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ITS as a market of development and cooperation opportunities in the field of innovation - a study based on the OPTI’CITIES project

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ABSTRACT
This paper presents stipulation of cooperation intensifying operations on the supranational, public and private level as in Opticities project, which is a cooperation of 6 European cities implementing ITS systems. Namely: Madrid, Lyon, Birmingham, Turin, Gothenburg, Wroclaw and research and development units. The main task and goal for Wroclaw will be a supervision over a realization of comprehensive vehicle’s identification project and a research verifying systems’ efficiency made by Neurosoft and Volvo France. One of crucial elements of the subsystem will be the technology of ADR boards video-identification – informing about dangerous substances or goods transported as a freight load.

KEYWORDS: ADR, dangerous goods, cooperation

1. The value and potential of the market

ITS, as an infrastructural branch of major importance is a well developing and promising market despite the economic crisis. Due to the assumption of systems inclusiveness mechanisms and products offered in the ITS global markets are characterized by interoperability, which gives the manufacturers and integrators opportunities of global development of their products and services. Industry reports estimate the global market of ITS will rise to $24 billion by 2017 with a growth rate of 12% per year.

At the EU budget summit held on February 7th-8th Poland was granted nearly 73 billion Euros which will be administered in the field of aid funds and commonality policy grants in the years 2014-2020. Thus, the current concern about the lack of finance for the development of infrastructure and new technologies, including telematics problems in the country, have been temporarily allayed. This allows a more optimistic planning of the development of innovative technologies and methods that will help to minimize the gap between the infrastructure of Poland and its western neighbors in the entry into the third decade of the twenty-first century.

The regular or congressional opinion-forming bodies are to implement the strategies that which enable this objective. The responsibility for the implementation of projects is assumed by all the sector entities, both public and private, which contribute to the overall performance of the work associated with the construction of roads, intelligent transport systems, communication systems and road safety. Apart from the implementation of trans-national cohesion strategies, each of the institutions and companies should have its own strategy for the development with a clearly marked target in the decade in which the subsidies with whole certainty will no longer be granted. Each of the actors of the market should be able to answer the question: ‘where will you be in 10 years and what goals will you have reached by that time?’
2. The EU’s role in the creation of ITS – creation of the development strategy

The tasks all industry entities will face lie, at least in part, within the decision-making framework of the executive bodies set up by the European Commission. One of the documents formulating such a strategy is ‘The ITS Deployment Road Map’ as of December 10th, 2012 issued by the the EasyWay Technical Coordination Team headed by Jonas Sundberg.

The report was prepared by the EasyWay Technical Coordination Team (TCT) as the implementation of the second part of the project under the same name. The report was a joint work of the TCT team and expert teams, analytical teams and business associates.

The data collected in this paper was to present a “balanced” prospect of the ITS development and the possibilities of deployment of such services in Europe in the next decade. The leading role in setting the strategy was and will be played by the authorities and operators of roads in particular countries - in Poland it is the GDDKiA which also functions as an architect, placing orders and coordinating the work of the relevant working groups in the creation of a national infrastructure development strategy. The priorities and actions proposed in this strategy to a large extent reflect the views and elaborated models of groups organized around the ITS Poland association.

The findings and conclusions drawn from the above-cited report, expressed mainly in the form of sketches of the stages of development, should not be seen as an absolute obligation, as they reflect differential assumptions regarding the regional development in terms of technological, economic and political life. This and any other development strategy should reflect the perspective of a particular time and must be updated in the course of time.

It is worth paying attention to two aspects raised in the document: 1. the enumeration of the various generations of ITS, whose arrangement answers the question about the target stage of development of particular branch for the moment, and 2. the current schedule for the development of technology – how we should look at the ITS industry in technological and product aspects.

Naturally, also in the context of their own business and the projects being implemented.

The differences between particular generations of ITS are not clear and the specific subsystems or services may belong to more than one generation. The following description can be considered an illustration of the predictions based on the status quo, rather than a rigid definition of the stages of development. Eventually, plans are subject to change.

Generation 1: Lack of coordination of investment and exploitation

The implementations of ICT services in the daily routine work are dealt with by responsible entities (mainly road operators, public transport operators, etc.). Systems and services are locally limited and implemented without the harmonization or coordination from the national level.

Generation 2: Harmonization of services

Services are developed in accordance with the common specifications and standards, offering harmonized services (e.g. common look and functionalities). The service deployment is still uncoordinated and is subject to discretion and individual decisions of the stakeholders.

Generation 3: Harmonized services, coordination in the initial stage

Services are developed in accordance with the specifications and standards. The coordination of the implementation is established according to certain priorities, in specific nodes, in the cities etc. where coordinated traffic and transport management is in operation. Promoting integration has been initiated, which ultimately enables e.g. multimodal and cross-border services for travelers.

Generation 4: Harmonized services, full coordination, partially integrated systems

Coordinated implementations (for key network elements) on the basis of commonly agreed plan. The actors’ activities strive towards establishing a European road transport system based on interoperable services. The system integration is still limited to dedicated cross-border corridors, urban areas, etc.

Generation 5: Full integration

All ITS systems are integrated and active. Each new vehicle interacts with the system automatically, regardless of the jurisdiction of the subsystem, country of origin etc.; the system is also able to manage the generic structure of both new and older generation vehicles. Drivers are free to use the information function and the traffic monitoring function of the system through their on-line system connection.

Generation 6 Further development

In the context of the above-mentioned generations a timetable of implementations which are crucial for the development of interoperable and multimodal ITS system has been drawn up. Below there is the schedule adopted by the cited Easy Way document where ‘milestones’ of the most important implementations have been marked. In the context of architecture development, data exchange protocols and basic traffic information:

2013 Creation of specifications for parking management systems.
2014 Completion of work on dictionaries of urban information for travelers in accordance with the DATEX II protocol.
2015 Completion of work on dictionaries of access limitations according to the Datex II protocol.
2015 Specification of the interfaces within the European Road Information.
2015 Definitions and quality criteria for linking the data available in the standards of detection levels and the quality of vehicle classification.
2015 Specification of interfaces concerning data exchange in European traffic routes (vehicles’ weight, weather conditions, time of travel, etc.) and metadata formats.
The prevalent and availability of traffic information on a European scale.

Datex II protocol availability on a European scale.

Transfer of existing and projected traffic conditions through integrated transmission facilities on a European scale.

Static speed limit standard on a European scale.

Implementation of the monitoring standard and road traffic management within 75% of the integrated road network.

Dynamic speed limit standard available in the European network.

In the context of the development of standards for technologies and products working as a measurement and communication field infrastructure:

2014 Development of minimum of standards for safety signs.

2015 Development of standard symbols and pictograms for safety signs.

2015 Development of standards of variable message signs (VMS) for technology and communication.

2015 Presentation of the proposed standard of information transmission to vehicles within the Smart-Drive Systems.

2015 Creation of pilot transport corridors being part of a multi-modal transport environment.

2016-2017 Complete monitoring of critical, selected sections of the road network.

2017 Implementation of information and traffic incidents management system.

2019 Creation of alternating traffic lanes management systems in the Easy Way road network.

2019 Standardization of interfaces (symbols, pictograms) on an European scale.

2019 Implementation of complete infrastructure management systems on the roads within the TEN-T program.

2019 Dynamic regulation of the allowed speed.

3. Innovative solutions – trends

Intelligent transport systems improve the overall transport infrastructure through the use of a wide range of, usually innovative, technological aspects. The use of navigation, vehicle identification and communication technologies such as the Global Positioning System (GPS), Dedicated Short Range Communication (DSRC), Make and Model Recognition etc. applied in the ITS improve the functioning of the monitoring and informing the drivers and vehicles. Increasing achievements in the field of environment and economy have also had a positive impact on investment in the intelligent transport systems market.

The main systems of the ITS market are those related to:

- Advanced Air Traffic Management Innovations (ATMI),
- Advanced Travelers Information System (ATIS),
- system of price regulation for the use of roads and toll collection, Advanced Public Transportation Systems (APTS) and Commercial Vehicle Operations (CVO).

Among these types of traffic management, public transport systems and their operation are the areas seen and implemented by the European Commission as the priority ones. Management of commercial vehicles fleets will gain importance in the near future due to constant improvements in transport infrastructure and in the logistics industry.

Currently developed and implemented applications in accordance with the directions of the development of the ITS market are primarily the fleet of vehicles monitoring and management, vehicle collision avoidance systems, traffic lights control systems and variable message signs systems, parking management systems and traffic safety systems. Priority and specific “fashion” for the implementation of such applications as the first ones in the developed ITS markets show the experience not only present in Poland, but mainly of the countries which are more advanced in the development of ITS, such as the USA, Canada, Germany, France, England or Japan. The main aim of the ITS architects in these countries is creating conditions for a smooth flow, traffic congestion, comfort and road safety.

The subject of the cited Easy Way report and its main objective was to identify indirectly the stimuli and limitations of the growth opportunities of the intelligent transport systems market. A positive identification of trends and key factors of the success in the industry is namely necessary and possible only because of the EU investment in research and development. Participation and investment of public institutions and companies (usually these initiatives are combined) in the areas of R&D create a profile of activity in particular areas and suggest the choice of the strategy of development for interested and already participating parties, especially investors and direct beneficiaries such as: Road Transport Inspection (ITD). Reports in the form of documents, such as that issued by Easy Way, constitute a specific list of market players and their objective assessment from the transnational perspective. They emphasize the properties of checked and problematic solutions related to intelligent transport systems and their interoperability at the European level as a target.

Research&Development works and implementation of as many entities as possible within the cited specifications will result in earlier achievement of the jointly agreed objectives; moreover, they will improve and mark the marketers’ strategies.

4. OPTI’CITIES – description of the project

An example of such cooperation intensifying efforts at transnational, public and private level is e.g. a project subsidized by the 7th framework programme called Opticities. The European Commission experts evaluating the projects submitted to the competition chose and allowed the co-operation of six European cities implementing ITS systems. They are: Madrid, Lyon, Birmingham, Turin, Goeteborg and Wroclaw. Apart from them, Research&Development units of public and non-public nature also take part in the project.

The vision of the Opticities project is to assist in the infrastructural development European cities with the assumption of development and testing easily transferrable innovative solutions adding value to the existing functionalities and using
them complementarily. ‘Opticities strategy focuses on optimizing the transport network through the development of public-private partnership and suggesting solutions for user-friendly passenger and transport solutions’ - says the document submitted to the commission assessing the projects in the competition.

Opticities assumes innovation in terms of:
- a new management model between private-public entities through creating a data exchange architecture, its quality and access to it;
- developing a European standard for multi-modal urban solutions in the context of data exchange and the exchange of data of common interfaces;
- presentation of predictive tools and support of the decision-making process in the management of transport in the form of multimodal Traffic Control System combined with the acquisition and analysis of data in urban traffic;
- creation of multimodal navigation working in real-time, integrated with route recalculation systems and their presentation in vehicles - it will be the first such attempt in the world - the leader of this solution is the city of Wrocław with engineering support of Volvo France and Neurosoft;
- implementation of pilot navigation in the urban transport and delivery to support drivers and fleet operators in optimizing schedules and distribution.

The European nature of the project is ensured through participation within a consortium of 23 partners from eight member states. The consortium includes six cities and other ITS industry entities (research institutes, manufacturers of hardware and software solutions and automobile manufacturers), as well as public roads and road transport operators.

The increase of the efficiency of systems run under the supervision of public supervisory bodies will be measurable in terms of: the increase of the systems’ performance in 5 years, the integrity of the systems and services of particular cities, the transferability of the results to be implemented in other European cities.

In the preparatory stage the efficiencies that should be met after the successful completion of the implementation stage were established. It is essential to remember that it is planned for a period of three years, which can make it difficult to measure and verify it in terms of the parallel work carried out. However, the effectiveness of the methods will be reflected in the following numbers accepted:
- reduce of CO2 consumption by 1.5 MT among the cities participating in the project due to the 6% modal change of means of transport;
- increasing market demand of 211 million Euro per year through the modernization of methods of design and implementation stages management, as well as the increase of implementation capacities of innovative products;
- 10% reduction in use of private cars which will generate 3.6 million square meters of public space in the partner cities.

4.1 The role of Wrocław and partners

The task and the main purpose of Wrocław is to supervise the project of creating the comprehensive vehicle identification station and to control the research aiming at verifying the efficiency of the systems implemented by Neurosoft with the cooperation of Volvo France.

The basis for the submission of such idea was observation of the current realities of traffic in metropolises and medium-sized cities. The increase in traffic in recent years has a negative impact on the public and private transport environment, which is a visible fact to every road user. Difficulties in public transport are caused by the constant increase in the number of the vehicles in the urban areas. The organization of urban traffic is characterized by inadequate to the real needs development. These trends result in a kind of ‘narrowing’ of urban infrastructure, slowing the traffic down and increasing the overall transportation costs.

Preventing the future problems anticipated on the basis of the current situation and report forecasts must result in actions aiming at avoiding serious communication difficulties and, in their context, social difficulties in the next decade. The implementation of multimodal transport rules should help in addressing current and future tasks of the traffic engineers. Transition of traffic management systems in the urban infrastructure (and not only) certainty requires telematics technology upgrades. Architecture of the road network, particularly in Western Europe is a more or less closed subject.

Implementing instruments for direct precise multi-threaded and individual analysis of the traffic flows, vehicle structure and the meteorological situation will add to the IT structure of the system the data necessary for a comprehensive analysis and prediction of the traffic congestion by reducing and minimizing travel times. The innovative solutions proposed by Wrocław in the OPTICITIES project are based on the acquisition of data collected on the main road of city entrances. Integrated data will be used to make the traffic more smooth and to improve safety being also a support tool for traffic engineers. The methodology and innovative techniques for identification of vehicles are discussed in the next section.

