Chapter 1
Transportation Systems

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1.1 Background of Transportation Systems

Persistently occurring revolutionary changes in the transportation systems continues to enhance the consumers experience and awareness. These transportation systems are deeply embedded in presently commercial and private businesses all around the globe. It has led the transportation industry to a subsequent level in terms of speed, services, time, and quality. This section focuses on the vicissitudes in the transport systems over the years. The need to evolve the former systems arose from the rapid growth and demand of advanced technologies as depicted in Fig. 1.1. This was due to the fact that new transportation systems were adaptive in nature and were adjustable to the unceasing changes in social, economic, and environmental factors. The foremost changes, which encapsulate the gradual substitution of old systems by the innovative and improved systems, are discussed below:

1.1.1 Roads

In the year 1700s, the early modern highways were constructed by John Loudon McAdam (1756–1836), around the time of Industrial Revolution by using cheap soil and stone concrete paving material (macadam). The roads were embanked a few feet higher than the surrounding terrain to allow drainage of waterway off the surface. The demand for such roads increased in the forthcoming years to eliminate wash

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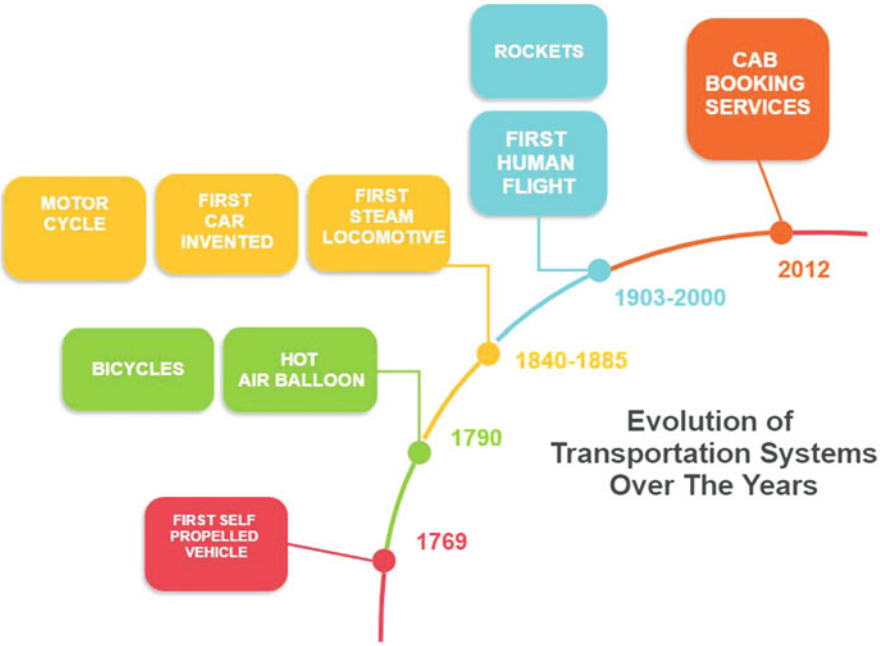

Fig. 1.1 Evolution of transportation systems

ways, bogging systems and dust on both municipal and agricultural roads. With the growth of motor transport in the early twentieth century, major western cities constructed roads initially by using cobblestones, wood paving, tar-bound macadam (tarmac), and concrete. In 1902, the world's first tarmac road was built then and named as Nottingham's Radcliffe Road [6].

1.1.2 Rails

In 1802, the first-ever ("Puffings Devils") steam-powered locomotive operated on smooth rails. It was designed and constructed by Richard Trevithick, a Cornish engineer, referred to as "father of railways" alongside, George Stephenson. Five years later, in 1807, Swansea and Mumbles Railway at Oyster mouth initiated the first passenger-carrying public railway. It was designed on existing tramlines by utilizing horse-drawn carriages. In England, in the 1820s, modern rail transport systems initially appeared [6].

1.1.3 Air

In 1783, the Montgolfier brothers invented the first air mode transport known as the hot air balloons. Jean-François Pilâtre de Rozier and François Laurent d'Arlandes were the chief explicitly confirmed individuals which took the human flight in Paris. They traveled 5 miles (approximately 8km) in the hot air balloon. Later, over a gap of 120 years, a ground-breaking change arose in the air transportation system. The Wright brothers made the first continuous, operated and powered heavier-than-air flight, and named it the Wright Flyer [6].

1.2 Growth of Transportation Industry

The transportation industry maintains a strong hold on the GDP growth of a country. It is one of the largest sectors that has been accumulating labor since its first-ever advancements in the sector. Transport industry pays a major surcharge to the governments which enhance the growth of countries globally. As millions of people, use multiple means of transport on a daily basis, the economic sector is forever to prosper. Different modes of transportation system include subways, metro buses, automobiles, air flights, and delivery of shipments through sea cargo. There is an evident relationship between quality and quantity of foundations of transportation, the stronger the relation, the better the economy [7].

