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APPLICATION OF INTELLIGENT TRANSPORTATION SYSTEMS IN LOGISTICS

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Abstract: In the second half of the 20th century, occasional intelligent traffic management solutions were used to control road traffic in more developed areas of large cities. Today, the requirements for ITS have extended, such as intelligent and integrated operation, multi-level information, continuous information, traffic management intervention, environmental impact assessment, decision support statistics, and so on. In the last 10 years, the use of intelligent transport systems has become widespread in Hungary, although the data provided by ITS is not used to the appropriate extent in the developments. The main goal of this article to present these opportunities of ITS, starting with a systematic review of the literature.
Keywords: Intelligent Transportation System, ITS, traffic management, smarty city, urban pollution

1. INTRODUCTION

The term of ITS has been used officially since 1994 and this acronym comes from the use of telematics devices in transport. The most expository definition: “ITS is the application of sensing, analysis, control and communications technologies to transportation in order to improve mobility, safety and efficiency” [1]. According to this definition, ITS can cover most of the transport sectors and it can also support the planning and development strategies. The definition is certain that the ITS system is a multidisciplinary research field, but this fact will be the discussed in the next chapters.

Intelligent transport systems are part of the concept of the smart city, so one of the cornerstones of the development into an intelligent society is the ITS theme. These aims to achieve traffic efficiency by minimizing traffic problems meanwhile the passengers is informed with prior information about current traffic, public transport vehicles real-time running information, seat availability and so on. Optimalization with these parameters can be reduce travel time of commuters as well as enhances their safety and comfort.

2. SYSTEMATIC LITERATURE REVIEW OF ITS

In 2.1 subchapter, the national and international regulations; In 2.2 subchapter the directives, the professional and social review of the Intelligent Transportation Systems; and in 2.3 subchapter the scientific review are presented.

2.1. National and international regulations, directives

On national level, the system of conditions and objectives for the operation of intelligent

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transport systems is summarized by regulations and on the international level such as the European Union, directives are used. The main aim of the directive to increase the interoperability of the main transport networks / corridors by improving mobility and transport parameters [1]. The Hungarian ITS regulation summarizes and extends the EU directives applicable to ITS service providers and developers. The Hungarian (national) regulation has written for the development of existing Trans-European Transport Network (TEN-T) and other main transport corridors, but it also provides support for traffic management in local congested areas and cities [2]. Overall, the legal background and policy strategies allow and even support the application of intelligent transport systems. There are many international projects, which aim at ITS-related research, development and implementation. The ITS professional and social overview is explained in the next subchapter.

2.2. Professional and social review

The Hungarian logistics strategy considers intelligent transport systems with the aim of increasing efficiency of their logistics services. This strategy mentions the term of ITS system at several points, which can play a role in increasing the efficiency of interoperability of road and rail transportation. Moreover, the intelligent transport systems greatly influence quality and operation of material flow and logistics systems. Basically, ITS should serve the following purposes: increasing the safety of transportation, designing transport systems / networks and increasing organizational efficiency; reduction of operating costs; environmental protection; minimalizing stress on passengers and drivers [3]. These goals require a high level of planning and organizational experience, and it can be achieved with a high level of IT support.

2.3. Scientific review with the Scopus

The Scopus database was used for this research because this platform contains approximately 82.4 million records. The filtering was applied only to the terms ITS and intelligent transport systems. The result of this filtering is 485 documents (article, conference paper, conference review etc.). This study was conducted in February 2021, and 8 documents have already been uploaded in this year on this topic. In recent years, an average of 35-40 pieces of ITS research have been registered in Scopus database.

The first figure confirms the statement about the multidisciplinary of the ITS topic. The 5 most affected subject areas in descending order:

- *Engineering*: electrical, mechanical, and logistical planning [4] etc.
- *Computer Sci*ence: algorithmic processes [5], automatization, coding, control, programming, data analysis [6] etc.
- *Social Science*: travel habits, expectations [7] etc.
- *Mathematics*: traffic flow modelling/analysis, composition [8] etc.
- *Decision Sciences*: examination of decision alternatives [9], decision support, etc.

