 84,6 million. Thanks to advanced infrastructures, the number of subscribers benefiting from the 4.5G service has exceeded 75 million. The number of broadband subscribers, which was tens of thousands in 2003, reached 85,7 million in 2021. In addition, our fiber length, which

was approximately 81 thousand km in 2002, has increased to 434 thousand km in 2021 (HGM, 2022) (Fig. 25).

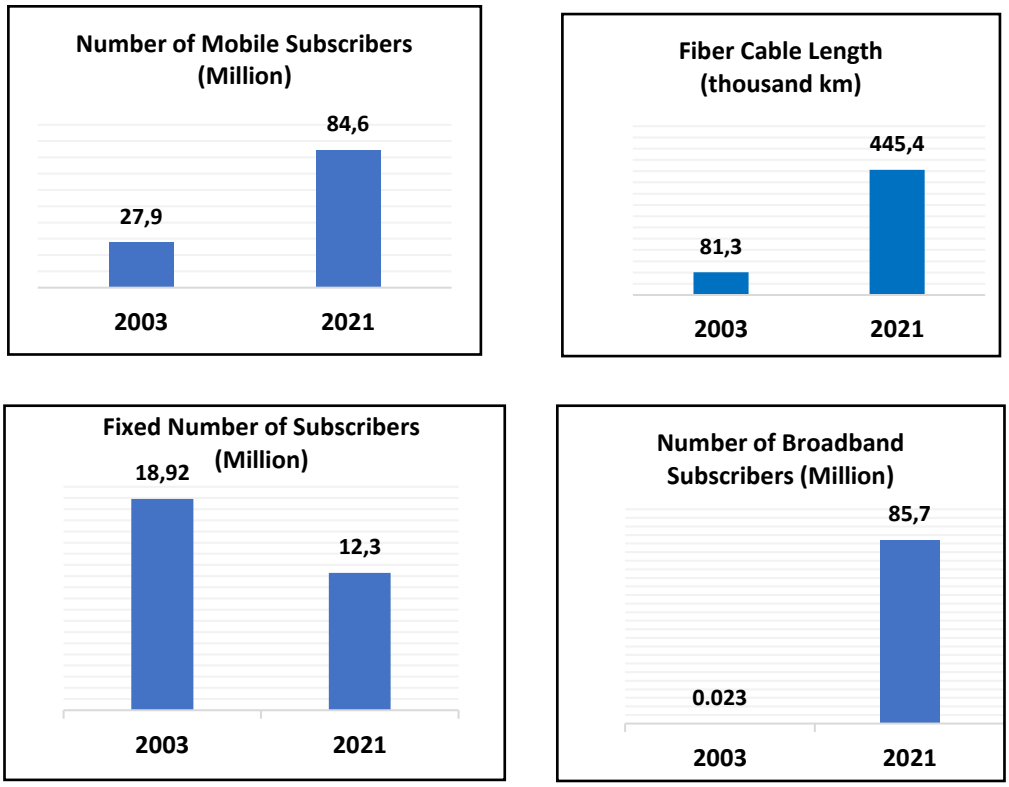



***Figure 25.*** *Number of mobile, fixed and broadband subscribers and fiber cable length (UAB, 2021)*

### *2.6. General evaluation of transportation investments*

When transportation systems are compared in general (Fig.26 and Fig.27);

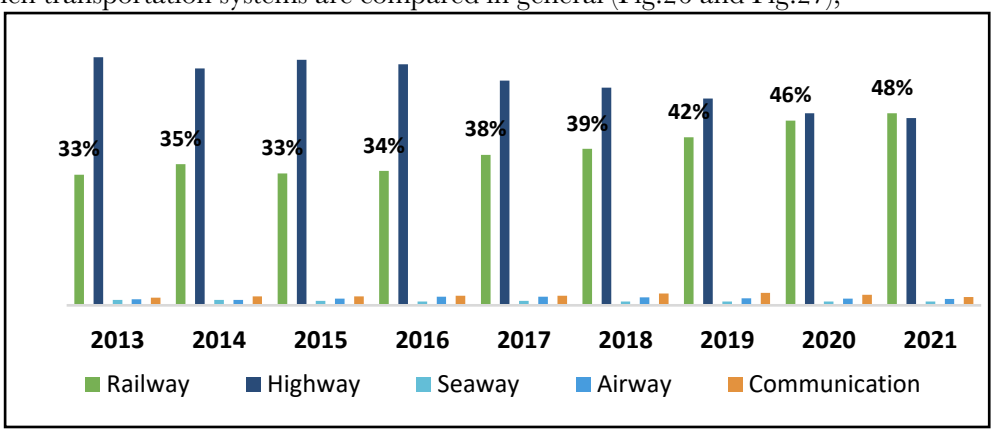



***Figure 26.*** *Distribution of investments by the Ministry of Transport and Infrastructure by years (UAB, 2021)*

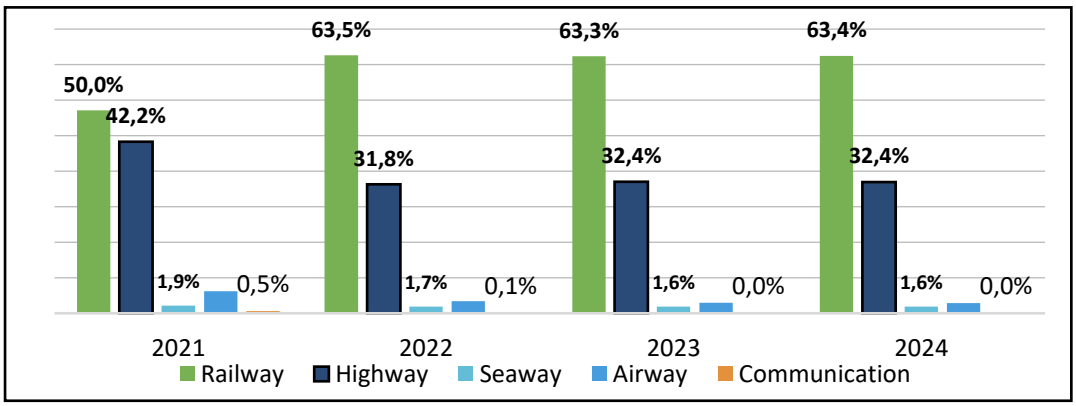



***Figure 27.*** *Distribution of the investments of the Ministry of Transport and Infrastructure for next years (UAB, 2021)*

While the Highway and Railway investments are in the first two ranks and around 90% between 2013-2022 period in the investments planned for the 2021-2024 period, reverse Railway and Highway investments are in the first two ranks and around 95%. Air and Seaway investments are almost negligible (UAB, 2021).