The system, as seen by the user, will support the driver in making decisions regarding the choice of the route, and in special cases, e.g. for vehicles carrying dangerous goods or vehicles with non-standard dimensions, weight or shape the system will order the driver to apply to the guidelines. A positive factor is the system alarming of the truck drivers who do not comply with the non-standard dimensions, weight or shape the system will order the driver to apply to the guidelines. A positive factor is the system alarming of the truck drivers who do not comply with the road guidance transmitted in the form of alarm messages. Such exceptions will be caught by extra video-identification points and directed to the designated recipients.

4.2 Methodology of the data preparation and presentation

The message transmitted over a communication device to a commercial vehicle driver will contain information concerning the vehicle (class, make, model, weight, height, the fact if it is carrying dangerous materials) and the route which was intended
as the most optimal concerning the time travel for this vehicle in the city structure. The information transmitted in real-time is to improve the urban traffic. Creating routes designated for carriers of goods is to relieve other routes. The Volvo freight management system will be one of the components used to build a fleet management system of freight vehicles in Wroclaw. It will be based on the data provided by measurement devices in the form of .xml files. The .xml file will contain the integrated data from measurement devices in the form of:

- quartz pressure sensors;
- laser scanners (outlines of objects);
- digital cameras (video-analysis);
- induction loops (an electromagnetic spectrum), will serve as input data to the automatic transit system operation.

At the stage of the project submission the following preparatory implementation and analysis methodology was adopted:

1. the analysis of system and functional needs;
2. design and construction of the model (mockup);
3. interfaces and communication protocols adjustment in order to integrate the sources and recipients;
4. identification of quality requirements for automatic image, weight and shape analysis systems;
5. adjusting the algorithms to the primary and secondary image processing to use a variant MMR method;
6. adjusting the algorithms of vehicle search in the image, object tracking, class and make and model identification with the use of the so-called hybrid techniques, that is with the use of additional identifying instruments (laser and quartz sensors);
7. development of research on the algorithms of vehicle's consistent model and make classification using the hybrid method:
   - classification based on morphological characteristics;
   - classification on the basis of a detailed image;
   - classification based on the 3D model;
8. development of algorithms for color classification of the vehicle:
   - analysis of the histograms of color occurrence;
9. improvement of ADR plates detection and reading
10. use of the image analysis for identification and classification of the road users;
11. use of automatic analysis of the pressure sensors for vehicles identification and classification;
12. use of automated analysis of laser sensors for measure the vehicle contours;
13. creating a method of fast transmission, circulation and the archiving of data;
14. proposing methods of data presentation.

4.3 An example of research issues - ADR plates reading

One of the essential elements of the vehicle identification and routing subsystems will be the technology of ADR plates (indicating the hazardous substance or goods carried as freight cargo) video-identification. This software element, originating from DSP techniques will be in particular dealt with by engineers from Neurosoft – a company having more than 20 years of experience in OCR technology based on neural networks.

Transportation of dangerous goods poses potentially higher risk of hazards on the road. The number of vehicles carrying goods continues to increase along with the increasing volume of traffic on the roads. Therefore, the knowledge of the routes (when, where, what dangerous goods are transported, the number of vehicles) through critical sections of the road network such as tunnels, bridges or urban areas is essential for the processes of traffic management and safety.

The A annex to the international convention on the transportation of goods and ADR dangerous substances (drawn on Geneva on September 30th, 1957, ratified by Poland in 1975, reapproved every two years, currently applicable in 46 countries) – contains a division of all hazardous materials manufactured in the world into 13 classes of risk (and detailed classification of these materials in particular classes). Additionally, this Annex sets out general and specific conditions of packing hazardous goods, requirements for labeling products, packages and vehicles carrying dangerous goods and the conditions for technical examination of packages and their special labeling.

The document also contains a list of all known dangerous materials that may be transported on public roads along with the unequivocal UN numbers assigned to them. The algorithms directing or alarming vehicles that are subject to load restrictions will be based on those guidelines.

Each transport company is obliged to place on the vehicle the ADR plate with its UN number and the designation of the hazard type corresponding to the transported cargo. ADR plate is usually mounted in front of the hood and the back of vehicles. ADR plate (orange reflective signboard placed on vehicles carrying dangerous substances) contains two identification numbers of transported substances, that is:

- hazard identification number - two or three digits (in the numerator);
- Material identification number - four digits (the denominator).

Standard plate size is 40x30 cm.

If hazardous substances are transported in specially marked containers or tanks, no additional information (codes / signs) are required to be placed on the ADR plate on the back of the vehicle - the markings are on the side of vehicles or containers.

All known automatic ADR plates recognition systems based on video-detection detect in the first stage the presence of the board on the image, then with the use of a variety of algorithms they recognize sequences of characters that appear on it (OCR). Due to the detection method they can be divided into two main groups - in the solutions available on the market there are different alternatives using elements of each of them:

- Analysis of each image/frame for the presence of the ADR plate;
- Recognition of the vehicle carrying hazardous materials with the use of other methods (laser) and then initiation...
(triggering) of one or a sequence of images containing an ADR plate.

In both cases the camera must be equipped with an infrared radiator so that the identification of the plate can be carried out in low light or no light conditions.

The position of the ADR plate in the image is determined on the basis of so-called characteristic signs of dangerous materials (length to height of the plate ratio, the regularity of occurrence of certain horizontal and vertical lines). It is essential to take into account the signs of unusual dimensions - the so-called small ADR plates. In this context it is problematic to recognize an empty plate – with no special signs - because they are easily confused with warning plates.

The system performs the reading of the material identification and hazard number with the use of OCR algorithms which analyze pre-selected areas, defined as places with a high probability of plate occurrence. If the system detects the presence of the plate and the result of the OCR recognition is not satisfactory the next frame / next image is automatically analyzed - until a better quality numbers recognition is achieved.

At the end of 2009 there were three measurement points in Germany equipped with a system which automatically identifies vehicles carrying dangerous materials. The promising results of the tests conducted at these points will contribute to the research conducted in Wroclaw.

5. Conclusion

In the international research and development activities carried out in Wroclaw public-private partnerships are included in the European strategy for the development of the ITS and expansion of transport infrastructure in accordance with its assumptions. Improving and testing the innovative technologies in urban areas will be an added value. The ultimate goal will be to multiply the most effective solutions as standard ones. In this way, in the public context the condition of interoperability will be met which will be a unique opportunity for innovative companies of fully protected implementation of public procurement of proven and very often unprecedented solutions into the market.

This great objective will be achieved in three years which will be a time of fascinating and ambitious tasks taken on the scale not practiced in the industry so far.

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ABSTRACT
The authors presents a description of the implemented project Intelligent Transportation Systems (ITS) in Bydgoszcz. Mainly it describe the purpose and functions of various segments of the System posed. The content is based on the concept and technical specifications of the project.

The paper consists of a diagnosis of the existing transport infrastructure of the city along with cause difficulties in traveling. Also raised issues of public transport infrastructure occurring in the city. Lists the existing constraints in organizing bus and trams connections in the city. Drew care in the middle of doing and planning investments in improving the operation of trams.

The following section presents an area, which there will be a draft System. Principal explanation shall be posed the tasks and goals of the implemented project and the results, that will be achieved by running a traffic control center and public transport. Describing the implemented ITS project consists of a presentation of the different sub-systems in the area of: traffic control by devices functioning of ITS, giving priority to pass through the junction for selected transport measures, constant traffic monitoring using video observation, public transport management, support for dynamic passenger information at bus stops and website, display information about the occupancy of parking space and display short messages informing about any obstacles on the way and guiding drivers to alternate routes.

Implemented components and control devices, including traffic observation should contribute to improve the passage of vehicles in Bydgoszcz. It is expected, that this will increase the efficiency of use of existing transport infrastructure, will help users to better plan their travel and contribute to increasing the attractiveness of public transport.

KEYWORDS: ITS, SCATS, CSR, Bydgoszcz

1. Introduction

A real life in XXI century, where humans are constantly struggling with the difficulties associated with congestion of urban road network, the factors affecting eliminating or reducing the loss of time caused by congestion in major transport corridors or while driving through the intersection contribute to a significant improvement of traffic conditions and to save resources.

Constant increase in development of information technology causes the appearance of newer and newer technologies in engineering traffic telematics. These tools facilitate and improve comfort of journey not only to drivers and passengers of personal transport, but also public transport, or even severe.

City of Bydgoszcz has prepared a draft of Intelligent Transport Systems (ITS), which took first place in the ranking of grant applications submitted under the competition 8.3 Rozwój Inteligentnych Systemów Transportowych POIiŚ. The predicted cost of the project is estimated at 69 063 102.00 PLN, of which the sum of 56 286 661.70 PLN is the amount of the grant from the European Regional Development Fund, which accounts for 85% of eligible costs [1].

The procedure for public procurement carried out in the restricted tender procedure was launched on 9 September 2011.
The process was to appoint the first five of the twenty companies with the most experience and best references. Then launched a tender procedure for the task, which was to select a contractor provided the criterion of lowest price and best execution concept design.

On 15 October 2012 Zarząd Dróg Miejskich i Komunikacji Publicznej (ZDMiKP) through a public bulletin announced the emergence of the contractor. It is a company Sprint S.A. which performance of the contract valued at 53 984 700.00 PLN. This company can boast of preparing a similar project for Trójmiasto agglomeration called “TRISTAR” which objectives include improvement in local transport, in the organization of traffic and safety, or to provide drivers with dynamic information on the prevailing traffic conditions. Also in Rybnik, the company carried out the task of Electronic Passenger Information, which purpose was to install 167 monitors displaying dynamic passenger information [2].

Project of Intelligent Transportation Systems in Bydgoszcz was divided into four segments:

- Traffic-control with real-time video surveillance,
- Public transport management with dynamic passenger information,
- Parking information,
- Guiding vehicles on the alternative roads.

According to the agreement signed on 9 January 2013, for the purchase, installation and commissioning of the project components, Sprint SA has a deadline of the task within two years. It is probable that the system will be launched in the first quarter of 2015.

2. Current state of road network

The spatial layout of the city is developed in a specific way in the east-west direction. The average length of an area of the city in this direction is 20 km and in the north-south 6 km. This is the main factor that is responsible for the shape of the road network in the city, and of the most important traffic routes. National and provincial roads, routed through the city shows the nature of basic framework of the street network. The main transport route is routed on the track of national road No. 80 connecting the farthest parts of the city in the east and the west. The main role is played by the national road No. 5 and 25, which are combination of southern and north inlet of the city. The road network, which is in the city, is focused mainly on the access to the central districts. The need to travel through this area of the city is mainly a consequence of the lack of direct connections between the other border settlements. This results in a significant increase in traffic flows, which accumulated in the city during peak hours makes the movement more difficult. Such a big accumulation of traffic in the central area of the city reduces security while driving through the intersection. That is why, it was necessary to introduce traffic control by traffic lights on a considerable part of the road network. Strict downtown and the areas immediately adjacent to this area are leading the main arteries of the city. Intersections controlled in this area significantly extend the travel time by generating wasted time connected with waiting for the green signal and the lengthening queue of vehicles at the inlets. It is noticeable that at complex junctions, through which the national roads are routed. An important fact is that only 31 of the 118 traffic lights form 11 coordinated systems. Other traffic controllers work as isolated systems [4].

In Bydgoszcz, as contrasted with a model example of public transport, the bus line network is a major connection network. Not enough developed tram network system causes a lack of coherence of existing connections. In addition, this network largely coincides with the bus routes. This has a negative impact on the efficiency of the public transport, as it is a tram infrastructure, which is a smaller percentage of collision with road vehicles, should serve as a basic framework for communication lines. Buses should be a complement to this system and transport passengers from peripheral areas to the main transport interchanges. However, the investments are performed and announced to change this situation, as given in November 2012, the investment linking Central Station with the existing tram network. In June 2013 the construction of a tram line to the largest area of the city – Fordon – will started. Further developments such as the construction of crossing for tram trains over the Kujawska street and extension the lines within the Solskiego and Piękna street and continue to Grunwaldzkie roundabout and Poznan' square should cause - with appropriate adjustment of bus lines - replacement of vehicles which acting main roles in public transport. Transport infrastructure has been enriched with dynamic passenger information system as part of a separate project “small ITS”, which was implemented with the launch of the tramway to the Central Station. Within the project all rail vehicles and public buses in Bydgoszcz have been equipped with a GPS module with on-board computer, allowing the location of the vehicle and determine the approximate time of arrival at bus or tram stop. Stops on the newly built road are equipped with LCD monitors that display chronologically information about line number and the actual time of arrival at the platform of bus/tram stop. This system allows the supervision of the carrier’s fleet and enables real-time preview of the line vehicle in a room of Public Transport Management ZDMiKP. Archived data also allow printing such parameters as travel time, time at stop and time of leaving this stop for any vehicle of particular line.

![Fig.1. Passenger service on the new platform stop equipped with a dynamic passenger information system.](image-url)
3. Objectives and tasks of the system

The area of implementation of the ITS includes the central part of the city, which is limited by Kamienna, Artystyczna and Zygmunt August street – in the north, Dworcowa, Królowej Jadwigi, Marszalka Focha, Krużgankowa and Szubińska street – in the west, Piękna, Solskiego and Wojska Polskiego street – in the south, Ujejskiego, Jana Pawła II and Wyszyńskiego street – in the east. The area also contains a traffic corridor from Fordońskie roundabout to Wyścigowa street, along the Fordońska street. The operating range of the system is indicated in Figure 2.