Concentrated infrastructure of transportation and highly dense connected networks are deeply connected to the levels of development. An efficient transport system increases the provision of social and economic opportunities for the general public which highly impact the country nationally and internationally. Not only that, it also facilitates towards a better society by increasing the employment rate, accessibility in markets, and pave ways for investors to invest in the profitable industry of transportation. On the contrary, deficiency in production units of transportation system leads to inflation in a country and it lowers the living standards.

At an aggregate level, a productive transportation system decreases costs, while poor transportation increases such costs. In addition, transportation impacts are not always intended and can have unexpected or unintentional effects. For example, when supplying customers with free or low-cost transit networks, congestion is always an unexpected result. Nevertheless, congestion can also be taken as a good indicator of a rising economy where it is difficult for capacity and infrastructure to keep up with the increasing demands for mobility. Transport bears a major social and environmental load that cannot be overlooked.

1.2.1 Importance of Transportation Industry

Transportation industries play a vibrant role in our day-to-day lives. Without the convenience of transportation, the world would not be able to function effortlessly and smoothly. Over the years, the significance of transportation industry has expressively amplified. Transportation industry provides assistance in moving objects of daily usage from one place to another. Around the globe, millions of citizens are dependent on the availability of different modes of transportation systems in order to transit to offices, schools, and other places of interest. The importance of transportation system assists in several aspects depicted in Fig. 1.2. These different aspects are discussed below.

- **Quick Marketing:** Transportation industry provides considerable assistance in the growth of businesses that contains items which demand "quick marketing" (also known as fast marketing).Short-lived items like fish and green vegetables are swiftly delivered to different customers even in inaccessible market sectors through vehicles thus raising the demand of merchandise [9]. With the rapid advancement in transportation systems, there is a need to keep up with the latest, affordable, and reliable modes of transport to benefit the business. Availability of safe and fast transportation modes such as motorbikes and automobiles (nation-

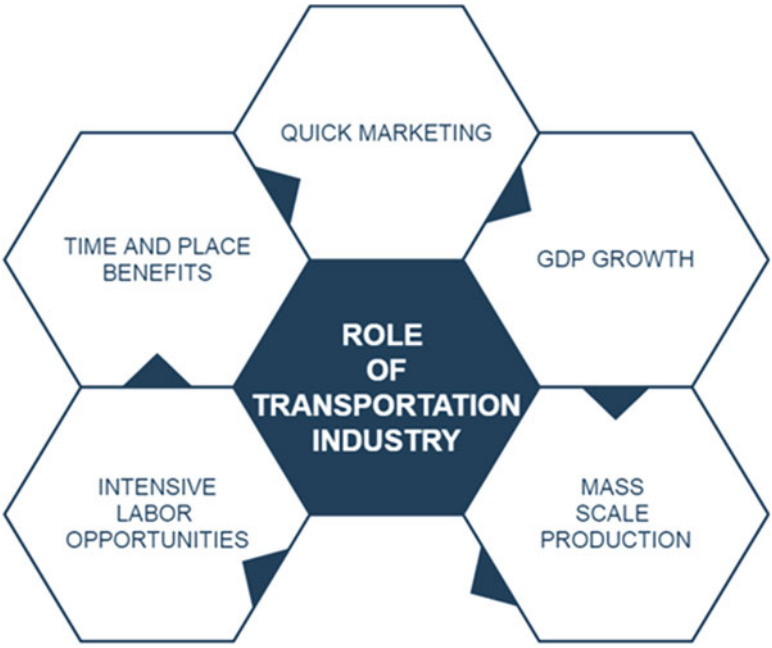

Fig. 1.2 Importance of transportation industry

ally), air cargo, and railway transport (internationally) has enabled effective collaboration between customers and the manufacturers.

- **Benefits of Time and Place:** A transportation system has eased up businesses by shortening the gap between time and place. Due to the climatic factors and the geographical conventions, industries are coerced to situate businesses far from the country local markets where they have little to no demands of the goods. Transport overcomes the barrier between the manufacturing and the utilization forces. Transportation industry has significantly increased the speed of transport by virtue of increased developments in the transportation modes. It enables the items to be disseminated in the minimum conceivable time.
- **Price Stability and Large-scale production:** One of the significant benefits imparted by transportation industry is their ability to dismantle any distinctions in item costs, i.e., products prices remain the same everywhere. When the production of goods is sufficiently enlarged, the transportation helps in delivering massive amounts of these products in the market from where the clients can purchase the products at lower costs. This results in mass production of items and goods. Transport places an evident impact upon the pricing of items by moving wares from surplus to shortage zones. This in turns levels the organic market factors and makes the cost of items stable. Transportation guarantees the progression of products under the control of the buyers throughout the period of utilization. Costs are likewise diminished due to the facility offered by transport for productions of goods at a larger scale.
- **Increases Employment:** Transport expands portability of work and capital. It causes individuals of one spot to relocate to different spots searching for occupations. Indeed, even capital, hardware, and other sort of gears are imported from far off nations through vehicles alone.
- **Economic Growth:** A country around the globe that lacks self-sufficiency relies on other nations to satisfy their necessities. This contributes to the economic growth by increasing employment and labor. Transportation has brought the nations together due to which it is considered to be the largest employment-intake sector. It also encourages the development and empowerment of business. The correlation between economic and transport industry is depicted in Fig. 1.3