## 3. ITS And C-ITS Investment Targets

### *3.1. Intelligent Transportation Systems (ITS) Goals*

ITS are advanced applications that provide innovative services for traffic management in different modes of transport, enable safer, more coordinated and smarter use of transport networks, and better inform various users (European Union, 2011). ITS uses information and communication technologies, control systems and other up-to-date systems and technologies to provide real-time, precise, efficient transportation control and management. In this way, ITS offers the necessary communication, applications and services between transportation and all factors (road, infrastructure, vehicle, user) included in transportation to the service of users (UAB,2021). ITS targets are given in the table below (Table 4).

***Table 4.*** *Intelligent Transportation Systems (ITS) Goals*

| | |
|---|---|
| Increasing safety in transportation | Reduction of loss of life and property |
| Ensuring interoperability and integration | Increasing the use of public transport in transportation |
| Increasing mobility | Reducing carbon emissions |
| Ensuring environmental benefits | Reducing traffic congestion |

With C-ITS, vehicle-vehicle and vehicle-infrastructure communication will be provided with communication devices placed in the vehicle and on the roadside, informing the drivers about all the incidents occurring on the road and ensuring a safe and comfortable journey. In addition, thanks to the developing communication technologies, drivers will be informed about ambulances, police and similar vehicles with priority of crossing and the response to incidents occurring on the highway will be faster (UAB, 2021).

C-ITS, which has just been tested in our country, is a work on the agenda with the creation of test corridors and the development of driverless / connected vehicle applications,

especially in European Union countries (UAB, 2021). In this context, project studies have started under the coordination of the General Directorate of Communications and the General Directorate of Highways, and as a result, the following studies are planned to be carried out (Yılmaz, A., 2022) (Fig. 28).

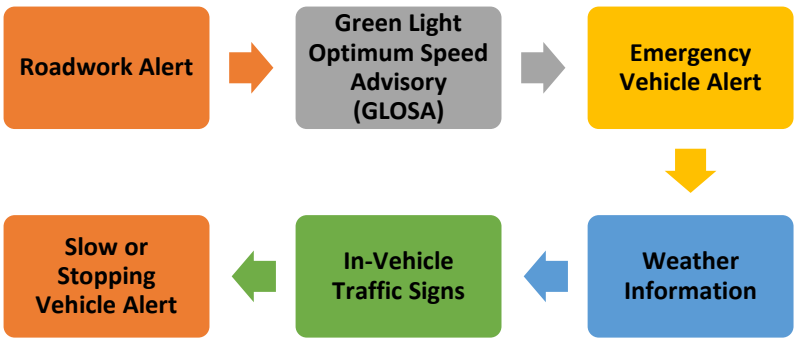



***Figure 28.*** *C-ITS testing and implementation corridor establishment studies (HGM, 2022)*

## 4. Saving Effect of Transportation Investments

In the distribution of the Ministry of Transport and Infrastructure's total investments of 1 trillion 131 billion 400 million, the highway takes the largest share with 61%, 691.7 billion TL, the railway with a 20% share of 220.7 billion TL, the third place by 10%, the fourth with 8%. communication with and finally by sea with 1% (UAB, 2021) (Table 5).

***Table 5.*** *The Saving Effect of Investments between 2003-2020*

| | | **Investment Amount 2003-2020 (Billion USD)** | **Annual Savings 2020 (Billion USD)** |
|---|---|---|---|
| Highway | Highway<br>Split path<br>Other Highways | 105,1 | 7,01 |
| Railway | HST<br>Urban lines<br>Conventional train lines<br>Logistics centers | 31,9 | 0,77 |
| Airline | Airports and related investments | 15,1 | 2,67 |
| Maritime | Marinas<br>Fishing shelters and rickshaws<br>Freight ports | 1,9 | 0,22 |
| Communication | PTT investments<br>Türksat investments<br>HGM investments<br>Türk Telekom investments | 15,2 | 3,48 |
| **Total** | | **169,2** | **14,15** |

*Source: (UAB, 2021)*

**When the savings are examined;**

- $2,8 billion in time savings,
- $3 billion in vehicle maintenance savings,
- $1,2 billion in fuel savings,
- 12,353 lives have been saved due to reductions in accidents.
- Environmental benefits;
- $20 million worth of paper savings
- $CO_2$ emissions savings of $10,3 million
- Savings on travel and accommodation expenses spent on public transactions

Approximately $1,8 billion in public employee productivity was saved as a result of reduced time spent by public servants in public affairs. The effect of all savings made between 2003 and 2020 is given in the table below (Table 6).

***Table 6.*** *The full impact of savings made between 2003-2020*

| | | **Investment Amount** | **GDP Effects** | **Production Effects** | **Employment Impacts** |
|---|---|---|---|---|---|
| | | **2003-2020 (Billion $)** | **2003-2020 (Billion $)** | **2003-2020 (Billion $)** | **2003-2020 Average thousand people per year** |
| Highway | Highway<br>Split path<br>Other Highways | 105,1 | 103 | 225,5 | 215 |
| Railway | TOTAL<br>Urban lines<br>Conventional train lines<br>Logistics centers | 31,9 | 29,2 | 64,5 | 62,5 |
| Airline | Airports and related investments | 15.1 | 144.6 | 330 | 274.7 |
| Maritime | Marinas<br>Fishing shelters and rickshaws<br>Freight ports | 1,9 | 2,5 | 5 | 5.3 |
| Communication | PTT investments<br>Türksat investments<br>HGM investments<br>Türk Telekom investments | 15,2 | 130,4 | 244 | 147,5 |
| **Total** | | **169,2** | **409** | **869** | **703,3** |

*Source: (UAB, 2021)*

The savings effect of all investments made by the Ministry of Transport and Infrastructure, including all public investment and public-private partnerships, contributed 3% to GDP between 2003 and 2020. In addition, employment opportunities were provided to 12,7 million citizens.