The main task of the project will be to accelerate the movement of tram transport in the two corridors. Central, east-west, is situated between the planned interchange Bydgoszcz East (under a separate project BiT City), and the Grunwaldzkie Roundabout. The second corridor in north-south direction, includes track in Gdańska Street from the intersection of the Jagiellońska and Marszałka Focha street to the intersection of the Artystyczna and Kamienna street - the boundary of the system. This will require reducing individual traffic in these corridors by controlling flow to them and to create better conditions at possible alternative routes. The purpose of the implementation of the central traffic and public transport management system is to improve the movement conditions on the streets within the area of operation of the system by providing the appropriate components.

The main expected results after running the system are relative savings in time [3]:

- a passing car in the area of functioning system at the level of 6.03%,
- the public transport travel in a tram in the area of system at the level of 8.33%.

Traffic Control Centre (CSR) will cover an area of 52 intersections with traffic lights, where 45 of them are currently working in the field of controlled traffic light signals, and the remaining 7 were included into the project installation of traffic lights. It is expected to reprogram all of the traffic lights drivers in the area in such way, which allow achieving optimization of the traffic control in the area covered in Figure 2. This task will consume up to 30 km of fiber optic cables [3].

Traffic control system will be supported by video surveillance. A planned task of video surveillance is mainly observation the area of intersections or selected item of infrastructure (road section) based on CCTV. In these areas will be also implemented automatic collection of data on characteristics of the vehicles through cameras ARCP. The aim of equipping the major intersections in the area covered by the central control is collecting data about vehicles entering the area, leaving it and next determining the approximate route of the vehicle. Monitoring the area also has the task of providing visual information for moderators (traffic engineers), for example in the detection of threats. Automatic recording characteristics of the vehicles is mainly based on a set of license plates with the overall dimensions of the vehicle (type classification) and it will also perform the functions of gathering data on the mobility of vehicles staying in the area of operating system. It will primarily enable to provide information for vehicle alternative route guidance subsystem [3].

Fig.2. Area of operation of ITS in Bydgoszcz[3]

Fig.3. The proposed ARCP cameras locations[3]

Public Transport ManagementSubsystem, which includes the supervision of dynamic passenger information, consists of three tasks. The first is the acceleration of tram traffic in the two major transport corridors. This activity will consist in giving absolute priority to passage in areas of intersections controlled by the CSR. In other corridors within the area, a priority will be transmitted in an active or passive way, depending on the interval scheduled time to arrive at the bus stop platform. The second task is to increase the attractiveness and quality of passenger service by the above-mentioned system of priorities to accelerate the speed of travel in the area of operation of ITS. Also, the installation of an information system at the stops, which will make it installed an additional 180 LCD monitors (90 locations) displaying a dynamic passenger information, should increase popularity of public transport. In addition, a priority providing function should contribute to improving the punctuality of arrival at bus stops. The third task is to increase the improvement of making decisions and also operational and strategic decisions in public transport.

In this subsystem, the project contractor is obliged to equip 80 trams in short-range radio transmitters so that it will be possible to give priority at intersections controlled by traffic lights based on data from the location of the vehicle relative to the time table schedule. Giving priority will be based on data from the on-board computers installed in vehicles as part of a contract under the
name "small ITS". This computer will be submitted to the drivers vehicle’s current position based on GPS. On-board computer in tram will connect to the radio signals reaching the driver and sent a telegram containing standardized information such as the number of the application, line number, course number, deviation from the timetable. Intersection controller will take into account the request of priority based on the data of traffic flows [3].

Fig.4. Scheme of providing priority for public transport[5],[5]

In addition, in this segment of the functioning system will be installed 20 pieces of new information kiosks with ticket distribution function. Three tramway turnouts will be equipped with complete automation of the drives.

Segment of Intelligent Transport Systems in Bydgoszcz Project, responsible for the guidance of vehicles on the alternative road, is to provide information to road users. This information will be sent directly to installed in the area of traffic management variable message signs (VMS) and to the newly developed website. This subsystem will provide information about any disruption to road traffic, the recommended travel speed on a particular section of the road, the overloads on specific sections of streets, ongoing road works, predicted average travel times to the nearest main road network element [3].

Fig.5. Simulation of variable message sign VMS displayed on any programmable LED matrix[5]

Within this segment 20 system loops will be installed, which task is to send to CSR the information about traffic flow into the central area. Separately, in 10 of them will be installed additionally weather stations, containing inter alia temperature sensors (environment, surface), the ambient humidity, atmospheric pressure, freezing temperature and concentration of the road brine. The objective is the acquisition and archiving of meteorological data occurring on the streets.

Developed web portal will visualize the prevailing traffic conditions on the road network in the control area of ITS, make available information about any difficulties in the streets, transmit possible real time images of characteristic points of road infrastructure from CCTV cameras. Will also facilitate users to plan a trip by choosing the optimal route, taking into account the actual traffic conditions prevailing on the road together with the forecast for the next 15, 30 and 60 minutes.

The last segment of the project is subsystem of parking information. Its purpose is to inform about the occupation of paid parking zones in Bydgoszcz. Will involve the installation of 101 new parking ticket machines, 26 tables displaying information about the access availability. Also, the zone controllers are provided with a 10 devices with auxiliary printing functions and taking pictures. Occupancy information will come from data collected by the parking machines about the amount of tickets purchased. The system will estimate the level of occupancy of the area by submitting the data to the display of parking boards. However, due to the nature of urban traffic in the city center, the system will not take into consideration the available number of free parking spaces. To drivers, by tables will be provided only clues about a occupancy state. For example, system will process the data about the number of tickets purchased and the number of groups of customers who have subscribed or are residents of the zone. In this way, the percentage of occupancy of street corridors will be defined. The data processed in this way, will be transferred to the tables in the form of guidelines whether the occupancy is high, moderate or low [3].

Fig.6. Examples of the content displayed on the parking information boards[5]

4. Conclusion

Project of Intelligent Transport Systems, which will be implemented in Bydgoszcz, is built with multiple segments. The most important segment is responsible for controlling inflow of vehicles into the central area of the city. Others, including a very important providing priority to passage of public transport vehicles, perform complementary part of the total traffic management.

Administration of the flow of vehicles through the control of ITS will be based on data received from the ARCP cameras. Traffic lights control algorithm is based on a SCATS system, which was implemented in Sydney, Dublin or Singapore. The company Sprint SA is an authorized distributor of this system in Poland, so it is expected that traffic control algorithms will be prepared properly.
Traffic Control Centre will be located in the building of ZDMiKP. Engineers working there will have access to a large format screen, built with 9 rimless LCD monitors size of 55". It will be a headquarters, which will run down information from all subsystems. It is expected to create three positions: the operator of dynamic passenger information subsystem and supervision of public transport, the operator of CCTV surveillance and the traffic controller.

All integrated with each other segments of the project should result in improved efficiency on movement around the city. Road infrastructure users in Poland usually do not associate with such a large amount of traffic information. After a period of time to adapt to new developments and learning how to use them, the driver but also the passengers of public transport should feel the improvement of the mobility conditions and shorten their travel time.

It is suspected that the profit will not be felt significantly during peak traffic, but beyond them displaying on variable message signs about the prevailing traffic conditions should lead to improvement in occupancy of main transport routes and intersections in the area of control of ITS.

The benefits of installing a system should be enjoyed by city traffic managers. They will have for review, up to date, everything that is happening on the city street network. Video monitoring allows direct insight into situations that will be visualized by SCATS system. Thanks to this, the integration of the control algorithms and the response of an experienced traffic engineer should bring even better results on manage the flow of vehicles.

Archiving such data will provide a desirable material for the persons responsible for the traffic research. Current traffic modeling based on the readings from the sensors installed in the control region of ITS will be one of the most important information that will help the planner to implement the best solutions for road projects.

Bibliography

Innovative solutions for improving safety at pedestrian crossings

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ABSTRACT
Many pedestrians in Poland are killed or injured while crossing the road. This paper gives an overview of innovative solutions aimed at improving safety of pedestrian crossings: automatic pedestrian detection, dynamic traffic signs and better lighting systems. Among the pedestrian detection systems, video technology with image analysis seems to be the most promising solution for the future – its problems, recent developments and advantages are presented. Pedestrian detectors are already utilized by dynamic traffic signs which include pulsating lights mounted on ”pedestrian crossing” signs, activated when pedestrians waiting to cross are detected.

KEYWORDS: traffic safety, pedestrian crossings, pedestrian detection

1. Introduction
Poland currently has the worst pedestrian traffic accident statistics in the European Union. Although there has been reduction in the number of fatalities in recent years, 1408 pedestrians were killed and 10320 injured in 2011. Pedestrians killed on Polish roads constitute 25% of all pedestrian fatalities in the European Union, while only 8% of EU population lives in Poland. In large Polish cities pedestrians constitute over 60 percent of all road accident victims. This alarming situation of pedestrians on Polish roads has been known and reported for many years [16], but actions taken so far improved pedestrian safety only to a small degree.

Accident statistics in Poland are based on the Polish Police accident database – SEWiK (System of evidence of accidents and collisions). These statistics show that about 30.8% of all pedestrian victims of road accidents in Poland were hit on marked pedestrian crossings.

The aim of this paper is to present innovative measures of improving safety of pedestrianroad crossings using automatic pedestrian detection. It is hoped that promoting best practices will lead to a reduction of the numbers of pedestrians killed or injured on Polish roads.

2. Pedestrian crossing design

2.1 Signalized crossings
A popular solution of increasing safety at pedestrian crossing is to introduce traffic signalization. Signalized crossings allow pedestrians to cross the road during signal phases when they are not in conflict with vehicles. This significantly improves pedestrian safety.

Use of signalization means that pedestrians cross only during specific dedicated time intervals. Fixed-time signals are the most common – in this solution the cycle time and durations of all phases are pre-determined.

An alternative arrangement is a traffic-actuated signal, where the green light allowing pedestrians to cross safely is activated by pedestrians pressing a pushbutton. In such cases, pedestrian phase is included in the signal cycle (at intersections) or started (at mid-block locations) [5].

2.2 Unsignalized crossings
Signalized crossings described above are rather expensive to build and maintain, therefore by far the most common are
unsignalized crossings. At these locations, pedestrians are more vulnerable, so it is essential to signpost these crossings in such a way that drivers can easily spot them from sufficiently far away.

Polish regulations [20] require that an unsignalized pedestrian crossing be marked with the D-6 traffic sign (“pedestrian crossing”). It should be located 0.5 m in front of the upstream edge of the crossing, facing the oncoming traffic. To enhance its visibility, the sign can be placed on a reflective background. In addition, the surface of pedestrian crossing is demarcated by white stripes painted on the road surface (P-10 horizontal sign “Zebra crossing”). The minimum crossing width is 4 m and the maximum is 16 m [21].

### 2.3 Speed reduction measures

Sometimes the signage described above is not sufficient to make the crossing safe. Pedestrian crossings can then be designed with additional elements which force drivers to reduce speed when approaching a crossing. Such traffic calming solutions include:

- **pedestrian refuge** – a curbed traffic islands placed in the center of a road at intersections or mid-block [31], it allows pedestrians to cross in stages and forces vehicles to slow down by bending away vehicle paths, the minimum width of refuge island should be 2 m [22];
- **roadway narrowing** – this is achieved by curving the alignment of the outer roadway edges at an appropriate length (max 20m) [23] when drivers feel more confined, they tend to drive slower, improving the visibility of pedestrians waiting to cross is an additional advantage;
- **raised crossing** – raising the crossing surface has a similar effect as the road hump, this solution is used for lower class roads, where there is no public transport bus traffic [21].

### 3. Pedestrian presence detection

#### 3.1 Detection technology

The simplest and by far the most common method of pedestrian presence detection near zebra crossings is the use of push buttons. However, this solution is not appealing to users and is often ignored by them, which leads to dangerous situations. Therefore there is a need for automatic and passive (i.e. not requiring physical actuation by the pedestrians) method of pedestrian presence detection. This task is crucial for advanced driver assistance systems that implement pedestrian protection as well as for infrastructure solutions that aim to minimize the risk of vehicle-pedestrian conflict. The objective of such systems is to undertake some pedestrian protective actions in case a pedestrian is detected in a potentially dangerous zone in front of the moving vehicle. Most of the conducted research is focused on autonomous on-board (vehicle mounted) systems, however due to occlusions (especially at intersections or pedestrian crossings), such systems often fail to detect a dangerous situation. Therefore, there is a growing interest in passive infrastructure-based pedestrian detection systems that use stationary sensors at intersections and/or pedestrian crossings and communicate with vehicles or crossing signalization to improve the overall performance of the road safety system [3, 12, 19].

There are five commonly used types of passive pedestrian detection technologies:

- **Piezometric** - senses a change of pressure on a pressuresensitive mat,
- **Ultrasonic** - emits an ultrasonic wave and measures the delay of the returning signal bouncing off an object within the field of view,
- **Passive infrared (PIR)** – detects the infrared radiation emitted by all objects within the field of view,
- **Microwave/Doppler radar** - emits a radio wave and measures the change in frequency of the returning signal bouncing off a moving object within the field of view,
- **Video analysis** – uses machine vision to detect movement and identify pedestrians and vehicles within the field of view.

Pressure-sensitive pads installed at curbside can detect the presence of pedestrians by measuring their weight and are less influenced by weather conditions and other environmental factors than other types of sensors. However they require costly installation and work correctly only if a pedestrian steps directly on them - otherwise they will not detect pedestrians at all.

During preliminary tests of ultrasonic, passive infrared and microwave sensors described in [2] the detection rates varied from 47 to 96 percent and exceeded 89 percent after the sensors were optimally positioned and calibrated. Subsequently, a combination of 2 Doppler radars for cross-walk and 2 infrared devices for curbsides as shown in Fig.1 resulted in 100 percent detection in a long-term testing on 60 crossings.