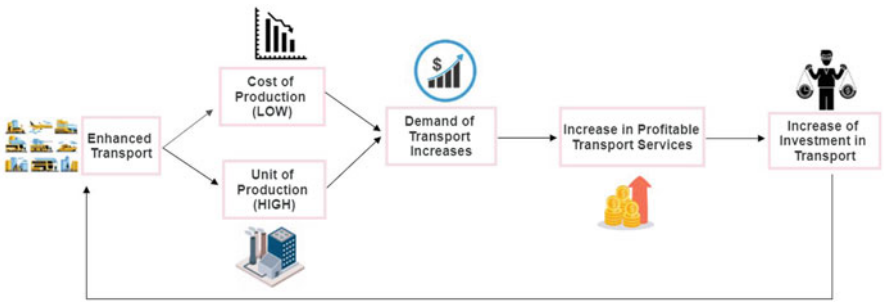

Fig. 1.3 Correlation between economic and transport industry

1.2.2 Growth Factors in Transportation Industry

Transportation systems are significantly concomitant with geography as it is concerned with measuring and assessing the relations between different areas and territories. For a nation's economic and social development, mobility is the elementary concern. Rapid advancements and unceasing emergence of technological aspects to transportation industry can swiftly ease the humans which in turns assist the financial sector, thus improving the country's civilization. The existing transportation industry cannot be pronounced by one factor, but there are several other factors contributing towards the growth of the transportation systems depicted in Fig. 1.4. Some of the factors are illustrated below:

- **Economic Factor:** Economic activities and the movement of all types of supplies from one destination to another are the two sides of a coin that collectively strengthen and reinforce a country's economy. Resourceful transport systems with advanced foundations can expand the business between the clients and the manufacturers. Thus, a proficient transport system can then benefit the overall economy. Reliable transport systems that offer low cost and less time benefits can provide services to markets on a larger scale. This will enable to impose "just in time" services to markets situated at distant places. As the delivery of goods and services has been improved due to the advancement in the transport systems, it enables the consumers to have access to varieties of goods from all across the world. This enables the clients to obtain quality products at lower costs. Efficient transportation with effective communication enables the production of goods and services in regions where it can attain the uppermost advantage. The production of goods in such region can improve the economic productivity as long as the proper transport is accessible for trade. So, for a country to grow economically, it is imperative that it should possess a virtuous transportation system.
- **Political Factor:** The growth of transportation systems is highly dependent on the political factors. Political facets include the safety and security conditions that are imposed on the transport system. It also defines the means in which different operations performed. The political aspect also outlines the trade agreements and contracts with other adjoining entities for the purpose of transit of goods and

Sr no.	Factors	Description
1.	**Economic**	Efficient transit of goods and services improves the economic productivity.
2.	**Political**	Implying safety conditions, trade agreements with other nations.
3.	**Social**	Providing healthcare facilities, social interaction through transport system.
4.	**Technological**	Using technology to make the transport system enhanced, inexpensive and cheaper.

Fig. 1.4 Growth factors

services. It defines the transnational connectivity and the interaction with other nations which can overall improve the country's economy.

- **Social Factor:** Transport system plays a very vibrant role in providing the necessities that improves and enhances the livelihoods. The need of providing healthcare facilities to people has made the use of different modes of transport systems unavoidable. The upsurge participation in cultural events and social interaction has also led to the growth of the transport system. Social activities have been stimulated to an immense extent due to the ease in mobility [10]. Now traveling from one place to another for any kind of societal collaboration is very stress-free. The more is the interaction, the better chances are there to improve and intensify the transit of goods and services among nations or also individuals. It thus humanizes the nation economic conditions.
- **Technological Factor:** Technological advancement has conveyed transportation services that are enhanced, inexpensive, and faster. People are now more likely to move efficiently from one endpoint to another. Similarly the transition of good and services is also enhanced and has become proficient over the period of time. Technology has led to the development of a friendly ecosystem. Use of GPS has headed people to get to their anticipated destination in a shorter period of time [8]. The hi-tech progression has also managed to lessen the fatal traffic accidents. Headlights in the dark assist the driver to drive safely, similarly the driver less automobiles have also led to the reduction of humanoid faults so that accidents can be reduced to an immense extent. Telecommunication has also endorsed the influence of "work from home" due to which the traffic mobbing on the roads can be reduced. Correspondingly, technology has directed the road administrators to highlight the highly congested areas so the traffic can be managed in an efficient way. This is owing to the technological innovations that the prevailing transport systems have made life easier and thought-provoking.