## 5. Türkiye Domestic and National Transportation Technology Products

### *5.1. Railway Domestic ITS Technology Products*

The main domestic technologies used in railway transportation; Control Systems, Rail Transportation Systems, Energy Storage Systems, Passenger Information Systems, Driver Information System, Automatic Train Tracking System, Signaling Systems, Traffic Control Center, Concierges System, Traffic Training Simulator, Tunnel lighting and Control Systems, Cer Motor Driver Unit and Digital Universal Telephone System can be listed. These technologies are produced by public (Tubitak Bilgem-Aselsan) and Private enterprise companies that produce them domestically.

***Domestic and National Train***

It is Türkiye's first electric mainline locomotive with TSI certificate, produced with domestic and national resources. It is a new generation locomotive with a minimum power of 5000 kW, AC-AC drive system, TSI certification and a speed of 140 km/ h. Traction System, TKYS, Transformer, APU, Converter Unit, especially, is designed and produced locally and nationally at a high rate. The National Electric Train Set, which is aimed to be exported to European Union countries as of 2023, is designed in TSI standards and its speed has been increased from 160 km/h to 200 km/h. In the future, efforts to accelerate to 225 kilometers per hour continue (TURASAS, 1894).

#### *5.1.1. Railway Domestic ITS Technology Products developed by Aselsan*

- **ASELSAN CESUR- Traction Motor Control/Driver Unit (CMKSB):** It is a new generation traction system component that has been developed for metro and light rail transportation vehicles and is completely national and originally designed to provide highly efficient control of traction motors.
- **ERTMS LEVEL 1&2 Automatic Protection System on Train:** It is based on the ERTMS traffic management system standard accepted in Europe. The system has been designed using the latest technologies and infrastructures. Development activities continue by prioritizing the modularity, long-term availability and reliability of the system.
    - Compliant with European ERTMS railway standards
    - Adaptable to any railway vehicle with its distributed, modular and compact structure
    - SIL4 level for critical functions
    - Less failure rate and efficient operation with modern technologies and design
    - Low operating costs with integrated measurement and test infrastructure
    - **Urban Rail Transport Signaling System:** It has been developed based on the Communication Based Train Control technique. Safe, efficient, punctual and high carrying capacity solutions are offered for today's modern and dense urban rail transportation systems.

- Intelligent traffic management on urban railway lines
- Automatic Train Management and driving techniques
- High capacity with moving block technology
- Fast integration to field and on-vehicle equipment with its IP-based and distributed architecture
- SIL4 level in critical components
- Efficient operation of energy and resources with smart applications
- Reducing railway operating costs with integrated measurement and testing infrastructure

- **TR-CMS (Train Control and Management System):** It is a train control and management system suitable for high speed trains, regional trains, EMUs, subways and all light rail vehicles. With its original software, hardware and algorithms, it has a flexible design that will provide high security and meet the requirements of the trains of the future. TR-CMS acts as the brain of the train and provides its central management. It coordinates emergency systems, braking systems, traction systems, power systems, door access systems, lighting, air conditioning, passenger information, in-vehicle and inter-vehicle communication systems.

- **TROBES – Train Energy Storage and Management System:** It is an energy storage and recovery system for rail vehicle systems. It has a modular structure that can be configured with battery and/or super capacitor. Developing battery technologies; It makes it possible to reach longer working hours with faster charging. In this way, it becomes possible to use the trams without a catenary in a more efficient and cost-effective way (ASELSAN,1975).

#### *5.1.2. Railway Domestic ITS Technology Products developed by TUBITAK-BILGEM*

- **Railway Signalling System (RSS):** It is the first Domestic Signaling System of our country in the field of Railway Signaling. Developed with TCDD, pilot applications were carried out.

- **Railway Traffic Control Center (RTCC):** It provides monitoring and control of railway traffic in the railway area in the area of responsibility. It makes it possible for traffic control operators called dispatcher to perform their operational tasks in a safe and easy-to-use environment. The system, ideal traffic control center solution for railway lines with its expansion-open architecture, wide reporting capabilities, user-friendly interfaces and short training requirement.

- **Railway Construction System (RCS):** Thanks to its detailed fault detection feature, system faults can be diagnosed as soon as possible, thus making a significant contribution to the operation of the business. Developed by Turkish engineers, the Railway İnterlocking System has been developed with easily available industrial equipment to meet the need for safe and cost-effective construction of conventional railway lines. With its modular structure, it enables the system to be expanded.

- **Rail Transportation Traffic Training Simulator (RAYTES)-BTE:** It is an education system in which newly appointed or currently working Traffic Controllers can receive vocational training in the Traffic Control Centers of the State Railways of the Republic of Türkiye (TCDD).

All components within the scope of the project have been developed by TUBITAK BILGEM. Thanks to this system, Traffic Controllers receive their vocational training in a real-life and safe environment (Tübitak Bilgem, 2022).

- **Local and National Tramway:** National and local tram *İpekböceği* was produced with the cooperation of Bursa municipality and Durmalar Machinery. Style design, Steel construction design, Chassis system design and Electrification design, including mechanical parts and digital technologies, were completed entirely by Turkish engineers using 60% domestic materials developed by Durmazlar Machinery. Finally, the original traction systems developed by Aselsan were also used in the tram, increasing the domestic contribution rate. The trams produced, which have completed the 30-year life test, have been tested and approved in international standards, come to the fore with their low energy consumption, quiet, environmentally friendly and safe design (Durma A.Ş., 1956) (KARSAN, 1966).