![Fig. 1. Plan view of pedestrian crossing with marked detection zones](image)

Other sources like [18], however, are less optimistic about the detection rate of the two most commonly used types of sensors: infrared and microwave. They report typical error rates in the 20 to 30 percent range and about 9 to 11 percent when the pedestrian movement area is constrained and/or the pedestrian detection area is well-defined. These results are similar to those reported in [15] and summarized in Table 1 below, where several representative studies were analyzed.
Table 1. Device Accuracy for Different Technologies

<table>
<thead>
<tr>
<th>Methodology</th>
<th>Detection ratio [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Controlled conditions</td>
</tr>
<tr>
<td>Passive infrared</td>
<td>93–100</td>
</tr>
<tr>
<td>Microwave</td>
<td>100</td>
</tr>
<tr>
<td>Video</td>
<td>100</td>
</tr>
</tbody>
</table>

In recent years video-based detection technology has attracted attention of many researchers. It is becoming or already has become the most commonly used method for pedestrian detection in urban traffic scenes as cameras are relatively cheap and provide high-speed, high-resolution and content-rich data [14]. Reviews of video-based pedestrian detection methods, applications and benchmarks can be found for example in [6, 8, 9, 17]. Many projects often combine two or more sensors that provide complementary information about the observed scene and thus increase the robustness of people detection. They include stereo-vision or data fusion of a monocular camera and lidar, radar, IR camera, time-of-flight camera etc. Multi-sensor systems for stationary intersection monitoring are described for example in [11]. Despite the above, cameras working in visible spectrum seem to be the most popular sensors in such systems.

3.2 Use of CCTV and image analysis

The main challenge of a vision-based pedestrian detection system is an efficient detection of people, which is usually quite difficult as:

- the appearance of pedestrians is very highly variable in terms of pose, colors, sizes and viewing angles,
- pedestrians must be identified in usually cluttered and dynamic urban scenes, where occlusions (by other pedestrians, vehicles or infrastructure) and changing lighting and weather conditions (e.g. shadows and snow) often introduce substantial information noise,
- taking into account the above, people detection must be carried out in (near) real-time and provide high detection rate with minimal number of false positives (false detections).

In spite of the fact, that the nature of on-board and infrastructure-based systems is slightly different, pedestrian detection methods are similar in both cases. Most commonly they are based on machine vision and machine learning principles, sometimes utilizing sensor fusion approach. The most significant difference is that with stationary systems, the sensors (cameras in particular) are not moving, so it is possible to apply advanced techniques of background/foreground separation, which makes further processing easier and more robust.

The processing pipeline of a typical vision-based pedestrian detection system can be divided into the following stages: preprocessing, initial candidate selection, classification and tracking, although some researches (e.g. [9]) show more detailed approach.

3.2.1 Preprocessing

The preprocessing module usually focuses on camera calibration and pose estimation that is necessary for the later stages, especially tracking in real-world coordinates. The most common approach is to initially estimate the intrinsic (optical properties of the camera and lens) and extrinsic (position and orientation with respect to some coordinate system, e.g. center of the pedestrian crossing) camera parameters based on geometrical properties of the observed scene and assume that they remain constant. As long as this assumption usually holds for the intrinsic parameters (provided the lens is not moved or zoomed), the pose of the camera can often change even though the camera is fixed to a road infrastructure. Seemingly rigid objects such as lamp posts or sign posts onto which cameras are often mounted are susceptible to wind and temperature variations, which can cause the construction to shake (wind) or tilt from the initial position (temperature). In the end, the orientation of the camera is changed, which results in blurred image, change of the field of view and incorrect 3D position estimation of observed pedestrians. In such a case, the extrinsic camera parameters have to be constantly updated [4].

Another issue in the preprocessing stage is image exposure/ contrast adjustment. This is usually taken care of automatically by camera lens with auto iris feature, but the results are often far from optimal (e.g. bright headlights cause the iris to close and important parts of the image are underexposed). Such poorly contrasted images are quite difficult for many contemporary detection algorithms [9]. An interesting solution to this problem is to use the emerging HDR cameras that provide highly contrasted images in extreme lighting conditions.

3.2.2 Initial candidate selection

Initial candidate selection is the generation of preliminary hypotheses or Regions Of Interest about the pedestrian locations in the image. These candidates are later sent to the classification module for verification, so it is very important that no pedestrian is missed in this stage, as it will not be possible to correct this error in the next phase. On the other hand, almost equally important is avoiding as many irrelevant background regions as possible, so as to reduce the classification time. The typical approach involves the use of a sliding window of various scales that is shifted over the image and selects all the possible candidates. This procedure, although quite simple, generates many spurious regions and further processing is often too complex for real-time applications. In order to limit the number of ROIs some visual cues like color, intensity, edges etc., interest points based on local discontinuities of the image brightness function or cascades of simple classifiers can be used to eliminate unwanted candidates. Another interesting approach is to use stereo vision that provides depth information about the observed scene. This allows for example to adjust the ROI size and position during initial scanning taking into account the location of the ground plane.

Motion analysis is another early cueing mechanism used during the initial scanning. It is particularly efficient in
infrastructure-based systems, where cameras are not moving and advanced background subtraction algorithms can be applied [13]. Stationary systems can also benefit from a priori information about the camera-scene geometry and easily eliminate from search such image areas where pedestrians are unlikely to appear (e.g. sky, building walls etc).

### 3.2.3 Classification

The object classification module is given a list of ROIs that are more or less likely to contain a pedestrian. Subsequently they are binary classified as pedestrian or nonpedestrian, with the goal of minimizing the number of false positives and false negatives. Sometimes the classification output is not binary, but it reflects the probability of a given ROI to contain a pedestrian. This is useful for the non-maxima suppression stage described below. First, some image features are extracted from each ROI, and then a classifier that was previously trained with a set of positive and negative learning samples is applied. The most popular classification methods used for pedestrian detection are: neural networks, support vector machine and boosting. It is difficult to say which approach is the most successful, however it must be noted that the latter one requires significantly longer training times than the other ones.

Regardless of the classifier used, proper feature selection is crucial for successful detection and classification. Perfect features should be discriminative, robust and easy to compute, but these requirements often contradict each other. The most popular features used for pedestrian detection are mainly based on gradients, motion, colors and textures and include: Wavelet/Haar-like features, edgelets, shapelets, local binary patterns, histogram of oriented gradients, motion features and many other. Many researchers combine several features [17] in order to improve the classification compared to a single feature, however the gain obtained is not always significant as features tend to encode similar characteristics.

After the classification, it may happen that several overlapping ROIs containing pedestrians correspond to a single person. The non-maxima suppression process aims at reducing these ROIs to a single one per pedestrian. This is particularly difficult in crowded scenes, where overlapping ROIs of different persons may be mistakenly merged together. Most of the applied algorithms use a standard multi-filtering approach based on the area of overlapping, however more sophisticated methods use a mean shift approach or the confidence level of ROIs to discard the overlapping regions of lower confidence [17].

Many systems contain one more phase that verifies and refines the ROIs already classified as pedestrians. The verification step discards potential false positives based on additional criteria and the refinement step outlines the pedestrian for the subsequent tracking module.

### 3.2.4 Tracking

The final step of pedestrian detection is tracking which not only serves for trajectory generation, but also increases the overall detection accuracy by predicting future positions of pedestrians. This information can be used by earlier modules to refine the hypotheses of pedestrian location, speed up the processing and reduce the number of false positives. It is worth mentioning that tracking is not essential for pedestrian detection and many if not majority of projects omit this step.

The two most commonly used approaches for tracking are: Kalman and particle filters. Although the former is definitely the most popular one, the latter seems to be more robust to occlusions and changes in pedestrian appearance or motion patterns.

### 3.2.5 Overall performance

Although, in the last decade, the problem of automatic people detection in video sequences has drawn attention of many research teams and a huge progress has been made in this area, the state-of-the-art algorithms are still very far from what is expected. Even under the ideal conditions, the rate of correct detections is less than 80% and it drops dramatically for smaller resolutions and/or occlusions [6].

One should note, however, that most research on people detection concerns horizontal or close to horizontal view and there has been relatively little research on top view pedestrian detection. The latter seems to be a little easier to deal with as it minimizes the influence of the most significant problems in contemporary people detection algorithms, namely, occlusions, people scale variations and background changes. Moreover, since top view systems are infrastructure-based, they can apply advanced background subtraction methods and/or stereovision that works well for relatively short ranges (see Fig. 2).

![Fig.2. Left and right images from a stereo camera system for pedestrian detection](image)

The reported recognition rate of few top view or almost top view systems [1, 7, 14] is much higher than that for the horizontal view systems. It should be noted, however, that the detection rate cited in [6] concerns unconstrained scenarios and by correct detection the separation of all (partially) visible humans is understood. Such a high precision is rarely requested from a traffic pedestrian detection system, where counting individuals is of less importance than detecting the fact that a number of pedestrians are on or near the crossing.
It is also worth noticing that video-based systems can extract more information from the observed scene than their conventional (infrared or microwave) counterparts. For example, in [13] a system is described that does not only detect pedestrian presence the curb, but also decides if they are actually going to cross the street or are simply passing by or standing there. As a result, it minimizes the number of unnecessary interruptions of the traffic flow. Another application could be to incorporate the video-based pedestrian detection systems in the city monitoring network.

4. Dynamic signage

4.1 Pedestrian presence warning systems

Dynamic or „active” road signage is an interesting solution increasing safety of pedestrian crossings. Such a system involves automatic detection of pedestrians and activation of light signals to warn drivers of pedestrian presence. Thus, drivers are prepared to slow down and more inclined to give way to pedestrians. The aim of such systems is to:

- increase visibility of the crossing,
- increase attention and concentration of drivers,
- force speed reduction of approaching vehicles.

There are several examples of dynamic signage systems based on the above principle. Some of these systems are described and compared below.

The first example consists of pulsating yellow lights mounted on top of an existing D-6 traffic sign “pedestrian crossing”. This system is equipped with infrared motion sensors which activate the yellow flashing warning lights when a pedestrian is detected inside detection zone (Fig. 3). Such systems are available on the market under brand names SignFlash and SeeMe [24, 25].

Another example of a similar system warning drivers of pedestrian presence is called “Välkky”. Instead of yellow flashing lights it has blue-white LED lights, mounted on existing D-6 sign poles. When pedestrians approach a crossing, Välkky warns drivers to keep more attention. [27]. Fig. 4 shows the principle of operation.

A different solution of a dynamic warning system involves lights embedded in the road surface at the edge of the crossing. Fig. 5 shows an example of such a system: SAFE-2-WALK by Traficon. This system uses video cameras for detecting pedestrians in predefined zones. Pedestrian detection activates the warning lights to alert motorists that crossing will be used. LED lights mark the edge of the crossing [30].

Comparison of basic features of the systems described above is shown in Table 2.

<table>
<thead>
<tr>
<th>Type of dynamic system</th>
<th>Type of detector</th>
<th>Light mounting location</th>
</tr>
</thead>
<tbody>
<tr>
<td>SeeMe / SignFlash</td>
<td>infrared</td>
<td>on top of an existing D-6 traffic sign</td>
</tr>
<tr>
<td>Välkky</td>
<td>infrared</td>
<td>on existing D-6 sign poles</td>
</tr>
<tr>
<td>Safe-2-Walk</td>
<td>video</td>
<td>embedded in the road surface</td>
</tr>
</tbody>
</table>

4.2 Applications in Poland

Systems presented in section 4.1 have recently started to be introduced in Poland. So far, there are no scientific studies to confirm their effectiveness in improving pedestrian safety. However, the response of local communities in areas where they have been installed is positive, indicating their usefulness.
Fig. 6 shows the implementation of the SignFlash system by APM in the village of Czeslaw, near Kraków [25].

A pilot installation of the Välkkysystem has been done in the city of Chorzów at two selected intersections. One of these sites is shown in Fig. 7.

5. Improving the visibility of crossings and pedestrians

The problem with conventional street lighting is that it is designed to illuminate the road surface evenly, so that any obstacle on the road appears dark against brighter background. This method is not very suitable for pedestrian crossings which should be illuminated more intensively to enhance safety. This extra illumination will inform drivers that they are approaching a pedestrian crossing. It should illuminate evenly not only the crossing area but also part of the sidewalk where pedestrians wait for the opportunity to cross the road. The light intensity should be such that pedestrians appear brighter than darker background despite all the ambient illumination [30, 26].

There are several examples of lighting systems specially designed for pedestrian crossings: “Calypso Zebra” by Schreder, IVS by Thorn, “Futurlux cross-walk” by APM, etc. All of these systems work on the principle of asymmetric illumination (Fig. 8) which helps to illuminate pedestrians not from the top but from the side of approaching traffic.

Solutions developed by Shreder and Thorn make use of metal-halide lamps, with power of between 100 W and 400W [29, 30]. The solution marketed by APM makes use of LED lamps, producing white light of high intensity. This solution is shown in Fig. 9.

In order to increase the visibility of the crossing itself, lights embedded in the pavement can be used. One example of such a system is Levelite [25]. It is similar in appearance to the „SAFE-2-WALK” system described in section 4.1 but the markers are lit permanently and are not activated by pedestrian presence.

6. Conclusions

Despite falling numbers of road accident fatalities, the safety situation of pedestrians in Poland is still very bad. It seems that traditional ways of designing and marking pedestrian crossings are not sufficient to ensure adequate safety improvement for vulnerable road users. New technology of pedestrian detection (especially video-based systems that are quickly advancing due to intensive research) and dynamic signing promise to improve pedestrian safety at road crossings.

Video-based systems are already comparable to conventional solutions and their performance is constantly growing due to research and development in this area. The advantages of video-based systems over the conventional ones in terms of additional functionality make them a promising prospect for practical applications in the nearest future.