1.3 Challenges to Transportation Industry

With the significant evolution and improvements in the transport system, comes the challenges as well. As the transport system is becoming more saturated and complex, certain other sophisticated innovative and revolutionized mechanisms are required to overcome the challenges. These challenges can be categorized as the social, political and the technical challenges. Each of these is explained in detail in the following sections:

1.3.1 Social and Political Challenges to Transportation Industry

There are different social and political challenges in the transportation industry that needs to be addressed and resolves. Some of them are discussed below:

- **Social Challenges:** Some of the social concerns related to the transportation systems are described below:
  - **Limited Communal Interactions as a Social Challenge:** The transport system has eased the process of people to transit. It has also upgraded the transport of goods and services thus improving trade. But there is a certain level of inequity in the traveling of people belonging to different social groups. Most of people have ownership of personal vehicles and thus have the benefit of moving stress-freely and reaching the destination is shorter period of time and in a comfortable environment. As opposed to this, a person that cannot afford the ownership of vehicles therefore uses public transport which consumes time and is not comfortable. This results in limited social communication. The social interactions between people are also less due to the dichotomy in the modes of transportation available for people belonging to different demographics. Therefore, it is the responsibility of the transport sectors to offer a comfortable and cost-effective environment for people who are using public transport to transit. People living in the urban areas have a variety of transportation modes available for going to their offices, schools, shopping malls, parks, etc. In contrast people living in rural area are more subjected to limited public transport.
  - **Environmental Factor as a Social Challenge:** The social challenges of the transport system can also be considered from the environmental point of view. The transport system has affected the lifestyle of people. There are certain negative health impacts of transport on humans. Pollution is one such distress that has become an important social concern as it risks the human health. The emission of pollutants from the vehicles has polluted the air thus causing breathing issues and other various diseases. Similarly the noise pollution has caused annoyance and psychological instabilities. Similarly, the water pollution has contaminated the rivers and streams leading to different health concerns. This pollution has affected the human health and is therefore a social challenge in the transportation system that needs to be addressed and resolved.

    There should be supervisory agencies that should define standards in order to retain these social concerns. They should monitor the conditions and should impose regulation or penalties if any of the standards are violated. A good transport system is required, which will increase the amount of people using transport thus, improving the country economy.

- **Political Challenges:** There are different political concerns associated with the transport system. Some of them are discussed below:
  - **Inefficient collaboration:** The collaboration between different organizations that are accountable for the transportation management systems lacks efficiency. Due to the limited economic and financial development, initiating the expansion programs and enhancement campaigns for improving the transportation system is usually very less. The need of different transport modes is not properly gratified due to the deficiency in inter modal scheduling and planning. These consequences are due to the inefficient communication between the transport sector and the economic sector. Political pressure is one of the main factors responsible for the ineffectiveness in collaboration between different sectors. This is owing to the partial investment being made in projects that are concerned with the maintenance and preservation of the transport infrastructures. The Regimes are least considerate and sympathetic towards the improvement of transportation systems, which is one of the reasons why the transport systems are not competently enhancing and advancing in most of the countries.
  - **Less Prioritized:** Transport agencies ordinarily propose many stimulating and innovative projects schemes to the government corporate sectors. But still such projects are least prioritized. The initiation of such projects requires full fledge funding. The successful completeness of such projects can revolutionize and transfigure the entire transportation system, thus benefiting the nation from different aspects. One such aspect can be tourism; this can contribute to the economic development as well. As a matter of fact, it is observable that countries with dynamic and robust transport systems are economically strong. Hence, for a country to economically cultivate, vigorous transport systems are probably imperative.

1.3.2 Technical Challenges to Transportation Industry

Due to the extraordinary consumption of different modes of transport, the transportation system is thus becoming multifaceted and saturated. Therefore to efficiently carry out the transit of population, services, and goods, it is necessary that the mobility system should function applicably and appropriately. There are certain technical challenges that the transportation system is facing. Some of these issues are discussed below:

- **Traffic Congestion:** Due to the intensification in use of automobiles, traffic congestion has become the most predominant challenge. Increased quantity of vehicles on the roads has led to the problems of overcrowding and mobbing. Overcrowding leads to traffic jams and roadblocks, thus disturbing the normal day-to-day routine. This congestion also leads to fatal roadside accidents.

Therefore, in order to reduce the traffic congestion, it is highly endorsed to use public transports so that jamming on the roads can be reduced thus saving time.

