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The impact of Intelligent Transportation Systems on road safety in Poland

Wpływ ITS na bezpieczeństwo ruchu drogowego w Polsce

Abstract. An Intelligent Transportation System is a modern solution which aims to improve the functioning of transport by, among other things: reducing congestion, shortening travel time, or improving road safety. This solution is used in many cities around the world, bringing economic effects and improving the comfort of life of the inhabitants. In Poland, as a result of the European Union's promotion of the development of intelligent transport systems through their co-financing, many cities have introduced such solutions. In the article, against the background of theoretical considerations, the impact of intelligent transport systems on road safety in the years 2014–2018 was analysed on the example of selected cities.

Key words: Intelligent Transportation System, cities, road safety

Synopsis: Inteligentny System Transportowy to nowoczesne rozwiązanie, którego celem jest poprawa funkcjonowania transportu poprzez między innymi: zmniejszenie kongestii, skrócenie czasu podróży czy poprawę bezpieczeństwa ruchu drogowego. Rozwiązanie to jest stosowane w wielu miastach na świecie, przynosząc efekty ekonomiczne, oraz poprawiając komfort życia mieszkańców. W Polsce w wyniku promowania przez Unię Europejską rozwoju inteligentnych systemów transportowych, poprzez ich dofinansowywanie, wiele miast wprowadziło tego typu rozwiązania. W artykule na tle rozważań teoretycznych przeanalizowany został wpływ inteligentnych systemów transportowych na bezpieczeństwo ruchu drogowego w latach 2014–2018 na przykładzie wybranych miast.

Słowa kluczowe: Inteligentny System Transportowy, miasta, bezpieczeństwo ruchu drogowego

Introduction

According to studies presenting world population forecasts, by 2030 almost 5 billion (61%) of the 8.1 billion people in the world will live in cities [Smart City... 2016, Eurostat 2019, Sumara 2019, Worldsensing]. This means that there will be more and more older people in cities, more cars, and more demand for transport services. This, in turn, will increase congestion, the demand for parking spaces, the number of road accidents and the deterioration of the environment. To address these risks, many cities around the world are introducing Intelligent Transportation Systems (ITS) to address urban transport problems and to pursue the Vision Zero concept [ISSA n.d.]. The implementation of Intelligent Transportation Systems solutions is having positive effects. In 1999 the Helsinki Public Transport Signal Priority and Passenger Information (HeLMi) system was launched. Six European cities participated in this programme. The energy savings achieved for all seven cities are equivalent to 57,000 tonnes of petrol [Szczukiewicz 2004]. In contrast, the application of the congestion charge introduced in London in 2003 reduced the size of the congestion in the toll zone by over 20% in 2006 already [Transport for London 2007, Ciepaj 2012]. In turn, in Kraków, after the implementation of the traffic management system, the driving time will be reduced. On the Kurdwanów–Krowodrza Górka route, where before the ITS implementation the scheduled driving time was 42 minutes, it has decreased to 36 minutes [Selwon 2017]. Also, more and more cities in Poland have this type of solutions, which improves the functioning of transport.

The aim of the article is to present ITS solutions introduced in selected voivodeship cities and an attempt to assess their impact on the number of road accidents in the years 2014–2018. The research methods adopted for the implementation of the problem are a diagnosis of the subject literature and documents and an analysis of quantitative data showing the discussed problem.

The Intelligent Transportation Systems concept and its benefits

The concept of Intelligent Transportation Systems was introduced at the first World Congress on Intelligent Transport Systems in Paris in 1994. It denotes systems that represent a wide range of different technologies (telecommunications, IT, automation and measuring) as well as management techniques used in transport in order to increase the safety of traffic participants, increase the efficiency of the transport system and protect environmental resource [European Communities 2004, Koźlak 2008, B.W. n.d.]. Since then, a variety of studies on ITS implementation and the desired and obtained benefits have been developed [Grant-Muller 2014, Kolosz 2015, Mitsakis 2015, Alrovi 2017]. These studies indicate specific groups of services (Table 1) resulting in specific changes (Table 2) [Oskarbski 2006, Koźlak 2008].