Several innovative solutions for improving safety at pedestrian crossings are available on the market and are being installed at selected locations. Dynamic pedestrian crossing signs utilize flashing lights activated by pedestrian sensors to warn drivers of pedestrian presence. New lighting systems improve visibility of pedestrians on a crossing by making use of high-intensity asymmetric illumination. However, the effectiveness of these solutions remains to be scientifically evaluated.
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The functionality problems of the ITS systems supporting rail transportation – survey results 2010-2012

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ABSTRACT  

The paper presents the problems of design and upgrading of ITS systems, supporting the transport processes associated with the end user. It was noted that the lack of adequate participation or end-user requirements into system design can lead to two groups of problems related to the functionality of ITS systems. First group of problems is incomplete and inconsistent functionality of various systems, resulting from the rejection by the designers of end users practical knowledge and life experience. The second group of problems is not use of full features of the systems by end users such as due to lack of training, lack of comprehensive instruction manual and the lack of sufficient knowledge of users. As examples presents results of surveys conducted in 2010 and 2012 among end users of rail systems such as: ISZTP - on-line train route ordering system, SEPE - operational registry system, SWDR - train dispatcher support system and SERWO - electronic record of current warnings issued.

KEYWORDS: railway systems, ISZTP, SEPE, SWDR, SERWO

1. Introduction

ISZTP (on-line train route ordering system) is an web application supporting procedure of ordering route for train by carriers. Timetable and train orders are used to determine which train had the right of way at any point along the line. This system is on-line electronic platform between carriers as users of railway systems and infrastructure management company PKP PLK S.A. ISZTP system is available to users 24 hours a day, 7 days a week, 365 days a year and use of the system is possible from anywhere with Internet access and the use of various electronic devices (laptops, tablets, smartphones).

SEPE (operational registry system) is a system which, apart from the information about train operation, stores the information about all the disturbances to the train runs. The registration of the incidents and events is performed based on the reports from train dispatchers and is being input in the system by the line controllers. The stored information contains the data on the time of the event, time at which the event ended, on the exact location of the event, its influence on the operation of the trains (i.e. the delays) as well as the person in default of the event.

SWDR (train dispatcher support system) is a system containing all the information needed by the train dispatcher such as the timetables, planned train runs, train delays (and the reasons for these), planned and actual parameters of the trains, the trains carrying hazardous materials and trains with oversize loading gauge as well as the routes of all trains. Train dispatcher (code ISDR) is a highly skilled job position directly involved in the train operations within the relevant signalling control areas and on the adjacent routes or railway sections. Similarly as in the case
of a line controller, the dispatcher’s job requires the knowledge of a number of instructions and regulations, however it is this particular position which bears a direct responsibility for the safe and regular train operations. The duties of the train dispatcher include making decisions about the correct preparation of the route, about the right sequence and direction of train despatching, in agreement with the current rules and with the timetable. Above all, the duty of the train dispatcher is to react immediately in case of a danger or a disturbance of a normal train operation due to the emergency situations and to the deviations from the timetable operations. Any decision taken by the train dispatcher has to be compliant to all instructions and to the Technical Regulations of a specific stop. The train dispatcher is supported in the decision making process by the SWDR system.

SERWO (electronic record of current warnings issued) is an application supporting the train dispatchers in the area of registering, issuing and handling of current warnings. A part of the system is a database storing the information about the railway lines, the routes, the trains and the reasons for the warnings. It allows (among others) the printout of the orders and stores an electronic log of current warnings. It substitutes the old wire message system for sending the information on the warnings and for confirming the receipt and the recording of a warning.

2. Functionality assessment of on-line train route ordering system (ISZTP)

2.1 Survey methodology

Survey were conducted in 2012 [2]. The on-line train route ordering system called ISZTP is an application available to a small group of users. The shipping volume in rail transport was used for selection of respondents in sample survey. The survey was conducted among the following carriers – in parentheses share of shopping volume from 1st quarter of 2012):

- PKP Cargo (59.31%),
- Lotos Kolej (7.96%),
- CTL Logistics (7.05%),
- DB Schenker (6.87%),
- STK (1.57%),
- Freightliner (1.54%),
- Rail Polska (1.50%).

The total share of shipping volume of these companies is 85.8%. Data were collected using the technique such as PAPI (Paper and Pencil Interview), CATI (Computer Aided Telephone Interview) and by post.

2.2 The results of survey

The questionnaire consisted of 5 short questions – 4 of the questions were closed questions and 1 of the questions were open, allowing descriptive answer, containing the respondent’s remarks and observations.

Question 1. „Do you think that introduction of on-line train route ordering system called ISZTP improved the train ordering procedure on the lines managed by PKP PLK S.A.?“

The results (Fig. 1) indicate a full positive rating with 30% of answers “Yes” and 70% of answers “Definitely Yes”. Moreover in two cases given that the ISZTP system has allowed reduce steps for ordering and planning to run the train by 50%.

Application ISZTP works according to the following rules:

- right quantity – the system does not have a quantitative restriction - neither in terms of the structure of the material or product in terms of the number of its users,
- right condition – none of the respondents did not pay attention to the technical failure of the system (lack of liquidity, activity, etc.);
- right time – the system is available to users 24 hours a day, 7 days a week, 365 days a year,
- right place – use of the system is possible from anywhere with Internet access and the use of various electronic devices (laptops, tablets, smartphones),
- right price – the use of the system is free - the customer is only the operational costs such as energy, internet access, a device for manual operation of the system application,
- right customer – the system application access is granted only to licensed operators.

Question 2. „If you could choose between the previous method of train route ordering method and present procedure, you would choose system ISZTP?“

Fig. 2. Distribution of the answers to question 2. „If you could choose between the previous method of train route ordering method and present procedure, you would choose system ISZTP?“
The aim of the second question was to obtain information on whether positive solutions and willingly be used by operators/customers in the previous route ordering system has been overlooked in the ISZTP. 100% of respondents said “Yes” (Fig. 2).

**Question 3. “Did the introduction of the ISZTP system increase the fleet logistic in your company?”**

![Fig.3. Distribution of the answers to question 3. „Did the introduction of the ISZTP system increase the fleet logistic in your company?”](image)

The third question related directly to the carrier’s fleet management. 71% positive answers (Fig. 3) were justified by significant shortening or even the lack of a waiting period for the construction timetable, resulting in improved efficiency of the circulation of rolling stock.

There are no answers to this question (29%) was due to the lack of studies in this field, or use by carriers other internal procedures to optimize the circulation issues in bulk wagons and locomotives. One can not deny that the system ISZTP improve this state of affairs, both the information about traffic problems, as well as the simplification of the procedures for access to the route. It is also clear that carriers who had noticed the problem, implementing their own internal solutions (software systems) to improve logistics.

**Question 4. „Did the introduction of the ISZTP system in your company required training course?”**

![Fig.4. Distribution of the answers to question 4. „Did the introduction of the ISZTP system in your company required training course?”](image)

The infrastructure management company PKP PLK S.A. organized a short, one-hour training of the individual carriers operating system ISZTP (web application). Users taking part in the training (70%) also coped with the assimilation of knowledge about the program, based mainly on personal experience and a short instruction manual in electronic format. This shows a good web design of online application of ISZTP system and the personal involvement of users in understanding its functional properties.

**Question 5. „What other data or utility should be included in the ISZTP system, in your opinion?”**

![Fig.5. Distribution of the answers to question 5. „What other data or utility should be included in the ISZTP system, in your opinion?”](image)

The aim of the fifth question was to obtain ideas and new solutions for the ISZTP system. All respondents showed a wide range of knowledge and pointed ISZTP improvements that can still be used (Fig. 5). As many as 90% of respondents indicated the need to change the procedure in case of rejection of electronic submission by the infrastructure manager. Currently, submissions are often rejected due to minor formal errors and must be submitted again. This results in:

- carrier must submit a new proposal,
- the date of route construction begins again,
- previously constructed sections of the route are useless (unnecessarily prepared).

In addition 70% of respondents reported the need to add a module that calculates the cost of the requested route already in the process of preparing the submission. Similar expectations of the users (70% of respondents) are applicable the procedures to exclude obvious errors in submission caused by the customer at each stage of the route procurement. For example, it should be indicated when in submission is train weighing 3,200 tons and a length of 50 meters by mistake. Add a graphical presentation about route information and route parameters, primarily on railway line number with prepared route, name of railway stations, allowable axle load, braked weight percentage required etc. This was reported by 60% of respondents.
Simplification of the routes construction procedure for the carrier is another proposal of 45% of respondents. In this regard, it is proposed to add to the automatic route indication map suggested by the system (based on provided by the carrier limit stations), whilst the information in the table at intermediate stations and the ability to modify the weight of the train in the station. Graphical view of a suggested route would also be useful for less experienced users who may not know about specific different types of infrastructure and technology restrictions.

The need to organize the information on the impediments, accidents and events reported by the management company was indicated by 30% of respondents. The remaining 15% of the responses related to the various problems submitted by the carriers that do not apply the same functionality and more systemic solutions in the overall customer service by the infrastructure manager. These are mainly [2]:

- unnecessary automatic logoff function after an hour of work, regardless of whether the system is carried out active work or if the system is in standby mode,
- the system should automatically identify the right branch for station of rolling stock and train that will be run,
- limited choice of routes available in the directory paths, due inter alia to renovations and modernization over the entire rail network,
- extended processing of submissions for international carriage - but it's related to expectation of acceptance of the submissions by the foreign railways,
- problems of long waiting time for route allocation on weekends or at night, due in part to reduced staffing employees during this period.

Based on the survey results it can be concluded that the system is useful and user-friendly. In an interview with the authors of the web application of ISZTP system obtained information that this is not a final version of the application.

3. Functionality assessment of SWDR, SEPE and SERWO systems

The survey performed in 2010 allowed a functional evaluation of the SWDR (train dispatcher support system) as well as the collection of information on suggested future modifications of the system [1]. The survey concerned the functionality of the system related to the communication with the users and to the system interoperability with SEPE (operational registry system) and SERWO (electronic record of current warnings issued).

3.1 Survey methodology

In 2010 a questionnaire study was performed among the users. The aim of the study was to evaluate the functionality of the SWDR system and to collect the information about the suggested improvements to the system. The study addressed the issues of the system functionality concerning the communication with the users and of the collaboration with SEPE and SERWO systems.

The surveys were carried out mainly using the CAWI method (Computer Aided Web Interview - a questionnaire available on a Web page). The method proved to be effective due to its low cost, high availability (24/7) and to the option of addressing the survey to a selected group of respondents (Internet discussion forum). In the presented case the electronic survey was made available on the Web page of the Train Dispatcher Trade Union of the Polish State Railways and on the discussion forum, as a specific thread. The Web page and the forum are owned by the Union which is a nationwide organisation with several thousand members. The sites are visited not only by the Trade Union members but also by other staff who have daily contact with the evaluated systems.

In order to include the persons not using the Internet (or using it incidentally) in the survey, the study was performed in parallel using CAPI, CATI and PAPI methods as well as by regular mail. In the CAPI method (Computer Aided Personal Interview) a laptop and a palmtop with the questionnaire were made available to the training and integration event participants [1].

3.2 The results of survey

The questionnaire consisted of 11 short questions included on one A4 page. Among 11 questions 8 requires just one answer (choice) to be provided and 3 were multiple choice questions. In addition, 2 of the questions were open, allowing descriptive answer, containing the respondent’s remarks and observations.

**Question 1.** “Do you think that introduction of SWDR (SEPE) system improved the punctuality of trains?”

![Fig.6. Distribution of the answers to question 1: “Do you think that introduction of SWDR (SEPE) system improved the punctuality of trains?”](image)

Answers to question 1 (Fig. 6) indicates that 49% of the respondents have noticed an improvement in the punctuality of the trains as an effect of the implementation of SWDR-SEPE systems. But at the same time 39% of respondents see no link between the functionality of the systems and the punctuality of the trains. May be reason for the latter answers may be low awareness of the users as to the right utilisation of the information from the system in further traffic management (this has also been confirmed by the fact that 12% of responses were ‘Do not know’).

**Question 2.** “Do you think the introduction of SEPE-SWDR system increased the capacity?”
As many as 46% of the respondents see no relation between the speed at which the information is provided and the efficiency of traffic management, leading to the high traffic smoothness and to maintaining the current capacity reserves (Fig. 7). This result may be due to two factors. The first one (and the most important one) is the lack of data in the system. The second factor is the potential inability of the users to utilise the information provided and the lack of trust for the data (indicated also in the answers to other questions). The remaining answers show that the respondents do see the opportunity of using the information provided by the system to increase the capacity of the elements of railway network (of a route – 23% of answers, of a section – 25% of answers and of a line – 34% of the answers). The total percentage in not 100% as this question was of a multiple choice nature. It is worth emphasizing that while increasing of the capacity of the railway network elements may to a large extent be achieved by reducing the train run times (by means of increasing the speed and by introducing modern traffic management devices) it seems that right traffic organisation and regulation (understood as a fast information flow between the staff directly responsible for train traffic) is still not appreciated as a method of increasing the capacity reserve.

Question 3. „Did the introduction of the system increase the speed of access to the needed information about a train?”

The advantages of the system in this domain were appreciated by as many as 90% of the respondents (the answers included 77% of ‘Largely Increased’ and 13% of ‘Somewhat increased’ answers). Unfortunately, the remaining 10% of the respondents do not see any advantages of an efficient access to actual information (Fig. 8).

Until now a train dispatcher could obtain all the information on a specific train (route, carrier, scheduled departure, scheduled passing time etc.) by phone to a relevant line controller. In case when that information was sought after by several train dispatchers the waiting time increased even to several dozen minutes.

At present, a number of train dispatchers may see all the necessary data on the same train on a computer monitor. Presently it seems almost impossible to manage smooth train traffic (especially in cases of cargo trains) without utilising the information on the traffic situation available in the system (while almost 90% of the trains concerned travel on the catalogue routes).