- **Maintenance Expenditures:** Time is continually evolving and the movement of people as well as services and goods is rapidly mounting. This calls for a need to upgrade the transport system on continuous basis. Upgradation and maintenance of the infrastructures of the transport system requires high costs.
- **Hazardous Accidents:** As the transportation system is constantly developing, high congestion on the roads leads to fatal and hazardous accidents. This is a technical challenge that entails the road administration to persistently monitor the congestion so that the overcrowding should be decreased and people can safely transit. These mobbing also leads to delay and postponement in the transfer of goods from one place to another thus adversely affecting the business as well.
- **Safety:** The safety of the people is the main concern. The transport system requires alerting mechanisms that activates when certain speed limit is crossed. The existing transport system needs upgradation. Additionally, there is a need for latest and hi-tech sensors and cameras to constantly monitor the movement of vehicles so that any abrupt change in the traffic flow can be identified at hand and thus safety measures can be timely taken to avoid any unfortunate circumstances.
- **Parking:** The ever-increasing need for the transport has resulted in the increased number of personal vehicles. Comparing to the older system when there was only the public transport and very few people owned personal vehicles, in today's era almost every family owns a personal vehicle for traveling purposes. This increase in the number of vehicles has led to the problem of parking. People do not find parking spaces easily which causes them to search for vacant spots thus wasting time and fuel. An advance real-time parking is thus needed that will notify the drivers about the vacant parking slots so that the drivers can park their vehicles while saving their time and fuel.

1.4 Impact of Intelligent Transportation Systems

Previously, the transportation systems were more prone to subjective errors. Congestion, poor traffic monitoring, and insufficiency in transport management resulted in disastrous accidents and other mishaps. These challenges called for an upgradation in the existing transport systems and from here the need of incorporating technology to the transport system arose. This gave rise to the intelligent transportation system which overcame most of the challenges that were occurring in the conventional transportation.

The Intelligent transportation system (ITS) has gained prominence as it offers an effective real-time traffic managing and monitoring systems [12]. It has enhanced the quality of transit, provided safety measures to users, helped in reaching the destination in shorter time with less fuel consumption, decrease in traffic overcrowding and most importantly reducing the roadside calamities and disastrous accidents.

The impact of ITS on the lifestyle of people as well as its effect on the nation is huge. Advancement in ITS has led people to make constant use of different modes of transport thus improving their routines. Robust ITS promotes more trade and businesses all across the world contributing to more financial and economic development. A detailed explanation about the ITS is given in the following subsections.

1.4.1 Overview of ITS

Emerging countries are persistently improving their transportation systems. Due to the concentration in economic growth and population, transport systems are facing a number of challenges which includes overcrowding, hazardous accidents, and poor traffic management [3]. These situations call for immediate consumption of the ITS so that such extreme concerns could be fixed to the possible extent. To introduce ITS in a country, it is imperative that the country should know how to efficaciously incorporate technologies into the transportation systems.

ITS is concerned with refining the productivity and proficiency of the services provided by transport system. It involves the transmission of instantaneous information in order to advance the traffic management, reduce congestion, and lessen the road accidents. All these benefits of ITS can be yielded by applying the advance technologies of communication, sensing devices, computers into the transportation system. At the communal level, ITS applications are concerned with reducing the road congestion, minimizing the road accidents thus improving the traffic management. For those managing the road, ITS helps in determining the areas that remains highly congested so that the traffic can be managed in a competent way.

ITS assists in overcoming the socioeconomic issues as well as helps in the economic and financial development of the nations. Intelligent Transportation System supports the development of industrialized countries as well as the developing nations. Proper implementation of ITS can effectively reduce the fuel consumption enabling people to travel in a secure and inexpensive mode. ITS consists of various components. One such component is the Vehicular ad hoc network (VANET) which is considered to be the most significant [4]. VANET uses ITS techniques to impart reliable information regarding the vehicle's location, its speed, upcoming headings, and road conditions [13]. It is hence predictable that further advancement and progression in the Intelligent Transportation System will result in a more user convenient, secure, and efficient transport system.

1.4.2 Applications of ITS

The foremost intention of intelligent transportation systems is to enhance the existing transportation system and improve the quality of transport [2, 5]. Different