Among the presented effects of the implementation of intelligent transportation systems, the benefits related to the improvement of road safety are clearly visible, reaching up to 80%. The area of road safety is one of the most important from the European Union's point of view [Directive 2010/40/EU…]. Intelligent Transportation Systems should include systems that promise the greatest potential for improving road safety, such as automatic speed supervision, intelligent speed adjustment, collision avoidance systems, and lane and track keeping assistance systems. Infomobility [Drive Safely…] is an important solution in this area [Smirnov et al. 2014]. In a study conducted in the UK it was discovered that reducing the average speed by 3 kph every year in Europe would save the lives of 5,000 to 6,000 people and allow for avoiding 120,000 to 140,000 accidents,

Table 1. Division of Intelligent Transport Systems according to ISO TC 204
Tabela 1. Dział inteligentnych systemów transportowych zgodnych z ISO TC 204

Category of services	Service number	Service name
Traveller information	1	pre-trip information
	2	on-trip driver information
	3	on-trip public trasport information
	4	personal information services
	5	route guidance and navigation
Traffic management	6	transportation planning support
	7	traffic control
	8	incicdent management
	9	demand management
	10	policing/enforcing traffic regulations
Vehicle	12	vision enhancement
	13	automated vehicle operation
	14	longitudinal collision avoidance
	15	lateral collision avoidance
	16	safety readiness
	17	pre-crash restrain deployment
Commercial Vehicle	18	commercial vehicle pre-clearance
	19	commercial vehicle administrative process
	20	automated roadside safety inspection
	21	commercial vehicle on-board safety monitoring
	22	commercial vehicle fleet management
Public transport	23	public transportation management
	24	demand responsive transport management
	25	shared transport management
Need for assistance (Emergency)	26	emergency notification and personal security
	27	emergency vehicle management
	28	hazardous materials and incident notification
Electronic Payment	29	electronic financial transaction
Safety	30	public travel safety
	31	safety enhacement for vulnerable road users
	32	intelligent junctions

Source: own work based on: [McQueen 1999, Bartczak 2004].

Table 2. Effects of Intelligent Transportation Systems
Tabela 2. Efekty inteligentnych systemów transportowych

Effect of application	Type of ITS application	The scale of the effect
Increase in the capacity of the street network	Highway Traffic Management System	up to 25%
	alternative route guidance system via variable message signs	up to 22%
	use of electronic toll collection (compared to traditional methods)	200–300%
Reduction of time loss in the street network	use of traffic lights	up to 48%
	control systems at highway entrances	up to 48%
	traffic incident management systems	up to 45%
	use of electronic toll collection systems (compared to traditional methods)	up to 71%
	priority of traffic lights for public transport vehicles (in addition to the reduction of time loss, it allows to increase punctuality up to 59%)	up to 54%
Improvement in road safety (reduction of accidents)	speed surveillance cameras	up to 80%
	traffic control at highway entrances	up to 50%
	advanced traffic control systems	up to 80%
	traffic incident management systems	up to 50%
Improvement of the effectiveness of rescue services	application of incident management systems and rescue services to reduce time of: − vehicle detection − the emergency services' travel arrangements	 up to 66% up to 43%
	application of automatic vehicle location systems for rescue services and vehicle navigation to the accident site – reduction of travel time	up to 40%
Environmental impact	demand management systems – reduction of exhaust emissions	up to 50%
	highway traffic management – reduction of fuel consumption	up to 42%
	urban traffic management systems – reduction of exhaust emissions	up to 30%

Source: own work based on: [Koźlak 2008].

which would generate savings of EUR 20 billion [Jamrozik 2008]. The effects of actions concerning ITS and improvement of road safety were presented in the report on Support study for the ex-post evaluation of the ITS Directive 2010/40/EU [Tsamis et al. 2018]. According to the annex to the aforementioned document, the pace of changes in Poland in 2017 in this area was slower as compared to 2004. Sweden, in particular, is very active in this area and achieves high road safety rates [Komenda Główna… 2019].

ITS in selected voivodship cities in Poland

Intelligent Transportation Systems are being implemented in many Polish cities. These were introduced particularly intensively in the years 2007–2015, among other operational programmes co-financed from European funds allocated for the period of financial perspective 2007–2013 [Centrum Unijnych Projektów Transportowych]. The EU's support resulted in the implementation of many ITS subsystems in almost all voivodeship cities. The scope of these implementations is presented in Table 3.