Question 4. „Did SWDR (SEPE) system improve the comfort of your work and of the decision-making?”

The respondents have rated the comfort of working with the system high (82% of respondents). The remaining 18% of respondents were of an opposite opinion (Fig. 9). The system supports the dispatcher very well in this domain and eliminates the time consuming telephone consultations with the controllers as well as the search in printed wire messages. The conclusion may therefore be that should the problems of delayed data input into the system be eliminated, the percentage of positive answers to this question would be close to 100%.

Question 5. „Is the level of access to various system tabs and the possibilities of their edition satisfactory at your work position?”

The responses provided indicate that the opinions on that point are divided (Fig. 10). Only 36% of respondents were satisfied while 54% assessed the access to the data as unsatisfactory.

The first reason of this result may be the workplace structure of the respondents. The participants of the survey were the personnel of large traffic control area for which more access to the system would mean more efficient job, hence the ‘unsatisfactory’ responses were most frequent in that group. For the system users from small stations, just the basic view of the data is satisfactory.
In addition some of them could fall into the group of users who responded ‘do not know’ (10%).

Another reason for the high share of the respondents claiming the access to be ‘satisfactory’ is a natural resistance of an employee towards extending his scope of responsibilities. This would mean new, additional activities of data input and data verification on top of often heavy workload related to train traffic management and train station operations.

Question 6. „Would more access to one of the options with the possibility of editing, help you at work?”

The results (Fig. 11) indicate that the definitive majority of respondents consider an extended access to the system to be helpful in their work (62% answers ‘yes’ and 41% of open answers) as opposed to 29% of respondents being of a different opinion (the percentages do not add up to 100% as the question had a multiple answer character).

![Fig. 11. Distribution of the answers to question 6: “Would more access to one of the options with the possibility of editing, help you at work?”](image)

The analysis of the open answers has shown that [3],[4]:
- in 80% cases ‘the possibility of inputting a real train passing time’ was indicated,
- almost 67% of respondents indicated the drawback to be ‘lack of possibilities of inputting an analysis of a train dispatched’,
- almost 10% of respondents indicated other ideas to enhance the system, e.g. integration of SEPE and SERWO systems, to allow the input of the information on a train delay and its causes directly at the point where the delay was incurred.

Question 7. „Does the system help you at work?”

The answers provided generally confirm the usefulness of the application (almost 91% of answers ‘yes’ – cf. Fig. 12). The information allowing right process of issuing the current warnings, information about a change of train number on the route – all of these are evaluated positively.

![Fig. 12. Distribution of the answers to question 7: “Does the system help you at work?”](image)

Question 8. „Do you think the operation of SWDR (SEPE) system and obtaining the information form it is difficult and complicated, or rather easy and intuitive?”

The respondents (Fig. 13) have given 89% positive answers – probably because of the clarity of the user interface and the order and good structure of data presentation. The remaining 11% of answers were the responses claiming the system is rather difficult or complicated.

![Fig. 13. Distribution of the answers to question 8: „Do you think the operation of SWDR (SEPE) system and obtaining the information form it is difficult and complicated, or rather easy and intuitive?”](image)

Question 9. „Have you done any training concerning the operation of these systems?”

The distribution of responses (Fig. 14) indicates that only a small number of personnel trainings took place (7%) and in 25% cases the knowledge on system use was being obtained from the co-workers, during the breaks in train traffic operations. The remaining 68% of the respondents declared they have learned to use the system by themselves. Such a way of deploying a new system certainly does not help the knowledge of the way it needs to be operated and does not provide knowledge on the system functions. These facts were revealed by the answers to the following question.

![Fig. 14. Distribution of the answers to question 9: „Have you done any training concerning the operation of these systems?”](image)

Question 10. „Do you think the system would be of more help to you if you were fully trained on the system and its features?”

The need to be trained on the use of the system was raised by 70% of the respondents. The remaining 30% do not see such a need
(Fig. 15). Thus, a training cycle should not be limited to passing basic information on the use of the application but also should include the studies of concrete examples of practical application of the information available in the system.

**Fig. 15. Distribution of the answers to question 10: Do you think the system would be of more help to you if you were fully trained on the system and its features?**

**Question 11. What other data should be included in the system?**

For this question 43% of respondents gave the answer ‘do not know’ and 17% consider the current capabilities of the system to be sufficient (Fig. 16). It is also important to stress that as many as 40% of the users have also given open answers to the question:
- 93% of the respondents indicated the need to provide an accurate and current information about the position of the train,
- the need to register the real times of trains passing the station was indicated in 85% of answers,
- about 50% of cases a need to integrate the system with the new application SERWO or the old system ROZKAZ has been pointed out as the needed system functionality.

**4. Conclusions**

The surveys and evaluation of the functionality of presented systems permits drawing the following conclusions. Some modifications are recommended to allow enhanced access to the systems for individual users but from the functionality point of view the systems perform well and the majority of functions available corresponds to the needs of the users [3],[4]. Data acquisition from the operating environment should be automated to a higher extent, so that the unnecessary intermediating links are eliminated. Introduction of changes in the mutual communication of traffic controllers and train dispatchers will improve the ergonomic parameters of their jobs. Another suggestion is to allow the train dispatcher to input directly the times at which the train passed the station and control areas. The intermediation of a line controller was reducing the ergonomic value and the safety of work, especially for the train dispatcher (who, while passing the required information to the traffic controller often had to take at the same time a number of other actions related to train traffic management. This situation is specifically important during freight train traffic and in many situations of delays incurred, emergency situations and other unexpected events. In extreme cases there may be situations when information about train passing is introduced into the system even after several hours. Such delayed information is of little use and may only serve formal and statistical purposes. After survey the current version of the system (2.2 of February 2011) is already meeting this postulate [3],[4]. Allowing the train dispatcher to input the analyses of the deployed trains without the intermediation of the traffic controllers was next suggestion and the new version of the system (March 2011) include the proper module. Systems integration (SWDR, SEPE and SERWO) into one application will make the operation of the system and the information processing more simple. Effective utilisation of presented systems requires that the software implementation is supported by a system of professional trainings.

The implementation of subsequent system versions should be preceded by direct consultations with the users, who possess the best knowledge about the current problems and the requirements of the system users in daily operations. Possible stages of building the funny-example system without systems engineering has been presented on figures 17 and 18. This is summary of conclusions especially above suggestion.

**Fig. 17. Possible preliminary conceptual phase of building the children’s swing without systems engineering**
The functionality problems of the ITS systems supporting rail transportation – survey results 2010-2012

Bibliography


Fig. 18. Possible results of building the children's swing without systems engineering[5]
BLIDS - A Bluetooth/WiFi based traffic data collection system for use in urban an interurban roads

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ABSTRACT
Mobility is one of the basic needs of today’s people. The amount of motor vehicles is ever increasing because of this. Hence there is more and more traffic load on every road, especially in and around urban areas. The maximum capacity of those roads is more and more often reached during peak hours, traffic jams and long travel time is the result. In big cities with high vehicle traffic numbers, it is necessary to operate traffic data collection systems for the control center.

One of the most compelling sensor class is the Bluetooth/WiFi-based traffic sensor, which is a non-intrusive and inexpensive alternative to LPR (License Plate Recognition) systems.

BLIDS-sensors, mounted next to the road, detect unique BT/WiFi-IDs from devices such as mobile phones and navigation systems that come within the reception range of the sensor. This unique BT/WiFi IDs are made anonymous and stored together with highly accurate exact time stamps directly on the sensor before they are transmitted to the BLIDS-server system.

From the information gathered from at least two sensors, real-time traffic information (e.g. travel-times, traffic jams, dwell time at intersections, origin/destination analysis as well as traffic flows) can be calculated.

The BLIDS network provides a wide range of applications. It starts with the installation of mobile solutions to provide temporary measurements and ends with fixed installations.

This paper examines the measures and preconditions that need to be fulfilled for a thorough usage of BLIDS-sensors in strategic route management systems.

KEYWORDS: Traffic management, Bluetooth/WiFi detectors, Traffic congestion, travel time, origin/destination, data privacy

1. BLIDS detection system in general

1.1 Definitions

Bluetooth is a wireless technology for transmission of voice and data over short distances in the unlicensed 2.4GHz ISM band. With the help of Bluetooth devices such as PCs, mobile phones and hands-free devices can wirelessly exchange data.

Wi-Fi is a popular technology that allows an electronic device to exchange data wirelessly (using radio waves) over a computer network, including high-speed Internet connections [1]

1 ISM - Industrial Scientific Medical

1.2 Components

A BLIDS detection system consists of the following main components:
• BLIDS sensor
• BLIDS server software

1.3 Function

BLIDS-sensors, mounted next to the road, acquire unique BT/WiFi-IDs from devices such as mobile phones and navigation systems that come within the reception range of the sensor. This unique BT/WiFi IDs are made anonymous (the data protection authority of the German state of HESSE praises BLIDS to be
The ever increasing traffic in urban areas – together with limited space for additional or extended traffic routes - requires more and more complex control measures.

Strategy management combines rule-based situation detection and an operator-based workflow system, and an activity management for implementing activities. An important ingredient is also a mechanism for solving contradictory activities.

A very important use case for strategic management is to give information to the drivers via VMS or C2R communication systems about the best route to take from a motorway to a city center or to the nearest park-and-ride scheme. See e.g. figure 1 for an example in the city of Leipzig.

Customarily strategic management systems use inductive loops or video sensors to measure the current traffic state on the routes in question. Sometimes complicated traffic models (see e.g. [2]) are used to determine the real flows and speeds on the routes from the stationary road counts. This data has a lot of drawbacks, if it should be used for strategic route decisions:

1. There is nearly no sensitivity to traffic jams that are not generated by traffic lights. Even jams generated by traffic lights can only be detected with high probability by very advanced algorithms (see [3]), and only if the sensor site is not far from the stop line.

2. The calibration and maintenance of the traffic models is crucial, error-prone and very time consuming.

3. The real travel times are never observed and thus there is no possibility for an online-calibration process.

The origin-destination information for a certain percentage of vehicles that traverse the network is a crucial output of the BLIDS sensors. It allows for the determination of precise turning rates at many intersections within the section. If the latter is too large, additional sensors could be placed within it. Common algorithms for origin-destination-estimation can be used to complete the missing relations.

It is not compulsory to monitor every vehicle passing a BLIDS sensor station - additional inductive loops on few spots will allow to extrapolate the “real” flows, thus giving a very good estimation for both, the travel times, the traffic demand and the turning rates for all roads considered.

2.1 Detection of traffic jams

A combination of the whole BLIDS sensor network with stationary detection could allow the determination of the actual position of a traffic jam with a high probability, thus interpolating the travel times on the road elements between the camera sites which are located at the section boundaries.
Figure 2 denotes how this could be done. The first step is to determine the routes between the different OD-pairs. If the travel time on one OD-pair is heavily increasing (indicating a traffic jam on this relation), and parts of the main route for this pair are shared by routes between other pairs, it is possible to estimate the position of the jam: if the travel times for these other routes are not increasing simultaneously, this is evidence that the jam is in the sections not shared by these routes. Thorough inspection of the counting values at intermediate junctions can give further advice. Note however that this approach has serious pitfalls, as traffic jams in the network can lead to unexpected changes in the route-choice-behavior. An accurate database with routes, sections and normal travel times thereon will be necessary.

3. BLIDS sensor network

To generate real time traffic data a specific area will be defined. Within this area BLIDS sensors are to be installed at major interchanges with strategic importance. In practice this means that at every interchange there will be one BLIDS sensor installed. Due to its wide detection range (250m in diameter) one sensor is able to cover even highways with several lanes (in both driving directions).

The BLIDS sensors can be connected via means of various types of networks (cable, GPRS, WiFi).

3.1 Network example

3.1.1 Network design

For this sample project the above shown area was selected (see Figure 1). In this map all the sites where the BLIDS sensors will be installed (BLIDS control points) are marked with a red dot.

At each BLIDS control point one BLIDS sensor will be installed. After acquiring the unique BT/WiFi IDs, they are made anonymous and fitted with an exact time stamp. The encrypted data is saved on a SD Card. Periodically the data are sent to the BLIDS server system for further processing.
3.2 Installation

3.2.1 Equipment

The sample network contains 21 BLIDS control points. At each control point there are in total 4 lanes each, monitored by the BLIDS sensors.

This implies the following necessary equipment per control point:

- 1 BLIDS sensor (either mounted in existing road side cabinets or in separate IP 66 housings)
- required accessories (power supplies)
- As equipment for the BLIDS network system in total is required:
  - 21 BLIDS sensors
  - 1 BLIDS server
  - accessories (power supplies)

3.2.2 Deployment

For the deployment at the control points the existing traffic light masts or gantries can be used. The BLIDS sensors can be installed either in a road side cabinet or mounted on gantries or on masts. One sensor can be installed in about 15 Min. A further advantage is that the installation needs no calibration.

4. Data privacy

Often data privacy is cited against the use of traffic detection systems. Basically, the Bluetooth/WiFi ID is unique for the specific mobile device but it will not be possible to connect it to the owner. There is no data available which allows to match the Bluetooth ID with the person carrying the device. With BLIDS the unique Bluetooth/WiFi IDs are made absolutely anonymous (Dr. Quiring-Kock, Commissioner for data protection in HESSEN, praises BLIDS to be state-of-the-art when checking through the technical details of the protection of privacy solution).

5. Conclusion

The adaptive network control systems currently in operation for traffic management in urban areas are based on detection of traffic volumes and convert these via elaborated models into travel times and streams. The drawback is a vulnerability to overlooking many traffic jams and a high calibration effort.