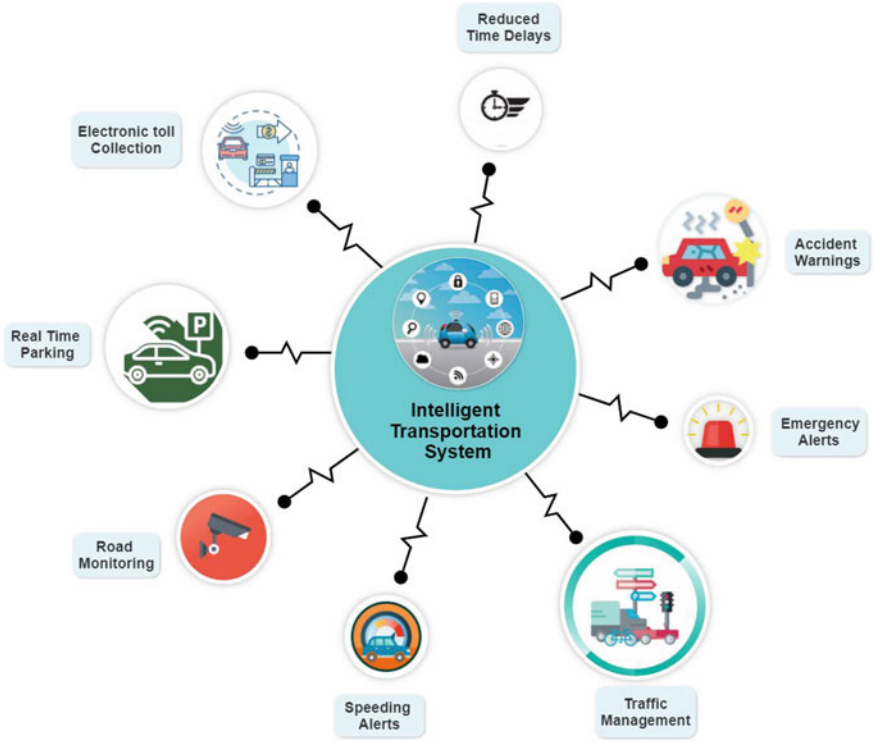

Fig. 1.5 Application of intelligent transport systems

monitoring and managing mechanism are used to enhance the transportation system. There is no doubt that, with the appearance of technology, the transport system has made rapid advancement and improvement. A colossal transformation can be observed that has changed the whole depiction of the transport. This is due to the constant emergence of technologies that has made the transport systems intelligent which are also shown in Fig. 1.5.

On a broader level, the functionalities offered by ITS can be categorized into two aspects, i.e., the Advance Traveler Information Systems (ATIS) and Advance Management System (ATMS). ATIS help people in making decisions regarding traveling whereas AMS focuses on the monitoring and controlling the transportation systems. Progression in ITS has led to the development in both ATIS and ATMS. There are voluminous applications of the intelligent transport systems in both of these categories.

- **Advance Traveler Information Systems:** This system collects, analyzes, and then delivers information to travelers so that they can easily transit from one location to another. It focuses on providing different mechanisms so that people can certainly make decisions about their traveling journeys. It imposes several

models that help in deciding the routes, means of transports, lane restrictions, available parking places, expected time to reach the destination, recommended speed, etc. These applications are discussed below:

- **Emergency Notification System:** This is one of the most significant benefits offered by intelligent transportation system. It is a real-time alerting system that notifies the drivers that an emergency vehicle is passing. This directs the drivers to slow down and give ways so that the emergency vehicles can pass easily.
- **Reduced time and fuel consumption:** Mobility is an advance application of Intelligent Transportation Systems (ITS) that aims at providing the ease of transit. It enables people to move effortlessly from one destination to another. The travel time prediction models help in specifying how much time is required to reach the destination. Amalgamation of vehicles with mobiles, Global Positioning System (GPS), and Media Access Control (MAC) has intended to deliver services such as taking the shortest paths. This saves the time as well as reduces the fuel consumption because we can now reach our desired destination in shorter time by selecting the optimal path amongst different paths.
- **Route Guidance Systems**: Route Guidance Systems (RGS) are used to notify the drivers about the environment such as traffic congestion on the roads, weather conditions, any mishap or accidents on the roads ahead, etc. The route guidance system uses various systems to identify the conditions of the roads and then notifying the drivers. This helps the travelers to timely decide on whether to switch or not to another route. The guidance systems use different algorithms such as inter-vehicular communication, sensor networks, P2P, VANET, neural networks for operating, etc.
- **Real-time parking:** The intelligent transportation system has paved ways for the real-time parking management. It uses cameras, sensors, payment systems, and mobile apps to determine the vacant slots in the parking areas. It then provides information to the drivers about the unoccupied and available parking spaces so that the drivers can easily park their vehicles. This real-time parking has also reduced the traffic jamming and mobbing as shown in Fig. 1.6.
- **Obstacle Alerts:** This warning technology uses radars, sensors, and cameras to warn the driver about any hindrance that is sensed through these devices. This prevents the vehicle from collision. This application warns the drivers about the obstacles approaching either from the forward or backward direction as the in-vehicle sensors are capable of sensing in both the direction.