### *5.2. Civil Aviation ITS Technologies*

- **Aircraft Tracking System :** It is the Route/Route Tracking System of Aircraft. The Aircraft Tracker periodically sent the aircraft's location, speed and altitude information to the Aircraft Tracking Center, and the aircraft's positions on the map are updated in accordance with the incoming location data (Tübitak Bilgem, 2022).
- **Aircraft Tracker:** It is an Aircraft Tracker tool and developed together by TUBITAK BILGEM and the State Airports Administration (DHMI), has internal and external impact sensors for automatic emergency notification. It has a key on it for manual emergency notification. Warning lights provide the pilot with visual feedback for emergency and in-device test results (Tübitak Bilgem, 2022).
- **atcTRsim / ATC Tower and Radar Simulator (atcTRsim):** It is the National Air Traffic Control Simulator. The atcTRsim system, which has the title of the first national Air Traffic Control Simulator, includes the Approach/Road Control Radar Simulator and Challenge Control Simulator with 360-degree visuals. Simulators can also work as peers. In the project, to which HAVELSAN contributed with its technological infrastructure and experience in the field of simulators, the Airfield Control Simulator with 360-degree rear projection started to be used for the first time in Türkiye (Tübitak Bilgem, 2022).
- **Air Traffic Controller Selection Software (ATCES):** Air Traffic Controller Selection Software. ATCSES was developed in conscording with TUBITAK BILGEM and The State Airports Administration (DHMI). The capabilities required to be present in air traffic controllers (reflex, 3D thinking, quick decision making, memory, attention, etc.) are safely tested electronically. 17 test applications and 1 person test have been developed to measure 9 different capabilities (Tübitak Bilgem, 2022).
- **Bird Detection Radar (KUSRAD):** KUŞRAD- Bird Detection Radar system. KUŞRAD was developed together with TÜBİTAK BİLGEM and State Airports Authority (DHMİ). The system, which operates 24 hours a day, can detect moving birds, flocks of birds and aircraft targets in an area within a 40 km radius, and can extract distance, altitude, direction, speed and route information (Tübitak Bilgem, 2022).

- **Fod Detection System (FODRAD):** It is an alarm system that detects the remnants of foreign matter (FOD) on the runway at airports. It is an mm-wave radar system that alerts the operator after detection and provides real-time representation of the position of the residue on the runway and the camera image (Tübitak Bilgem, 2022).
- **National Surveillance Radar (MGR):** Simultaneously, with advanced digital signal processing methods, aircraft within a range of 60 nautical miles are detected and tracked in different weather conditions (Tübitak Bilgem, 2022).
- **Radar Testing Software (ASTERIXCARE):** It is the software that tests the accuracy of radar data. AsterixCARE, developed together by TUBITAK BILGEM and the State Airports Administration (DHMI), is a powerful and expandable application that can be used for testing, analyzing and verifying radar data (Tübitak Bilgem, 2022).

### *5.3. Highway Domestic ITS Technology Products*

#### *5.3.1. Traffic Management and Control Domestic ITS Technology Products*

***Table 7.*** *Traffic Management and Control Majors of Domestic ITS Technology Products*

| **Vehicle Tally System** | **Electronic Inspection Systems** |
|---|---|
| License Plate Recognition System | Traffic density and analysis |
| Red Light Violation Detection System | Bus-Stop Passenger Information System |
| Parking Violation Detection System | Deep Learning Based Contact & Passenger Counting Systems |
| Corridor Speed Violation Detection System | Fleet Management System |
| Dynamic İntersection Management System | Vehicle Telemetry System |

*Source: (Asis Elektronik, 2018; ISSD, 2009; İSBAK, 1986;ONUR, 1980).*

#### *5.3.2. İBB & İSBAK Domestic Its Solutions and Applications*

Istanbul Metropolitan Municipality launched domestic ITS technologies in 2004 through its subsidiary ISBAK A.Ş. Some of these applications' density map, green wave, smart stop, Mobese etc. These applications have led metropolitan municipalities and other municipalities both in Istanbul and throughout Türkiye towards domestic ITS technologies. Today, hundreds of private sector companies that produce ITS technology solutions have been established and produce solutions to the transportation problems of local governments. We know that all municipalities use at least one of these solutions. Istanbul, Ankara, Bursa, Izmir, Gaziantep, Konya, Antalya, Kocaeli, Hatay, Kayseri, Adana, Eskisehir, Denizli, Manisa, Kahramanmaraş are among the metropolitan municipalities that use ITS domestic technologies the most. In addition, our other municipalities bring a new domestic ITS technology to their cities every day.

**Traffic Management Systems**

- Traffic Signal Controller ExpertraTM2A9
- ExpertraTM2A9 Central İntersection Management Software

Traffic Signal Lights

- Traffic Signal Lamp with LightraTM LED
- Traffic Signal Lamp with LightraTM Power LED

Pedestrian Buttons

- PedestraTM Zero Energy Pedestrian Button: Provides pedestrian safety at Signalized Intersections.
- PedestraTM Accessible Pedestrian Button: Reduces carbon emissions with low energy consumption.

**Electronic Inspection Systems**

**EDS 3.0 Central Software:** With EDS 3.0 center software, 13 separate breach detection systems can be managed with cloud technology from a single center and can operate in harmony with all communication systems. Türkiye's leading domestic traffic violation inspection and detection software certified by international standards and accredited organizations.