One solution to eliminate these disadvantages of the static data recovery is the use of BLIDS sensor systems. These provide information used to obtain data on travel time, origin-destination and real-time monitoring of the system performance. This makes it possible to react immediately to changes in traffic flows and to achieve an optimised traffic management.

Bibliography

Intelligent container terminals
- ITS solutions for seaports

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ABSTRACT
Maritime container traffic has been the fastest-growing part of the world transport market for years. Building global supply chains requires the involvement of many actors, both operating within the area of maritime transport as well as hinterlands. Seaports are the focal points of all parties engaged in the transport process, determining their effectiveness. For this reason, dedicated intelligent systems are increasingly used in container terminals to improve their capacity and performance. ITS solutions for seaports should therefore be defined as a four-layer model - port sector, seaport, terminal and cargo/mean level. Obviously, these complex systems need to work together to generate significant synergy effects. For this purpose, it is necessary to use modern technology for identification (RFID, OCR, X-ray), transfer, communication, processing and data sharing. Of importance is that container terminals are also equipped with fully automated transport (AGV) and lifting (ASC) equipment. Therefore, seaports and container terminals demonstrate an interesting example of an intelligent node for the intermodal transport system.

KEYWORDS: seaport, ITS, container terminal, logistics, supply chain

1. Global challenges to the development of seaports

1.1 Maritime container traffic and its importance in the global economy

The globalization process observed in the last two decades, based on the liberalization of world trade, has created a huge demand for transport services. Relocation of the global production of manufactured goods from Europe and North America to Asia (outsourcing & offshoring), as well as a rapid growth of the emerging and developing economies, have increased maritime traffic on the oceans. The crucial technology, suitable for the valuable goods transport, is containerization. So, world container traffic has been growing for years at an average speed of 10%. As a consequence, a total number of about 160 million TEU (20-foot equivalent unit) was transported in the global scale in Year 2012 (approx. 1.5 billion tonnes) [1].

In order to cope with increased transportation volumes and to benefit from the economies of scale, ship owners are continually increasing the capacity of their deep-sea container vessels, recently culminating in the projected 16,000 TEU (CMA CGM’s Alexander von Humboldt) or 18,000 TEU (Maersk’s Triple-E class) container ship generation. Similarly, the total capacity of the world container vessels reached a level of 17,103 thou. TEU in April 2013 [2].

At the same time, the number of boxes served by seaports reached a level of 426 million TEU all over the world (2012). Operators of seaport container terminals have primarily responded to this development by increasing their terminals in size and making use of more efficient transportation and handling equipment. There are, however, a great number of existing terminals, which have already reached their limits and can no longer expand.

Hence, a new, intelligent solution based on existing infrastructure has been implemented in container terminals as well as in seaports as a whole.

1.2 ITS in maritime transport

According to the European definition, intelligent transport systems (ITS) are an advanced application which, without embodying intelligence as such, aim to provide innovative services relating to
different modes of transport and traffic management by enabling various users to be better informed and make safer, more coordinated and ‘smarter’ use of their transport network [3]. The above presented attitude refers to road transport (urban areas or high capacity road infrastructure) in majority (see the title of Directive 2010/40/EU). In the case of other modes, the following solutions respond to traffic management systems as identified in Figure 1.

![Traffic Management Systems](image)

**Fig. 1. Modal structure of the European classification of the TMS**

In the maritime transport sector a vessel traffic monitoring and information system (VTMIS) is regarded as a crucial element of ITS [5]. The system consists of such elements as an automatic identification system (AIS), a long range identification and tracking system (LRIT) [6] as well as it being coherent with the SafeSeaNet (SSN) European initiative [7]. Despite the wide range of elements of maritime ITS, seaport solutions are not included in the EU transport policy as a based area of ITS implementation. However, the business practice confirms the common utilization of ICT and telematic systems in seaports and terminals.

A seaport represents a complex system of highly dynamic interactions between various handling, transportation and storage units and incomplete knowledge of future events. As a transport node, a seaport focuses on a number of different means of transport (maritime, road, rail, IWW, pipe), as well as renders a variety of services (stevedoring, handling, forwarding, logistics, etc.) and operates in different dedicated facilities (e.g. bulk, ferry, container terminals; storage areas and warehouses, land and sea infrastructure connections). It should be emphasized that the wide external interconnections between a port and its surroundings need proper coordination and control. The international environment of a port’s operation, concerning mostly safety and security issues as well as the border crossing requirements (customs, immigration), is the next crucial step in sharing information and coordination. Seaport development should also take into account the specifics of a port’s activity (e.g. ISPS code, regulation of IMO, ISO, ADR).

Growing competitiveness and increased security requirements need to be improved in order for a seaport to be effective. This includes improving the following areas:

- optimization of cargo, ensuring that containers, personnel, ships, trucks, and rail traffic move in and out of ports as efficiently as possible,
- maximization of the mobility and productivity of personnel by enabling them to access data and communicate with each other from any point in the facility,
- monitoring all security issues throughout a seaport by screening its perimeter, as well as containers and other means of transport that enter or leave the facility,
- compliance with governmental regulations and communicate efficiently with the coast guard, customs office and other control services,
- promoting tenants’ satisfaction by providing an efficient operating environment and value-added service,
- unification and upgrading the facility’s communication system for greater operational efficiency [8].

Special attention should be focused on container terminals where a significant number of boxes is flowing through the facility (see Table 1).

<table>
<thead>
<tr>
<th>Scale</th>
<th>Seaport</th>
<th>Container traffic</th>
</tr>
</thead>
<tbody>
<tr>
<td>World</td>
<td>Shanghai</td>
<td>32.5 million TEU</td>
</tr>
<tr>
<td>Europe</td>
<td>Rotterdam</td>
<td>11.8 million TEU</td>
</tr>
<tr>
<td>Baltic</td>
<td>St. Petersburg</td>
<td>2.5 million TEU</td>
</tr>
<tr>
<td>Poland</td>
<td>Gdansk</td>
<td>929 thou. TEU</td>
</tr>
</tbody>
</table>

For this reason, on a terminal level, the following kinds of areas with particular decisions should be supported by dedicated ITS systems [13]:

- operate planning (empty container distribution, storage and stacking policies, crane assignment and split, berth allocation, stowage planning),
- real-time control (landside transport, quayside transport, slot assignment, crane scheduling and operational sequencing).

The last field for improving a seaport’s operation is service and management of the means of transport (vehicles, vessels, trains, handling equipment) as well as the cargo units (or passengers). This refers mostly to booking systems and cargo scanning (security seals).

Again, the complexity of a seaport’s transport system should be emphasized. Therefore, an intelligent system of planning, coordination and control of a seaport’s activities must outline and define the function (or set of functions) and its goal(s). The core of the system should therefore be a database solution interconnected with a dedicated application used in particular fields and levels of a seaport’s activity. Last, but not least, it is necessary to integrate various parts and processes occurring in a seaport, its terminals as well as financial, institutional and social environment. Finally, the crucial benefits from implementing the ITS can be presented [14]:

- integration - the ability to combine different technologies, hardware and software in order to obtain a more efficient flow of information,
- flexibility - the ability to create new structural configuration in order to better accommodate the needs,
- efficiency - ability to increase and promote the benefits,
- intelligence - as the ability to make independent decisions in changing circumstances.
2. ITS solution for seaports and container terminals

2.1 ICT and telematic systems in the seaport sector

Utilization of information and communication technology in the transport sector could be investigated on the following levels [15]:
- micro-level: company processes support systems,
- mezzo-level: improving data exchange between the partners/companies/organizations/agencies,
- macro-level: coordination and efficiency improvement of the transport systems.

Table 2. ITS systems used in seaports [16]

<table>
<thead>
<tr>
<th>Medium</th>
<th>Objective</th>
<th>ITS technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freight</td>
<td>Security</td>
<td>Freight traceability / security</td>
</tr>
<tr>
<td></td>
<td>Security quality</td>
<td>Electronic seals, tampering</td>
</tr>
<tr>
<td></td>
<td>Dangerous freight</td>
<td>Temperature, humidity, vibration sensors</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Electronic identification</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fleet management system</td>
</tr>
<tr>
<td>Transport mode</td>
<td>Mechanical condition</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Monitoring</td>
<td>Sensors: fuel level, tire status, speed, mechanical</td>
</tr>
<tr>
<td></td>
<td>monitoring</td>
<td></td>
</tr>
<tr>
<td>Infrastructure</td>
<td>Monitoring traffic conditions</td>
<td>Traffic management systems</td>
</tr>
<tr>
<td></td>
<td>Weather conditions</td>
<td>Weather stations monitoring rain, fog, precipitation,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>atmospheric pressure, wind conditions, etc.</td>
</tr>
<tr>
<td>Driver</td>
<td>Identification</td>
<td>Automated identification systems</td>
</tr>
<tr>
<td></td>
<td>Route conditions</td>
<td>Traveller information systems</td>
</tr>
<tr>
<td></td>
<td>Driving times</td>
<td>Fleet management systems</td>
</tr>
<tr>
<td>Equipment (cranes, trailers, other)</td>
<td>Depending on the type of freight</td>
<td>Automated identification systems</td>
</tr>
</tbody>
</table>

Table 2. ITS systems used in seaports [16]

In the case of maritime transport and seaports, the development process of ITS systems occurs at each listed level. To be more precise, a list of ITS solutions for seaports is presented in Table 2. Two main challenges to seaports’ ITS is freight traceability & security as well as infrastructure efficiency. Similarly, the crucial application/technology can be counted. These are: the port community system, terminal operation system, automated identification system and fleet management system. It should be emphasized that this kind of application is dedicated to a particular seaport terminal, so in multi-terminal seaports (common practice) such kinds of the systems should be multiple as well as integrating. On the other hand, because of competing terminals with highly sensitive business information located directly next to each other, special confidential solutions should be implemented into the system.

2.2 ITS solutions model for seaports

Implementation of telematic solutions and building intelligent systems in seaports strongly affects not only their efficiency, reliability and safety of port operations, but also integration between the ports and their environment. The environment of a port system includes cargo owners, shippers, passengers, and carriers of all modes of external transport available in a port [14]. Because of the wide selection of ICT and telematic systems implemented in seaports, a base model of a seaport's ITS has to be structured. Taking into account the objectives of the system activity, a four-level model can be defined and described (Fig. 2).

![Fig. 2. The layer model of ITS for seaports](image)

Despite the presented division of the seaports ITS application, interaction between the particular levels is necessary. On the one hand, the higher-rank systems consist of lower-rank systems; on the other hand, the lower-rank systems feed the higher with information [18].

The Port Community System (PCS) is placed at the top of the model. PCS integrates international trade, public agencies and transporters. Such kinds of the systems can be regarded as external ITS solutions. Port Community Systems have played a major role in facilitating a more efficient movement of goods while allowing customs and other governmental agencies to maintain effective control.
The following list of documents can be replaced through the use of PCS: manifests and associated amendments, customs release notes, ship's out-turn/discharge reports and amendments, bonded removal documents (for example, inter port, ICD, CFS, etc.), local transshipment documentation, lines’ commercial release, acceptance of rent/storage charges, delivery instructions to transport operators (road/rail), export delivery advice, export arrivals, export load list, loading reports, customs scanning/examination/sealing requirements, port health/quarantine and other governmental departments’ activities, requests to out-turn in sheds/warehouses (devanning), shed/warehouse out-turn reports and amendments, customs declarations for exports, ship planning notifications and amendments, dangerous/hazardous goods reporting [19].

The PCS solutions operate in numerous seaports around the world. Examples are listed below [20]:
- DAKOSY in Hamburg,
- PORTNET in Singapore,
- INTIS in Rotterdam,
- ADEMAR PROTIS+ in Le Havre,
- PROTIS in Marseille,
- HIT in Hong Kong,
- EDI in Kobe,
- PACE in London,
- ORION in Charleston,
- Tradegate ECA in Sydney,
- SEAGHA in Antwerp.

What is important, the PSC systems from the different seaports can be integrated into one solution like in case of the EurotransPortnet system (Antwerp, Le Havre, Rotterdam, Bremen/Bremerhaven, Hamburg and Felixstowe) or EUROMAR (Marseille, Genoa and Valencia) [21].

The second layer of the model is constituted by access control systems. As they border the seaports, the external - internal nature of the solution could be indicated. Because of the variety of the available application with the different scope of activity, there are a number of system examples: The Port Access Control System (PACS), Gate Operating System (GOS) or Access Security Systems (ASS). The main features of the access systems are as follows [22]:
- data (imaging) collection,
- recognition (e.g. license plate, container number),
- high-resolution damage inspection imaging,
- measurements (cargo units, means of transport),
- access / area control and alarms,
- storing of all vehicle, train, container, trailer and personnel traffic data.

Gate access systems [22] exist in many global, European and Baltic seaports (e.g. Helsinki, HaminaKotka, Cuxhaven, Tallinn, Gioia Tauro, Tilbury).

The next level of ITS in seaports is the Terminal Management System (TMS) or Terminal Operation System (TOS). The system focuses on optimizing maritime freight processes, loading and unloading of ships, and logistics planning, including operations and location, human resources, equipment and warehousing. According to market players, TOS needs to be [23]:
- reliable, built on a dependable technology platform;
- flexible and adaptable so it can be configured to local operating needs;
- scalable so it grows with the needs of the operator;
- seamlessly integrated with other systems and backed by dependable support.

Under a single umbrella of TOS, the following features should be available: EDI, DGPS positioning, activity charging, vessel planning, intermodal rail planning, networked multi-terminal management, resource planning, gatehouse security and vehicle booking [24].

There exists a selection of the TOS systems available on the market. As was mentioned before, TOS systems are dedicated solutions for a terminal (terminal operator), offered by IT companies. Similarly, complete and standard TOS applications are offered (e.g. COSMOS, NAVIS, Autostore CTMS, MES CTMS, Mainsail TMS).