Table 3. Selected ITS subsystems implemented in voivodship cities in Poland
Tabela 3. Wybrane podsystemy ITS wdrożone w miastach wojewódzkich w Polsce

City	Signalling control sub-system	Induction loops	Subsystem for driver information using variable message signs	Video surveillance subsystem	Subsystem for vehicle registration at red light	Sectional speed measurement subsystem	Temporary speed measurement subsystem	Recognition of registration plates	Vehicle dynamic weighing subsystem	Parking information subsystem	Meteorological information subsystem	Early detection of traffic events subsystem
Białystok	×	×	×	×	×	×	*	×	*			×
Bydgoszcz	×	×	×	×		×		×		×	×	×
Gdansk	×	×	×	×	×	×	×	×	*	×	×	×
Gorzów Wielkopolski	*	×										
Katowice	×	×	*	×				×	*			
Kielce	×	×										
Kraków	×	×	×	×			×	×		×	×	*
Lublin	×	×	×	×		×		×				×
Łódź	×	×	×	×		×	×	×	×	×		×
Olsztyn	×	×	×	×	×		×	×		×	×	×
Opole	×	×	×	×				×	×	×	×	×
Poznań	×	×	×	×	×	×	×	×	×	×		×
Rzeszów	×	×	×	×	×			×	×	×	×	×
Szczecin	*	×	×	×					*		×	×
Toruń	×	×		×								
Warsaw	×	×	×	×			×	×	×	×	×	×
Wrocław	×	×	×	×	×	×	×	×	×	×	×	×
Zielona Góra*												

*cities currently designing intelligent transportation systems.

Source: own wok based on [Tomaszewska 2016, Motofakty.pl 2017].

The scope of the works introduced varies greatly from city to city. In Warsaw, the Integrated Traffic Management System has been operating since 2008. Szczecin has had the system since the end of 2012. At the end of 2015, the cities of Gdynia, Gdańsk and Sopot launched their own ITS (Tristar), and so did the city of Białystok [Fabisiak 2016] in June of the same year. In Gdańsk, Sopot and Gdynia at the end of 2015, shortly after the launch of the Tristar system, the time of travel by public transport has decreased by 6.5%, and by car – by 5.5%. The system was designed to give priority to public transport vehicles [Fabisiak 2016]. In Białystok, as the only city in Poland, the system covered the entire city area. Such solution allowed for comprehensive control and better timing of traffic signalling. In the Tom Traffic Index report for 2016, Białystok turned out to be the least congested city among those that implemented ITS systems in Poland [Krawczyk 2017], and in the 2019 report it was one of the few cities in which the congestion increased by only 1% [Tomtom 2019]. Positive effects of ITS implementation were also confirmed in Bydgoszcz. The basic objective of the project was to shorten the time of travel by tramway transport by 8.3% and motor vehicles by 6.0%. As a result of the introduction of the system, the time of travel by tram was shortened by about 13% and by about 31% for motor vehicles [Oficjalny Serwis Bydgoszczy 2019]. In Rzeszów, in turn, the implementation of ITS contributed to the increase in punctuality of public transport vehicles from 50 to 80% [Madej 2018]. In each of the cities where an ITS system has been implemented, positive changes in various areas of transport functioning were observed.

Impact assessment of intelligent transport systems for road safety

The theoretical considerations and the presented implementations in voivodship cities show that many of them have systems affecting road traffic safety. Table 4 presents the number of passenger cars in selected cities in Poland in the years 2014–2018.

As can be seen from the table, the number of cars in all listed cities has increased. The cities with the highest number of vehicles are Warsaw, Kraków, Wrocław, Łódź and Poznań. The increase in the number of passenger cars and transformations in the road infrastructure affect the number of road accidents. Data concerning the number of road accidents show that the number of road accidents did not decrease in every city where an ITS was implemented (Table 5).

The data presented in the table show that the highest number of accidents per 100 thousand inhabitants takes place in Łódź, Rzeszów and Poznań. In some voivodeship cities in 2018, as compared to 2014, the number of road accidents has increased. These are such cities as: Białystok, Gdańsk and Poznań. The biggest increase in the number of accidents can be observed in Poznań. The causes of road accidents in this city are: failure to give the right of way, failure to adjust the driving speed to road conditions, incorrect lane change, incorrect reversing, and failure to maintain an appropriate distance between vehicles [KaT 2020]. Despite the fact that Poznań has an ITS system, the number of road accidents increased significantly. The reason for this situation may be the fact that the system covers only a part of the city as well as the increase in the number of passenger cars. Out of the 18 examined cities, only three observed an increase in the number of accidents, while in the remaining ones there is a decrease in the number of accidents, which despite the increase in the number of cars and road renovations carried out in many cities may indicate that an ITS system improves road traffic safety.