The place of origin of the research is also important, as it is a popular research topic in areas that have many large metropolises / cities coupled with high social development (Figure 2.). The developed countries of the Asian continent are at the forefront of ITS-related scientific research due to their flexible mobility solutions, high technological development and availability of cheap electric devices in their densely populated areas [10].

Typically, China, Japan, Indonesia, Arab countries where a significant number of publications were made. Europe also has a relatively high population density. It is good to know that daily commuting by public transport is popular in Western Europe, but big cities still suffer from traffic jams and poor air quality [11].

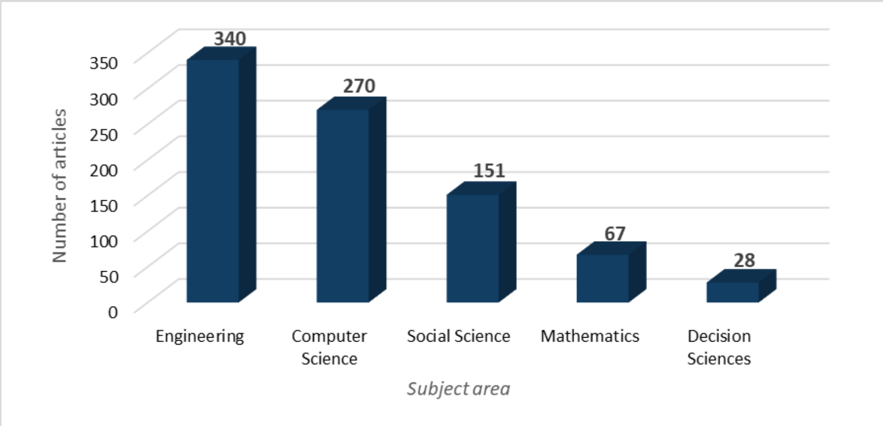

Figure 1. ITS 5 most affected subject areas

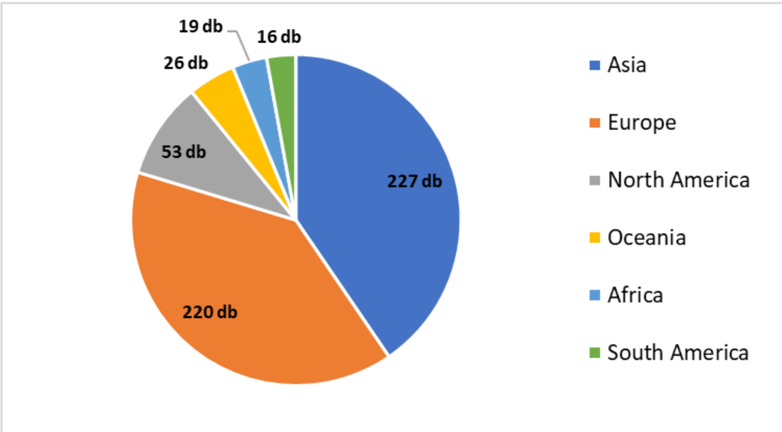

Figure 2. Number of ITS articles in the world

North America ranks third on the list, with more than 80% of the 53 ITS research are coming from the US. The other continents have written about 15-20 researches in this topic. It can be stated that due to the explosion-like population growth and migration to the city characteristic of these areas, it may become an upscale research area for ITS.

3. OFFICIAL DESCRIPTION OF ITS

The efficient operation of ITS can support the operation of logistics services, this fact is supported by the systematic literature research presented earlier. The main features are discussed in the following chapters.

3.1. Road transportation safety and information at macro level

The study of intelligent transport systems is multifaceted, as the applied intelligence must be able to provide / provide accurate data. On macroscopic level, ITS services are involved in the transport corridors. These networks had been established and mainly used in the paths of history in Europe and Asia, as these roads with large populations affected areas and joined other trade routes (Hansa-, Silk road etc.).