Modules in EDS 3.0 Central Software

- Average Speed EDS Software Module
- Red Light EDS Software Module
- Safety Strip EDS Software Module
- Park EDS Software Module
- Crosswalk EDS Software Module
- Offset Scanning EDS Software Module
- Reverse EDS Software Module
- Scanning Area EDS Software Module
- TramWay EDS Software Module
- Return Ban EDS Software Module
- Mobile EDS Software Module
- Instant Speed EDS Software Module
- Gabari EDS Software Module

**Traffic Measurement & Information System Solutions**

- Variable Message System (VMS)
- Variable Traffic Signs (VTS)

- Semi-Dynamic System (SDS)
- Speed Warning System (SWS)
- Parking Information Screen (PIS)

**Public Transportation Systems Solutions**

- Passenger Information: Information Contact Point-BilgiLED
- Platform Separator Systems
- In-Car Camera System

**Central Management Solutions**

They are management centers that combine separate management platforms and smart city services, classifying them according to their severity and providing quick and easy access to critical data.

- Transportation Management Center
- Public Transportation Control and Management Center
- Traffic Control Center
- Electronic Inspection System Center
- Disaster Management Center (AKOM)
- Tunnel Management Center
- Parking Management Center
- Rail Systems Management Center
- Environmental Management Center

**Smart City Management Software (SCM)**

- Taxi Overhead Lamp (temperature, humidity, air quality, noise level...) measuring system
- Fleet Management System Solution

It provides safety and manageability in transportation with technological solutions with fleet

**Management System Software:** It uses all management system applications.

**Fleet Management Center Software:** It helps monitor and inspect Public Transportation Vehicle Fleets.

**Lighting Systems**

- Intelligent Lighting Control System Software:
- Road Lighting Fixtures
- Tunnel Lighting Fixtures
- General Purpose Projector

**Smart Parking Management Systems**

- Pricing Systems
- Closed Parking Vehicle Detection and Steering Systems
- Outdoor Car Parking Vehicle Detection and Steering Systems
- Parking Management Software

### *5.3.3. Ground Access-Its Products Developed By Ibb And Ibb-Affiliates*

- Public Transportation Inspection System (TUDES)
- Transportation Assistant
- License Inspection System
- Service Route and Public Transportation System
- IBB MobileTrafik Application
- Istanbul Your App (Roof software that combines smart urbanization application)
- Where's My Bus App
- İspark Parking Application
- Istanbulkart - My Digital Card
- IBB Deniz Taxi (Sea Taxi Rental Application)
- Istanbul City Map (Smart urbanization app)
- Isbike (Bicycle Rental Application)
- Mobiett (Smart Stop App)
- iTaksi (Taxi Rental App)
- Metro Istanbul
- I-service (Service Management and Reservation Program)
- Walk & Discover

### *5.3.4. ASELSAN Domestic Its Technologıes*

- **Traffic Management System:** Traffic Management Systems developed by ASELSAN, in order to use the roads more effectively and to prevent traffic accidents, event detection, weather/road condition measurement, measurement of traffic data, intersection attendance control, assenger information/direction, ıt performs video management functions.
- **Automation Systems:** Within the scope of automation systems, vehicle and license plate recognition systems, advanced agricultural automation system, disaster and emergency management systems, developed and put into service.

- **Intelligent Intersection Controller - H64**
- **Variable Message Signs - DMI**

Applications are also available (ASELSAN, 1975). There are hundreds of private sector and Technopolis companies such as INTETRA, ORTANA, EMAY engineering, ASIAN traffic, etc. that produce similar domestic technologies or make projects (INTETRA, 2005; ORTANA, 1992; EMAY, 1980; Asian Traffic, 2011).

#### *5.3.5. TUNNEL Security Technologies*

In addition to being able to detect unexpected situations in tunnels, it measures and reports vehicle density and the number of vehicles passing through. Unexpected situations in tunnels are as below (Table 8).

***Table 8.*** *Unexpected Situations for Event Detection Systems*

| **Standing Vehicle Detection** | **Pedestrian Detection** |
|---|---|
| Smoke Detection | Reverse Vehicle Detection |
| Suspicious Package Detection on the Road | Vehicles Passed |
| Fast/Slow Vehicle Detection | Instant Density Information |
| Vehicle Traffic Density Measurement | |

### Avrasya Tunnel

In cooperation with CBOT and Eurasia Tunnel, a new AI-based virtual assistant project was signed to serve 24/7. "Eurasia Tunnel 24/7", the first domestic chatbot based on Artificial Intelligence in the sector developed in collabration considential with CBOT, in addition to answering questions about the use of the tunnel; The Eurasia Tunnel is automatically monitored 24/7 with more than 400 cameras. Unusual situations detected by the event detection system are intervened by teams in a few minutes. The response time in a car accident is less than 2 minutes on average. In this sense, the Eurasia Tunnel, one of the most advanced tunnels in the world, has won many of the most prestigious awards in the world (Avrasya Tüneli, 2022).

#### *5.3.6. Domestic ITS Technologies in Highways and Bridges*

### Kuzey Marmara Highway (KMO)

- **TECHNOPC BOX PC Solution:** By using the BOX PC model in the Northern Marmara Highway Rapid Transit System, it provides a performance success of over 99% on multi-lane roads with a single camera. Technopc's Industrial BOX PC model, which has the first domestic product certificate in computer production in Türkiye, is used in the Rapid Transit Systems (HGS) of the giant project of 398 kilometers that will ease the traffic in Istanbul. It reads the license plates of the vehicles passing through the system, receives the information and transfers it to the payment system (Kuzey Marmara Otoyol İşletmesi, 2022).
- **Fiber Optic Based Acoustic Detection System (FOTAS):** KMO provides service in two different locations, between Silivri-Kınalı intersection and Eyüp-

Odayeri on the European side, and between Pendik-Kurnaköy and Akyazı on the Anatolian side. With the Yavuz Sultan Selim Bridge and Istanbul Airport connection roads, and a 400-kilometer highway route in total, the traffic over the Bosphorus crossing capacities is decreasing. KMO, which has the widest 4-lane tunnels in the world, has started the new project in cooperation with TUBITAK, which will ensure highway safety and provide immediate and effective response service in an event that may occur on the road. The project, which will be the world's and Türkiye's first fiber optic and artificial intelligence-based education system, is planned to be completed in 2022. With this project, TÜBİTAK BİLGEM (Information and Information Security Advanced Technologies Research Center) aimed to instantly detect and describe the incident that occurred on the highway using a fiber optic detection system and autonomous drone.The project implementation is in two stages.The first stage is to detect anomalies in ground vibrations using fiber optic sensors, and the second stage is to send drones to the region where the anomaly is detected and activate it.Information and images collected by drones during monitoring are sent to the station assigned or closest to take necessary actions. Thanks to Artificial Intelligence, the project can evaluate different scenarios instantly, and the details and size of the events can be easily analyzed. The Fiber Optic Based Acoustic Detection System (FOTAS), which emerged with the collaboration of TÜBİTAK BİLGEM and SAMM Technology, using a number of technologies such as laser, fiber optics, electronics, signal processing, and Artificial Intelligence, is a domestic and national product and FOTAS is a system used for the first time in the world (Bilgem, 2022).