Table 4. Number of passenger cars in selected cities in Poland in the years 2014–2018 [pcs.]
Tabela 4. Liczba samochodów osobowych w wybranych miastach w Polsce w latach 2014–2018 [szt.]

City	Year				
	2014	2015	2016	2017	2018
Białystok	111 480	116 510	122 421	127 969	134 603
Bydgoszcz	182 640	188 143	194 402	200 554	208 691
Gdańsk	250 545	255 176	265 308	275 418	288 384
Gorzów Wlk.	62 188	63 792	66 878	69 369	72 963
Katowice	180 879	189 419	199 139	208 617	216 348
Kielce	89 085	92 658	97 343	102 079	107 211
Kraków	406 925	424 026	448 004	468 657	494 021
Lublin	158 361	164 618	172 128	180 399	189 281
Łódź	341 170	351 870	365 931	380 267	396 349
Olsztyn	78 621	81 335	84 701	87 598	91 604
Opole	71 894	74 322	77 610	83 381	88 156
Poznań	327 748	338 984	356 788	371 610	388 958
Rzeszów	86 437	90 973	96 672	103 057	108 750
Szczecin	189 720	197 426	205 779	214 074	223 160
Toruń	91 973	95 247	99 307	103 487	108 108
Warsaw	1 075 500	1 131 120	1 194 068	1 261 803	1 332 923
Wrocław	365 058	381 831	403 063	420 935	442 005
Zielona Góra	60 251	65 194	70 298	75 175	80 335

Source: [GUS, Bank Danych Lokalnych].

Table 5. Number of road accidents in voivodship cities in Poland in the years 2014–2018 per 100 thousand inhabitants
Tabela 5. Liczba wypadków drogowych w miastach wojewódzkich w Polsce w latach 2014–2018 na 100 tys. mieszkańców

City	Year				
	2014	2015	2016	2017	2018
Białystok	46.7	51.8	53.0	54.9	53.1
Bydgoszcz	58.3	55.7	50.4	37.9	48.7
Gdańsk	115.2	109.4	108.6	112.2	118.8
Gorzów Wielkopolski	53.1	41.1	50.8	45.2	37.8
Katowice	91.7	93.4	102.7	85.5	85.3
Kielce	142.9	148.6	142.6	129.7	130.4
Kraków	151.0	151.7	154.6	135.0	125.9
Lublin	65.3	58.3	64.9	62.3	62.1
Łódź	252.8	243.9	245.3	232.5	228.3
Olsztyn	152.8	140.7	169.9	148.6	147.9
Opole	148.3	125.6	132.0	113.9	130.2
Poznań	54.5	56.2	79.2	166.1	161.1
Rzeszów	221.6	207.3	218.2	224.7	164.5
Szczecin	151.9	136.6	112.2	127.1	108.6
Toruń	32.0	21.2	32.6	26.2	26.2
Warsaw	64.3	55.3	52.4	61.0	62.3
Wrocław	102.0	87.3	90.9	88.5	93.5
Zielona Góra	60.7	67.7	59.0	67.4	38.5

Source: [GUS, Bank Danych Lokalnych].

Summary

The considerations carried out in the paper allowed to indicate a few conclusions and generalisations below.

- Intelligent Transportation Systems have been deployed worldwide for many years and the reasons for this are the growing urban population and the desire to improve communication, travel, and life.
- In Poland, the implementation of intelligent transport systems related to obtaining funds for this purpose under the EU programme. Many cities have used the funds for this purpose, including almost all voivodeship cities, introducing solutions to a varying extent in order to reduce congestion, the number road accidents, and travel time.
- The implemented solutions have improved the functioning of the city transport in various areas. The main benefits relate primarily to the reduction of travel time by public transport.
- The analysis of quantitative data concerning the number of accidents per 100,000 inhabitants in the surveyed cities indicates that out of 18 cities under consideration, only in three of them was there an increase in the number of accidents per 100,000 inhabitants, a statistic which should be considered a positive factor in ITS implementation.
- In order to clearly indicate the impact of ITS on the number of road accidents, especially in Poznań, it seems reasonable to carry out detailed research, as to indicate the main causes of the increase in the number of road accidents.
- It should be noted that the deployment of ITS is virtually an ongoing process resulting from the social needs on the one hand, and the growing capabilities of the system on the other hand, and these factors may influence the development of subsystems that will have a significant impact on improving road safety in cities.

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