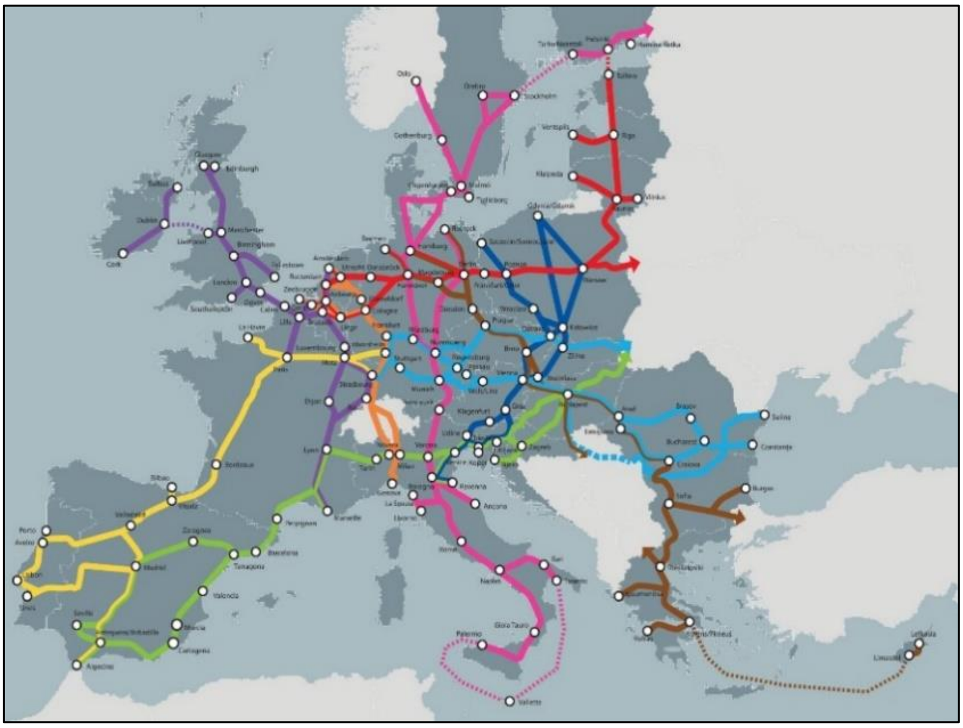

Figure 3. Trans-European Transport Networks [12]

Complemented by the Trans-European Transport Network (TEN-T) in the east, the so-called Helsinki corridors cover the entire European continent (Figure 3.). These are the transport corridors by road, rail and water alternatives according to the geographic features. In the case of international material flows and transport, it is essential to carry out cross-border transactions efficiently. This means increasing the degree of interoperability between states. Interoperability can be enhanced at national borders by speeding up processes, for example by waiving identity checks or by using uniform registration systems. Examples of a uniform system are the stranded use of toll obligations or train control systems in international rail transport [13]. In international passenger transport, processes at border crossings can be speeded up and even abandoned, but this fact is not true for freight transport. Congestions at border stations can result in delays of several hours in terms of delivery times, which has further negative effects on the industrial and other customer needs. With the help of an intelligent information system in the work of border station workers can also be facilitated, and drivers can make an optimal decision based on current information. In the case of using ITS the preferred decision proposal will be developed. At the same time, the role of ITS in road networks is also important, because it is a feature of motorways that traffic stops indefinitely due to a complete roadblock caused by an accident [14]. ITS systems can solve this problem by integrating e-call applications into an intelligent system. The e-call means “emergency call” when the car detects an accident then calling the emergency number in that region. (112 in the EU, 911 in the US, etc.) The e-call application also works, if the accident is caused by the driver's unconsciousness because the system dials automatically. The SIM card in the structure dials and forwards the exact location of the accident to the authorities [15]. As there is no possibility to turn back on the motorway, in the event of a road closure, it is necessary to inform as soon as possible how to prevent a fault beyond your control. Such information may be given with led signs or in a direct manner. Accidents and congestion can be conveyed through these systems, but also suggested route options, arrival times and other informative traffic messages. For example, is there free space in the next truck parking. The latter mode of information it can be a popular service according to the smart city concept.