**1915 Çanakkale Bridge**

Malkara-Çanakkale Highway and Çanakkale Bridge have become one of the most important suspension bridges in the world in this area equipped with Smart Transportation Systems. Within the scope of the project, 225 thousand 250 meters long fiber optic communication infrastructure, 34 variable message signs, 62 event detection camera systems, 6 meteorological measuring stations, 1 disaster recovery center and 1 emergency call system were equipped within the scope of ITS infrastructure. The risks of fog, icing and accidents are monitored with Artificial Intelligence on a 24/7 basis in control centers. With the LED highway lighting system implemented for the first time in Türkiye, approximately 3 million 530 thousand kilowatt-hours of energy will be saved annually compared to other systems. In this way, 300 tons of carbon emissions will be prevented. As a result, this giant work, which is largely human and environmentally friendly, using domestic ITS technologies, will save 382 million euros annually, 31 million euros in fuel consumption and 1 billion 900,000 euros environmentally with a reduction in carbon emissions equivalent to 3,234 trees. Thus, the total amount of savings will reach 415 million euros annually. With the opening of the project 1,5 years earlier than expected, the contribution of 628 million euros to the country's economy, its impact on gross national product was 2 billion 442 million euros, its impact on production was 5 billion 362 million euros, its impact on employment was 118 thousand people (1915 Çanakkale, 2022).

#### *5.3.7. ITS Fee Collection Systems*

**AKİS TICKET / e-Payment and Ticket App and Ospt Cipurse Based Smart Card:** AKiS BiLET is CIPURSE1-based, contactless smart card technology working on a nationally developed smart card operating system (AKİS) by OSPT Alliance member TUBITAK BILGEM. AKiS BiLET is specifically designed to be used as a payment tool in electronic fare collection systems in the transportation area due to the advanced security infrastructure it provides, low costs and clear standards. It is also the first domestic smart card solution in the areas of contactless card applications such as access authorization control and parking systems. Applies to all modes of transport.

**ASELSAN Fare Collection Systems (FCS):** It is designed with the most advanced technologies to be used in the pricing of bridges, highways, tunnels and similar infrastructures. OGS, KGS and cash systems established by ASELSAN, which is one of the sector leader in Türkiye, are compatible with the standards of other countries, especially the EU. FCS is suitable for open (distance-independent) toll collection methods for bridges, tunnels, and closed (distance-dependent) toll collection methods as for highways.

### *5.4. Domestic and National Vehicles and Technologies*

#### *5.4.1. Türkiye Domestic and National Vehicles*

**Türkiye's Automobile Enterprise Group** (**Togg):** According to the data of the Ministry of Industry and Technology, the domestic rate of passenger cars in our country varies between 19,6% and 66,3%.In Togg, whose intellectual and industrial property rights are "independent and free", whose intellectual and industrial property rights belong to 100% of Türkiye.it is aimed that the domestic rate will start with 51% in the first model and will increase to 68% in the next model to be released in 2026. Togg will establish a total of 1000 charging stations within 12 months in order to create smart and fast charging services.75% of the total 101 suppliers are local, of which the majority are from TAYSAD (Automotive Suppliers Assocation of Türkiye) member organizations and 25% are from all over the world. Togg and Farasis have made a partnership agreement hich name SİRO to meet their battery needs. According to this agreement, 15 gigawatt-hour battery cells and modules will be produced under the Siro partnership. With this investment, 2 thousand 200 people will be employed, 400 of which will be qualified. In order to produce the Togg vehicle, the paint, body and assembly facilities of the Gemlik factory have reached the completion stage as of April 2022 (Ekonomist, 2022).

**Electric and Autonomous Domestic Buses, Metrobuses and Trucks:** Bozankaya, Temsa, Karsan, Otokar, BMC and Anadolu Isuzu are companies that produce domestic buses. Bozankaya electric buses are produced in Karsan factory within the framework of cooperation with Karsan. Karsan Exporting to Romania, France, Germany, Portugal, Spain, Norway and America, Karsan exported 133 electric vehicles in 2021.

More than 250 electric vehicles of Karsan serve on the roads in Europe. One of the first fully autonomous buses of Europe and America has been prepared and it serves in Romania and Michigan State University in America.

- In Norway, the autonomous e-ATAK bus will carry passengers within the city for the first time in the world (Green Logistics, 2021).
- F-MAX (Türkiye's First Domestic and National Gearbox, 2021) which is the first truck to use domestic and national gearboxes and its domesticity rate exceeds 90%.

- The domestic metrobus with a capacity of 290 people, produced for the first time in Türkiye in Bursa, is also a first with its 25 meters length and 3 articulations (AKIA, 2013).
- Avenue EV, a 100% domestic electric bus developed in cooperation with TEMSA-ASELSAN (Domestic Bus to be Produced by Aselsan and Temsa, 2021).

#### *5.4.2. Domestic and National Vehicle Technologies*

**Batteries and Chargers Technologies**

ASPİLSAN Energy is a local company producing domestic technology products described below, which is owned by the Foundation for strengthening the Turkish Armed Forces with a 98% stake;

- All Kinds of Ni-Cd, Ni-MH, Li-Ion, Li-Po Batteries and Batteries
- Solar Cell, Heat Cell and Fuel Cell
- Renewable Energy
- Energy Storage Systems
- Chargers
- Battery/Battery Laboratory Testing Systems
- Nickel Cadmium Complete Aircraft Batteries and Cells

all electric vehicles, e-Bicycle, e-Scooter.