- **Advance Traffic Management System (ATMS):** This system makes use of real-time information collection, processing, analyzing, and then using it for the management of transport system. The data collected from enriched sources with quality information helps in managing and controlling the operations of the transport systems. It makes use of different mechanism such as emergency warnings, road conditions, transit services, and the transfer of goods and services

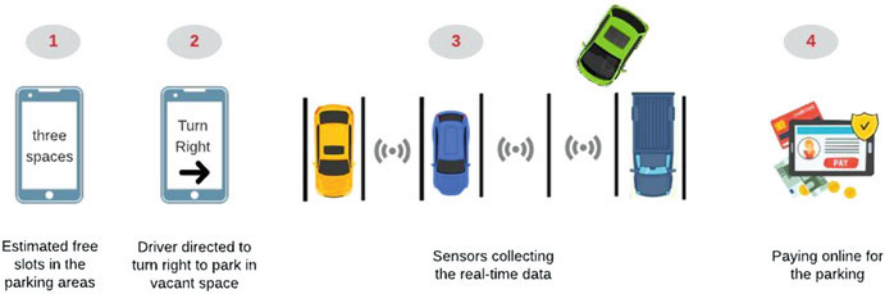

Fig. 1.6 Real-time parking system

for trade and business purposes, etc. It consists of some of the following applications:

- **Smart Traffic Management:** It involves tools, amenities, and services associated with different modes of transport and the traffic management system which enables people to have better understanding about the traffic system. The key objective is to proficiently control the traffic congestion, supervising the traffic lights, managing the flow of vehicles. The traffic system uses camera, radars, different sensing devices, and advanced networks to regulate the traffic congestion. Thus saving time, energy and reducing the road accidents.
- **Speed imposition:** Installation of speed monitoring cameras has upgraded the transportation system to an immense extent. It monitors the speeds of the vehicles where the over-speeding vehicles are caused penalties. The enforcement to follow a certain speeding limit has inestimably reduced the road accidents and due to which the traffic congestion has also been condensed. In addition to this, Adaptive Cruise Control (ACC) technology is largely used which concentrates on adjusting the speed between vehicles. Some examples of this technology include the drive-by-wire regulators in the car and the in-vehicle distance cautionary systems.
- **Electronic toll collection:** It is a very stimulating application of the intelligent transportation systems where the drivers are charged with a toll without stopping. Conventionally, the divers would entail to stand is long queues and wait for their turn to pass through the toll plaza thus consuming users time. The electronic toll collection system has supplementary ease the user's life. Now, the users have registered accounts for the billing procedures. The vehicles do not have to stop or stand in lines; rather there are sensors and cameras installed at the toll plaza that recognizes the license plates of the cars and the users can later pay the toll. This has competently reduced the time consumption, thus letting the users to reach their destination in shorter period of time.

– **Transit Management:** The transit organizations are responsible for monitoring the transit operations. This is done through the surveillance cameras, the Computer-Aided Dispatch (CAD) systems, and the automated vehicle location (AVL) systems [1]. CAD systems are used for dispatching the responder's personnel. It delivers services that are used by call-takers and 911operators for recording the calls in order to recognize the location of the responder and then dispatching its personnel. AVL is used by agencies to track the location of a vehicle by using the GPS over the internet. These surveillance's mechanism provides safety and security to public transport systems.

1.4.3 Challenges Overcome by Intelligent Transportation Systems

Transportation and traveling plays a very essential part in our day-to-day lives. We use different modes of transport to transit to offices, learning, shopping, and pleasure. Similarly, companies customize transport for their trade devotions. We have now become exceedingly reliant on transportation to accomplish our daily tasks. People are keen towards a transport system that is much safer, faster, reliable, and comfortable. There were a lot of challenges that people faced in the conventional transportation system. But after the immersion of technologies in the conventional transport, the transportation systems now are very intellectual. The intelligent transport system has eliminated most of the challenges previously faced and its prime emphasis is to provide people with resilient transit opportunities. Some of the challenges that have been overcome by these modern transport systems are:

- **Enhanced Mobility:** Previously the transport systems were not much reliable, due to the lack of smart solutions to congestion problems. People would get jammed in long traffic congestion. They would be late for offices; children would not reach the learning institution on time. This was adversely disturbing the overall day-to-day routine. It also resulted in the transit delays of delivering good and services thus affecting the trade and businesses. Nonetheless, with the emergence of advance technologies to this conventional transport system, the challenges have been overcome to a greater degree. The traffic congestion has now been excessively controlled. The drivers have in-vehicles and traffic management information that guides them about the congested network and notifying them if the road ahead is clear. Controlling and adjusting the traffic congestion has immensely reduced the travel time.
- **Finding appropriate routes:** Formerly people had no awareness about the conditions of the roads ahead on which they were traveling. Sometimes they may come across routes that are not apposite. For example, there is some ongoing road construction, road maintenance or road accidents ahead. People get stuck or they would require changing the route all cross and driving back from the place. This

result is delays and wastage of fuel. Route guidance systems have enabled the drivers to timely decide to take appropriate routes for reaching the destination. People use the smart navigation system that guide them about the circumstances on the road and thus saves travel time.