3.2. Smart city conception

From ITS perspective, smart city is a mesoscopic service size. An integral part of the smart city concept is the service provided by ITS. An essential element of the term “smart” is gathering information about environment around us. For an intelligent system to be able to intervene or formulate a decision proposal, it is necessary to know its surrounding environment and its past and present state [16]. For data collection, the location of optimal data collection points and suitable data collection tools should be determined. Explaining the previous parking problem in more detail shows the difficulty of designing the ITS and smart city concept. There is an underground garage with a maximum capacity, parking spaces with occupancy sensors, roadside real-time information boards to display the available capacity and the IT resource that serves this [17]. In the morning rush hour, the search for a parking space is in principle easier if the current occupancy of the parking garage can be read from the occupancy signs. If the information works directly on the basis of the information of the occupancy sensor of the parking spaces, then at 90-95 percent saturation the system no longer shows a realistic picture. It is likely that by the time the vehicle gets the garage there will be no more free parking space. More accurate forecast can be brought closer to the real status with information provided by even more data collection tools. Monitor the gates of the parking facility for all the vehicles entering and leaving. By collecting as much useful data as possible, an intelligent program is able to send the optimal decision proposal for information compared to the actual cases. Another possibility to carry on the previous line of thought is that a pre-secured parking space awaits the traveller in case of an individual request. Meso-level ITS systems also include the monitoring of public transport and its publication at the information level. Nowadays, information on the exact position of scheduled line is available with sufficient accuracy, and the forecast of arrival at a stop is determined with a tolerance of 1 minute. Further efficiency gains would be achieved if a smartphone application could also display delay of public transportation compared to traffic situations. This solution, if it is able to work with individual mobile phone route planners, would create another ITS solution to solve everyday traffic problems.

3.3. Traffic management

In the case of traffic management in micro-level transport systems, there are many ways to exclude conceptual and operational errors using intelligent transport systems. Traffic control it means, based on a logic, control is performed using uniform signals to start or stop commuters or vehicles. It can be done with human control (e.g. manual signalling device, police body signals, etc.) or with a programmed signalling device, the most common and standard device of which in road traffic is the 3-color traffic light [18]. Signs used in road traffic are known all over the world, but in addition to basic operation, they have various useful additional functions that increase the level of traffic safety. A useful additional solution when there is a timer next to a display indicator light. This solution is not an intelligent solution because it displays a predefined but public information. This countdown timer also provides useful information to road users in the case of green and red signals (like Figure 4.). This is a useful information for the drivers to be able to react quickly during start-up, thus increasing the throughput of the node. Furthermore, at the green signal, it supports the flowing traffic with information on whether the vehicle will cross the free signal, if not, there is enough time to stop safely (as Figure 4.). This function is also used with a flashing green signal in the last seconds of the green signal phase time (for example in Austria). Both procedures contribute to the minimization of accidents resulting from sudden braking and to fluent starting between phases.

Figure 4. Traffic light with countdown timer [19]