Ministry of Energy as the latest news; The study for the first domestic and national lithium battery produced from boron waste was characterized by ASPİLSAN Energy and tested in lithium battery cells (2022), and it passed the test successfully. At the ETİ Maden Lithium Production Facility, it is planned to produce 10 tons per year in the first phase. When the facility comes into operation at full capacity, an annual production of 600 tons is targeted. Produced lithium batteries will be used in domestic automobile Togg, phones, tablets, computers, stations and electrical tools (ASPİLSAN, 1980).

**ASELSAN High Voltage Power Distribution Unit (HVPDU-B):** ASELSAN High Voltage Power Distribution Unit (HVPDU-B) is a unit with different configuration options designed for system-specific power distribution needs. It is designed to meet the needs of medium and heavy class hybrid and electric vehicles such as electric buses and electric garbage trucks (ASELSAN, 1975).

**OPTRAC-610:** ASELSAN OPTRAC-610 Motor Driver Unit is the medium and low power member of the OPTRAC motor driver series. It provides functional safety by combining intelligent control functions with motor control and high performance. It addresses the need for driver units in low andmiddle class electric/hybrid vehicles (ASELSAN, 1975).

**OPTRAC-625:** ASELSAN OPTRAC-625 Motor Driver Unit is the medium-power and multi-phase member of the OPTRAC motor driver series. It also provides functional safety by combining intelligent control functions with motor control and high performance. It addresses the need for driver units in medium and heavy class electric/hybrid vehicles (ASELSAN, 1975).

**Driver Dashboard:** ASELSAN Driver Instrument Panel provides the driver in the electric vehicle; It reports speed, battery status, recovery information and warning signs. It complies with international standards, can be easily mounted on an electric vehicle and can be freely programmed with software (ASELSAN, 1975).

**TCDD move for Indigenous E-Scooter in Micro Mobility:** Micro Mobility Common Sense Meeting was held with the participation of electric scooter companies and public authorities in coordination with the Ministry of Transport and Infrastructure. At the meeting, the principles for the legal regulation of electric scooters were determined. At this meeting, TCDD announced that it has started work on the production of electric scooters. For now, TCDD receives services from domestic initiatives and will serve in train stations in the first place and carry out Skuter production, which will be called "Çuf Çuf".

### *5.5. Seaway Domestic ITS Technology Products*

**Traction System for Marine Vehicles:** ASELSAN produces system solutions for both surface and underwater marine vehicles with its electric traction system products of different powers. Considering the technical features, the electric motors and frequency converters, which will be the most advanced members of the ASELSAN electric traction systems family, are designed to support the national ships of the Naval Forces Command (ASELSAN, 1975).

**LEVENT Unmanned Surface Marine Vehicle:** LEVENT Unmanned Surface Marine Vehicle can be used in different tasks such as reconnaissance-surveillance, emergency response and communication relay, thanks to its modular design consisting of different payloads. With its autonomous navigation and remote command capabilities, the system operates safely at speeds up to 30 knots, even beyond the line of sight (horizon). The modular system units are designed to be easily mounted on the existing boats in the inventory (ASELSAN, 1975). Made an agreement with HAVELSAN in 2018 (MarineDealNews, 2019; HAVELSAN, 1982).

**Marine Pollution Detection Project:** The project, realized with the scientific support of Istanbul Technical University Turkish Straits Maritime Application and Research Center, aims to detect pollution from ships using remote sensing technologies and to protect the marine environment, coastline and human health in the Bosphorus. The remote monitoring system used for the project was installed on a bridge, Yavuz Sultan Selim Bridge, for the first time in the world, and started to be used. Contribution of the Project

- The type, spread and dimensions of the pollution can be predicted.
- Consequences and effects of pollution can be analyzed
- Sustainable protection will be provided for the people of the region, the marine environment and the coastline.
- As an exemplary application model, it can be recommended to the Turkish Straits and the country's coastline.
- The dynamic data to be obtained will contribute to scientific studies (ICA, 2016).

**Integration into the International Digital System:** General Directorate of Coastal Safety (KEGM) made an agreement with HAVELSAN to be delivered in 2023 for integration into the international digital system where all international maritime traffic can

be tracked, ship, cargo and route recognition and planning can be made (Coastal Safety Directorate integrates into the international digital system, 2019; HAVELSAN, 1982).

### *5.6. Technology Development Zones (TGB)*

According to the December 2021 data of the Ministry of Industry and Technology of T.C. Ministry of Industry and Technology, the number of TGB regions announced in Türkiye has reached 92. While 73 of these regions are actively operating, 19 of them are still under construction. The total number of companies operating in technology development regions and carrying out R&D studies has reached 7,331 and 75,657 personnel are employed in these companies. 1,542 companies operating in technology development regions are companies established by academicians or partnered by academicians. The number of projects finished so far in technology development zones reached 43,527 and the number of projects studied reached 12,131 (Teknoloji Geliştirme Bölgeleri Derneği, 2010).With multidisciplinary structure in these technocities Intelligent Transportation Systems (Software, Ar-Ge, Start-Up) more than half of companies and projects (ISSD, 2009; AYESAŞ, 1990; ORTEM, 1998; FORDOTOSAN, 1928; BİLTİR, 1992).