- **Safety:** The intelligent transportation system has condensed the roadside accidents and has provided a safer means of transport. Previously, traveling safely was a prevalent challenge which has been overcame by ITS. At the instant, the traffic flow is smoothly controlled and monitored. This fallout in reducing the chances of calamities and hazardous accidents. ITS has also reduced the risk associated with Vulnerable Road User (VRU) [11]. VRU is the term used for users that are at most risk than other on the road infrastructures which includes the cyclist, pedestrian, etc. They are broadly categorized as the non-motorized users. Intelligent transport system has enabled the automobile manufacturing companies to designed vehicles in such a manner to offer protection to the VRU. The vehicles have forward pre-installed cameras and other in-vehicle applications that constantly warn the driver about the collision. This assists the drivers to identify if there is a non-motorize users closer to his vehicle so that he can avoid collision.
- **Road Management:** Intelligent transportation system has provided massive benefits to the road management system. Previously it was a very cumbersome job for the management to monitor the roads. At present, ITS are constantly devising hi-tech mechanisms that monitors the roads and based on their usage identifying when most probably the roads needs maintenance. Incorporating advance technologies to the traffic management systems helps the administrators to easily manage the traffic signals and network.

1.5 Conclusion and Future Directions

Advancement in the transportation systems has eased the traveler's day-to-day routine. It has reduced the imprecision's and has made the transit effective and efficient. With constant incorporation of technologies, the transport system is persistently improving. It is further enhancing the consumers experience and awareness, thus increasing the use of different means of transport.

Currently, the transport systems are intelligent enough to perform tasks that were manually performed by humans. Amalgamation of hi-tech mechanisms, artificial intelligence and networks has completely revolutionized the world. ITS has immensely reduced the challenges which were previously faced by the conventional transport system. Smart traffic management, congestion control, emergency notification, reduced accidents, route guidance systems, real-time parking management and transit management are some of the applications of ITS. These improvements have contributed to the overall development of the nation, thus making countries economically strong and resilient.

Future of ITS lies in further advancing the information, communication, and technological mechanism to make transport system much more robust. It should provide consumers with more accurate and precise information. Data collection and analyzing mechanisms should be performed my models/algorithms that are less prone to errors and are more efficient. The traffic management systems should adopt more vigorous measures so that the safety and security of people should not be compromised at any cost.

Despite the various advantages provided by the existing transport system, there is always room for further improvements. The cellular devices and computers are extensively used for transferring and receiving data which is majorly used for the route guidance purposes. ITS in the future should use cars to transmit data instead of cellular phones. This will provide instantaneous benefits to the drivers and the travelers about the traffic conditions, route guidance, etc. This future aspect focuses on considering the cars as data points on the networks rather than the cellular phones or other devices.

References

1. (2012). Retrieved from 100PercentBronx: http://100percentbronx.blogspot.com/2012/05/liu-mismanagement-of-911-upgrade-picked.html?m=0.
2. Aujla, G. S., Jindal, A., & Kumar, N. (2018). EVaaS: Electric vehicle-as-a-service for energy trading in SDN-enabled smart transportation system. *Computer Networks, 143*, 247–262.
3. Chaudhary, R., Jindal, A., Aujla, G. S., Aggarwal, S., Kumar, N., & Choo, K.-K. R. (2019). BEST: Blockchain-based secure energy trading in SDN-enabled intelligent transportation system. *Computers & Security, 85*, 288–299.
4. Dua, A., Sharma, P., Ganju, S., Jindal, A., Aujla, G. S., Kumar, N., & Rodrigues, J. J. P. C. (2018). RoVAN: A rough set-based scheme for cluster head selection in vehicular ad-hoc networks. In *2018 IEEE Global Communications Conference (GLOBECOM)* (pp. 206–212). IEEE
5. Ercan, T. (2013). *Sustainability analysis of intelligent transportation systems*. University of Central Florida.
6. History of Transport (2021). Retrieved from https://en.wikipedia.org
7. Learning: Growth of the Transportation Industry and Importance of the Transportation Business (2018). Retrieved from desientrepreneurs: https://www.desientrepreneurs.com/
8. McTigue, K. (2019). News: Economic Benefits of the Global Positioning System. Retrieved from: https://www.nist.gov/news-events/news/2019/10/economic-benefits-global-positioning-system
9. Raut, S., Biswal, S., & Rout, S. (2015). Significance of Transportation and its Contribution to Economy. Retrieved from SlideShare Website: https://www.slideshare.net/sunil133/significance-of-transportation-55618349
10. Rodrigue, J. (2020). *The Geography of Transport Systems* (5th ed.). Routledge.
11. Safety of Vulnerable Road Users. (2020). Retrieved January 2021, from https://rno-its.piarc.org/en/network-operations-its-road-safety/vulnerable-road-users
12. What is Intelligent Transportation System(ITS): Applications and Examples (2019). Retrieved January 2021, from https://www.aindralabs.com
13. Yousefi, S., Mousavi, M. S., & Fathy, M. (2006). Vehicular ad hoc networks (VANETs): Challenges and perspectives. In *2006 6th International Conference on ITS Telecommunications*. Chengdu: IEEE.