It is true that the previous example is not an intelligent solution, but the application of the solution refers to design intelligence. Intelligent traffic management requires traffic monitoring first. The design and creation of an intersection traffic light program is based on determining the amount of traffic. Traffic counting was initially solved by counting by physical presence. The appropriate indicator was estimated from the intensity of traffic in the morning / afternoon peak and off-peak periods. The lamp program was created based on these needs. Based on the data collection, the intensity of traffic passing through the directions / phases of the node can be determined. With the fluctuating nature of traffic and the possibility provided by technology, traffic counting habits have changed. Monitoring traffic with a sensor or detector can impact with the basic structure of traffic control programs [20]. The use of a detector indicates the demand in each branch and the system intervenes in the control to satisfy this (push-button or detector demand signalling). As the need demand, a substantially non-operating lamp program will be taken effect. There is a higher-level implementation of this that already belongs to ITS. But continuous monitoring and inspection of traffic is not enough for this. Immediate information processing and fast response about the saturation of directions and lanes can be used to flexibly change the signal signalling nodes' requirements, is the optimal signalling program. This proves that data processing is not an easy task so it can already be classified as BigData. Big data is about large amounts of data that change at high speeds and are very diverse, as is traffic. From the large amount of data, it is necessary to extract the appropriate decision support information, which also serves the optimal operation for ITS. This theory also proves that ITS has a high demand for software. In addition, the hardware capacity is not insignificant even and the data collection infrastructure. At this level, it is no longer enough to have sensor data, but monitoring with cameras, so that all elements of the road infrastructure and traffic are covered as much as possible [21]. By analysing this image with artificial intelligence, the traffic intensity can be determined. Analysis of visual images can also show additional relevant information such as vehicle categories, license plate identification, etc. Finally cooperative / interconnected micro-level ITS systems are able to provide throughput and transit time for entire high-traffic road sections by minimizing accelerations / decelerations.

3.4. Green side of ITS

One of the well-known goals of intelligent transport systems is to reduce the amount of noise and air pollution caused by transport. The future objectives of mobility and urban logistics include, first and foremost, the development of fixed-track transport and, secondarily, the development of the general public transport sector in the name of sustainability and health [22]. It is good to know that as a result of approach-oriented activities and large-scale railway developments, cars will not disappear from the roads either, so it is necessary to reduce these pollution by other technologies available. However, with the effective use of ITS, these pollutants shown in the figures below can also be reduced.

Figure 5/a. Noise pollution in Paris [24]

Figure 5/b. Air quality map [25]

It can be observed that the degree of noise pollution and poor air quality are mainly caused by surface traffic - the upper figures show that the greatest pollution occurs along busy roads. Aviation noise pollution only directly disturbs the area of surroundings of airports. Furthermore, rail transport pollutes its environment with significant noise effects, while direct air pollution from tram rail traction is not significant. In contrast, in both pollution, road transport plays a role in appearing in negative statistics. The greatest problem is greenhouse gas emissions from the side of road transportation is carbon (CO2) and nitrogen dioxide (NO2) emission.

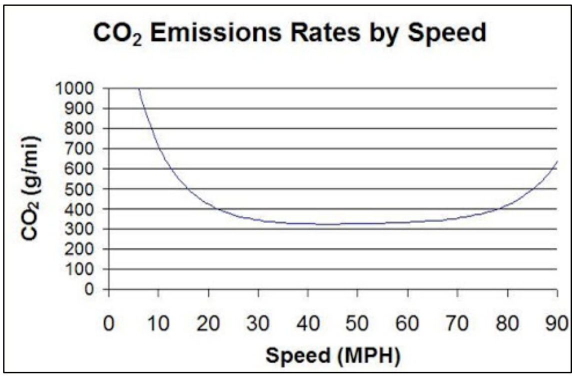

Figure 6. CO_2 emotion rates by speed [26]

Road transport vehicles emit the most noise and air pollution in the acceleration phase (as Figure 6.). So if traffic management is randomly organized (for example, in the case of inaccurate green wave programming), inadvertently, many accelerations and decelerations will increase greenhouse gas emissions, as if traffic were accelerating once to the mandatory maximum speed and upholding traffic outside the built-up area. So it depends on the programming or the reliability of increasingly intelligent traffic management (ITS) systems.

7. Conclusions

It can be stated that the topic of intelligent transport systems plays an important role in freight transport as well as in social mobility. In the framework of the present research work, using a systematic literature research method, it was possible to ascertain that this is a professional, social, scientific and legal side of ITS systems and a versatile and high-potential research area. This is evidenced by its functions, which also affect our everyday lives. Furthermore, the concept of the intelligent transport system confirms the theory that process development, the application of intelligent solutions, the integration of systems have a positive impact not only on the areas of transport, but also on its periphery.

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