**Examples of Technopolis Companies Producing ITS Technology**

- **ISSD:** Still continuing its activities in its offices in METU Technopolis, ISSD develops market-leading products by producing solutions in traffic management and traffic control. Dynamic İntersection Management System, CHAOS, developed by ISSD, is actively used in approximately 750 points throughout our country and in 6 countries around the world (ISSD, 2009).
- **Parabol:** Parabol, another company in METU Technopolis, has been operating in the smart mobility sector with its mobility management and analysis solutions since 2011, producing solutions that touch the lives of millions of people in 10 countries and 40 cities (PARABOL, 2011).
- **ITU ARI Technopolis : GA Hub Programme:** With the IGA Hub Program, implemented by ITU Seed as part of the cooperation between IGA Istanbul Airport and ITU ARI Technopolis, it is aimed to support entrepreneurs in the field of Civil Aviation and Airport Management.Within the scope of Civil Aviation and Airport Management; While technological and commercializable initiatives in areas such as smart airport, robotics, sustainability, digitalization, IoT, security, and mobility are supported, IGA's opportunities such as network, office and mentorship meet with entrepreneurs (Arıteknokent, 2003).

Apart from these, dozens of technoparks companies are working on one or more applications of ITS technologies. TGBD can be examined for all the details about technoparks (TGBD, 2022).

## 6. Conclusions

ITS is a set of systems that include human and environmentally friendly practices that reduce the negative effects of increased mobility and accelerate mobility, support sustainable transportation, shorten travel times, maximize traffic safety, reduce congestion, reduce fuel consumption, and ensure sustainable development of energy efficiency. In this sense, it is obvious how important, valuable, and interdisciplinary ITS is. Although devices that allow monitoring traffic density, predicting weather and road conditions, traffic cameras and variable message boards (VMS) used on the roads are only a few of the devices

used in ITS, our country imports these from abroad and incorporates them into the ecosystem. This is a very costly business for our country. Instead, enabling the production of ITS devices in our country will close the foreign trade deficit and increasing its use will contribute significantly to domestic production. In addition, ITS will significantly contribute to the country's economy by increasing employment opportunities, reducing the unemployment rate and reducing infrastructure costs. In this sense, there are remarkable developments in our country in the Defense Industry. Our National Defense Industry advancements can also be achieved in ITS with the domestic production incentives thereby improving the nationalization. In addition, cooperation and communication between public institutions, universities, non-governmental organizations and private sector companies operating on the ITS can be improved.by supporting R&D studies providing incentive support to encourage domestic production. It is essential to fulfill government incentives and support patent services in order not to fall behind in international competition in ITS with countries such as America, England, Korea, Germany, and Japan.

In a rapidly digitalizing world, facilitating and fulfilling data sharing to ensure the integration and cooperation of ITS stakeholders are of great importance. Therefore, providing and maintaining data sharing by institutions providing services in this field can be encouraged by law.

The implementation of the ITS Architecture, defined in the ITS strategy document and action plans, by the relevant institutions is the basis of the development of this field in our country for the future. Promotional films are one of the essential ways to increase awareness of ITS among younger generations through national television channels and social media.

When Türkiye transportation investments are evaluated together with ITS province, it is vital to realize recommandations below.

**1.** Increasing awareness of ITS, increasing cooperation and incentives with local governments to spread applications across the country, investing in additional ITS and C-ITS technology in transportation infrastructure, and updating relevant legislation.

**2.** Activities aimed at increasing the opportunities for harmonious and efficient cooperation between NGOs (ITS Türkiye, Union of Municipalities of Türkiye, Automotive Industry Association, etc.), Private Sector Companies, Universities (Bandırma University, Yildiz Technical University, METU, OKAN University, etc.), Municipalities, Ministries, General Directorates.

**3.** 1st Transportation Councils, Conferences (1st and 2nd International Intelligent Transportation Systems- Bandırma University), Intertraffic, Transist etc. The proliferation of events such as congresses and fairs, Graduate programs (Bandırma University, Department of Intelligent Transportation Systems and Technologies), Academic Journals (Intelligent Transportation Systems and Applications Journal- Bandırma University), Research Centers (BAUSMER-Bandırma, METU-Biltir) HGM, AUS-TÜRKİYE and TBB Continuing to hold webinars and training programs about ITS.

**4.** Increasing the production and domesticity rates of the electric domestic vehicle developed by Togg, ensuring the domestic supply of products such as charging, batteries and planning for significantly increasing investment in renewable energy sources.

**5.** Implementation of action plans within the scope of the main themes of Digitalization, Mobility and Logistics in the 12th Transportation Council for a strong and comprehensive national architecture.

**6.** Increasing the number of incentives for companies working in the field of ITS in technopolis.

**7.** Transfer of additional resources for the production of domestic and national ITS technologies within Teknofest.

**8.** Tax exemption or similar incentives to domestic companies producing ITS technologies.

**9.** Especially in order to ensure the sustainability of transportation investments made in recent years, the necessary policies, budgets, legislation, and strategies are developed in cooperation with private, public and NGOs.

As a result, Türkiye has to make it sustainable according to the ITS architecture by implementing the strategies and action plans described above in order not to fall behind in the ITS and C-ITS World competition. For this purpose, Türkiye has to establish the infrastructure to produce national and domestic ITS technologies as an example of the defense industry. Private, public and NGOs working in the field of ITS should be encouraged and new specialized and research universities and vocational education institutions (Vocational High Schools, Faculties of Technical Education, etc.) that form academic infrastructure such as Bandırma University should be organized and opened as priority educational institutions.

In order to meet the need for qualified personnel working in the field of ITS and to train staff at undergraduate-master's-doctoral levels for employment in local governments or to raise awareness through joint training to be organized by TBB (Türkiye Municipalities Organization) and to announce ITS developments and to increase public awareness, it is important to organize conferences, symposiums, workshops, and fairs with the education sector. In this sense, it will contribute significantly to the production of ITS and C-ITS domestic technologies with the training carried out both during the training phase and in the projects.

There are two important and positive factors that stand out in the investment analysis of the Türkiye transportation sector one of which is the investments made in transportation infrastructure in the last decade (Highways, Bridges, Marmaray, Eurasia Perch, Çanakkale Bridge, Osmangazi Bridge, Double roads, Istanbul Airport, Fiber infrastructure, the increase and spread of mobile applications in local governments, etc.) and the second one is the technology companies established by the young population. However, interagency data sharing and coordination is not at the desired level which can be viewed as a deficiency.

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