Last, but not least, elements of ITS are systems prepared for particular and specific issues of items of a seaport’s operation. As examples of the leading application, the following solutions can be listed:
- Container Security Seals (CSS),
- Fleet Management System (FMS),
- Vehicle Booking System (VBS),
- Vessel Planning Module (VPM),
- Container Positioning System (CPS).

In practice, all the above mentioned systems are included and coordinated within the TOS system.

3. ITS technology in seaports

3.1 Technology solutions for ITS

ITS solutions for seaport and maritime transport are equipped with common tools and technologies like in other modes of transport. The core element of the system is IT hardware and software with database storage.

The second element of the architecture is communication and information transfer technology and devices. Both wired (e.g. optical fibre) and wireless (Wi-Fi, GSM, GPS) solutions are available.

A very important element of a seaport and maritime transport’s ITS system is the Automatic Identification System (AIS) and Automatic Positioning System (APS). In this case, a specific solution has been developed.

On the one hand, AIS can be regarded as an automatic tracking system used on ships and by vessel traffic services (VTS) for identifying and locating vessels by electronically exchanging data with other nearby ships, AIS base stations, and satellites. What is important, the system uses different satellites networks (Globalstar, Iridium, Inmarsat) equipped with a special application for maritime traffic monitoring. Thanks to this, proper planning of a seaport’s operation can be prepared.
A slightly different sort of automatic identification systems should also be recognized in a seaport area. In this case, utilization of the following technologies is necessary:

- Optical Character Recognition (OCR) - gate systems, container number identification, damage inspection;
- License Plate Recognition (LPR) - special feature and application based on OCR technology;
- Radio Frequency Identification Devices (RFID) - identification of: container, vehicle or storage area;
- ID card system with PIN code readers - drivers, port workers;
- Sensors, X-ray and radiation detection units, biometric devices - cargo scanning and sealing.

3.2. Automated equipment for fully controlled ITS in a container terminal

A special feature of the seaport ITS system, different from other modes of transport, is the automatic seaport equipment in a container terminal. The technology solution for improving the overall productivity of a container terminal and to reduce the berthing times of vessels is to enhance the degree of automation of the handling and transportation equipment. Such attitude is fully coherent with the ITS development in container terminals. Elimination of the drivers or operators increases the reliability of the terminal operation while improving the dependence on ICT. Since a container terminal represents a complex system with various interrelated components, computerized logistics control systems recently gained considerably more attention [25].

Three types of automatic equipment in a container terminal can be listed (Table 3).

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Transport</th>
<th>Lifting</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGV</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>ALV</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>ASC</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>

The most common solution is the Automated Guided Vehicle (AGV). These types of terminal operations are provided in Hamburg, Rotterdam and Singapore. A vehicle serves container transport between a quay (STS crane) and stackyard [27]. An ITS system, based on the AGV technology system, has to include fleet management and navigation applications as well as control of the AGV fleet [28].

The benefits offered by Automated Guided Vehicles for ports can be elaborated as follows [30]:
- they are cost-efficient and time-efficient,
- they increase the efficiency of the overall processes in a terminal,
- traffic pertaining to the transportation of the cargo internally in the ports is well regulated,
- potential accidents and consequent injuries are reduced substantially because of the absence of human traffic.

Today, the AGV development process is directed towards capacity and flexibility development or increasing the functional scope (ALV). The concept of C-AGV offers a load capacity of 61 tonnes. A vehicle can carry casettes with double-stacked 40-foot containers or two 20-foot containers in a single tier. Major improvements to manoeuvrability have been made by incorporating individual electrically-driven and steered bogie axles which enable the C-AGV’s to be moved in any direction and turn 360 degrees [31]. An Automated Lifting Vehicle (ALV) is another way of AGV development. The vehicle mostly engaged in transport services (horizontal movement) is also fitted with the possibility of lifting a container up from the yard. So far, this kind of equipment is still in its infancy stage.

The second type of terminal equipment is an Automated Stacking Crane (ASC). It performs fully-automated housekeeping and management of container stacks. It also forms the link between quayside and landside equipment such as ship-to-shore cranes, transport vehicles and trucks [32]. The crucial benefits from ASC implementation are defined as follows [33]:
- high stacking density, optimum use of space,
- high working speeds, high handling rates,
- crane and system software, maximum efficiency,
- drive technology that makes efficient use of resources.

Implementation of automatic transport systems in a terminal creates an Automatic Container Terminal (ACT). So, integration of the ITS applications and ACT can radically improve the efficiency and effectiveness of a seaport and make its implementation into the supply chain management process easier.

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Automated supervision systems for Limited Traffic Zones

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ABSTRACT

More and more cities implement solution for motorized traffic reduction in separate areas of the cities. These areas include mostly cultural and historic centers, promenades and often all centers of large cities. To achieve traffic reduction, special fees for entrance to the city center are introduced and special bus lanes for emergency vehicles and public transport are isolated. Such solutions with paid or limited entrance to city centers occur in London and Berlin and dedicated bus lanes has also appeared in Poland in the major urban centers. These examples are often referred by the authorities of other cities wishing to introduce similar schemes. In order to effectively enforce the respect for the rules in Limited Traffic Zones automatic monitoring and supervision solutions are introduced. Automatic Number Plate Recognition (ANPR or ALPR – Automatic License Plate Recognition) is one of the elementary and most widely used system for LTZ security and effectiveness. ANPR allows the identification of the vehicles that appear on the entrances to the Limited Traffic Zone or move within the zone (for example, the bus lane). This article presents an implemented and successfully operating automatic Limited Traffic Zone in Katowice.

KEYWORDS: Limited Traffic Zone, safety, Automatic License Plate Recognition

1. Limited Traffic Zones

1.1 Introduction

Heavy traffic is the main problem in the cities and on frequently attended roads. Significant congestion of the road transport system during peak hours or increased intensity leads to traffic congestion, commonly called traffic jam. They are formed as a result of poor planning of transport routes, existence of bottlenecks, and lack of existing infrastructure adaptation to the current traffic load [6]. Centers of large cities were planned at a time when there were no cars. Hence their incompatibility with the existing conditions.

The occurrence of traffic congestion is a negative factor in the functioning of society. It causes delays in people and goods transport. It also increases environment pollution, especially in urban areas - where people work and live. As a negative economic factor, traffic congestion cause unnecessary fuel consumption. It is estimated [2] that the total losses resulting from the occurrence of congestion in European countries are as follows: 1.5% of GDP in the UK, 1.3% of GDP in France and 0.9% of GDP in Germany. For the United States of America, this cost amount to 0.6% of GDP (in 2007).

In order to move traffic out of the city to the highway ring roads, special fees are introduced for the entrance to the city centers. These special zones function as restricted areas. Entry is limited to the zone. Vehicles are allowed to move freely within its borders. Restriction of movement is forced through the introduction of the congestion charge for the entrance to the designated zone. Its boundaries include the usual central districts or historic centers (the old town, pedestrian streets, promenades, etc.). Fees are to encourage travelers to optimize the number of trips, to choose an alternative means of communication (use of public transport), to better plan the route or even the time of departure. It should be noted, however, that city centers are still "centers of the cities" where stores and other commercial premises are located, where goods should be delivered. Commercial vehicles during discharge
obstruct traffic lanes and increase air pollution [6]. In [6] some initiatives have been proposed (in the context of Spanish cities), seeking to release the inner cities from vehicles.

Introduction of charges where road infrastructure has limited capacity seems to be the best solution in terms of congestion reduction [2, 1]. Despite the success of the operating zones there is a large public opposition for the implementation of such schemes [2, 1]. Examples include referendums conducted among citizens in Edinburgh (2005), Manchester (2008) or the political debate and opposition in New York (2008) [2]. Detailed analysis of dissenting voices was considered in [1].

1.2 Examples and solutions of LTZ in Europe.

The center of London is an example of operating limited traffic zone. The zone was introduced in 2003 and has now 10 years of functioning. London Charging zone is a restricted area with a fee for entry. It initially covered an area of 21 km² and the entrance to the zone was £ 5. At present the zone covers larger area and the charge varies from £ 9 to £ 12 [3]. Figure 1 presents the map of Congestion Charging Zone. The fee is charged on weekdays from 7:00 to 18:00. There are exemptions and some vehicles can drive in the zone free of charge. These include vehicles of: public service, public transport, taxis. Those vehicles complying with the Euro 5 standard for air quality qualify for a 100 per cent discount [3]. Residents of the area can get a 90 per cent discount. There are several methods of payment, promoted one is by automatic charging (Auto Pay method).

![Fig.1. Congestion Charging Zone in London](image)

The functioning of the London system is based on the automatic license plate recognition. Every vehicle entering the zone is verified with the database, which stores information about fees and exemptions from the payment. In case of absence of appropriate record a penalty is issued automatically to the vehicle owner.

There is also special zone of low emission in London, called the Low Emission Zone. It operates since 2008. The introduction of this area was motivated by the desire to reduce emissions in the capital of Great Britain.

For users with the largest and most polluting vehicles equipped with diesel engines the solution is to adapt to the new conditions: the change to a more eco-friendly vehicle, the installation of a filter or pay the daily congestion charge. The fee ranges from 100 pounds (for larger minivans) to 200 pounds for buses and vehicles exceeding the gross weight of five tons [3].

Similar to London's solution is the „Stockholm congestion tax” (Swedish: Trängselskatt and Stockholm), introduced in Stockholm in 1 August 2007, after seven months of testing in the first half of 2006. It is the second solution is introduced in Europe. It is worth mentioning that in the remaining 14 agglomerations Swedish citizens in referendums spoken out negatively for the introduction of similar zones. The zone operates on the basis of monthly tax dependent on the time inside the area. The owner of the car gets a bill through the e-mail or directly to the Internet bank. The third option includes automatic toll charging.

Technical solution of the Stockholm zone is based on wireless RFID technology. Vehicles are equipped with transmitters lent to drivers. An important element of the system is the video subsystem. Its task is to automatically recognize number plates of vehicles without transmitters. It also verifies the correspondence of data from the transmitters with the database data. Finally, it collects evidence against the owners who avoids charges. Fees are collected in an automated manner from a bank account from people who have equipped vehicles with transmitters. There are also unmanned electronic toll stations, a total of 18, located on the borders of the zone.

Another example of restricted traffic zone is the Umweltzone. Umweltzone are ecological zones that are functioning in German cities. In Berlin the zone was introduced at the beginning of 2008 [4]. In contrast to the restricted traffic areas in London or Stockholm, entry to the center is free of charge. Fee is charged only for the issue of a special badge denoting emissions standards for a vehicle. The number on the sticker denotes the area where the driver can freely move. The most restrictive zone is the one designated with four (green badge). To get the badge with “4” and the possibility of entering the green zone a vehicle must meet at least Euro 4 emissions standard. The regulations of each zone are determined by individual cities. In Berlin, the zone is restricted to the internal ring of S-Bahn. Hence, the entrance to the center is exclusively reserved for those vehicles meeting the appropriate standards. For an unauthorized entry there is a penalty of 40 Euro.

Milan is an example of Italian city which introduced charges for city center entry. The zone is called the “Area C” and corresponds to the central Cerchia dei Bastioni area [5]. The zone was introduced in 2012. The entrance is limited with a valid entry ticket (5 Euros) which must be activated before entering. The activation is possible with the use of SMS service, a telephone, the Web, or directly in the office. The zone has 43 access points, 7 of which are solely for public transport. ALPR cameras operate in all access points.

Vehicles with low or zero-emission (motorcycles, scooters, electric vehicles, hybrid or gas-powered) or vehicles transporting persons with disabilities or in need of medical attention are not subjected to charges. During hours of operation (from 7:30 to 18 or 19:30 depending on the day) it is forbidden to enter the area for standard gasoline vehicles with Euro 0 and diesel vehicles.
with the standard of „Euro 0, 1, 2, 3” exceeding 7.5 meters in length. Temporarily, diesel vehicles that comply with the „Euro 3” belonging to area residents, vans and tourist vehicles have the opportunity to enter the zone.

1.3 Implementation LTZ in Poland.

There is also some movement observed in Poland where major cities are considering or already working on introduction of restricted traffic zones. Examples include Krakow, Lodz and Katowice.

In Krakow, for example, implementation of access control system for traffic calming zones and supervision of public transport lanes is realized within the project “Development of public transport management system in Krakow”. The task is to implement the control system of bus passes and implement solutions that could affect drivers’ behavior and attitude within the “B” zone. An automatic access control system to the “B” zone will be introduced. It will control bus lanes and enable automatic detection of movement violation by unauthorized vehicles. The system will provide the possibility of quick punishments for drivers committing offenses. By elimination of unauthorized vehicles to enter the “B” area, the attractiveness of downtown Krakow, mainly the Main Square and Plant district, will increase.

2. The SOR Katowice system

2.1 Opening

The SOR Katowice system was built by PHU TELSAT [8] within the street: Mariacka, Stanisława and Mielęckiego. It is a comprehensive system for monitoring traffic in a restricted traffic zone. It operates on the basis of automatic license plates recognition (ALPR system). The system is designed to enforce restrictions on the availability of transport and parking to a restricted area, located in the center of Katowice. An additional objective of the scheme is to improve the city functioning by providing ongoing supervision in scheduled areas for occurrence of events affecting the proper operation of urban infrastructure, public transport, pedestrian and vehicle traffic, threats to people and property.

By using dedicated ALPR cameras [7], the system identifies the license plates of vehicles entering or leaving the zone in existing access points (see fig. 2 for the example). Then, the system automatically handle the vehicles with subscription (“known to the system”) or through a single system operator entries or departures from the zone (Those vehicles, „unknown to the system”, are handled by system operator, who grants single pass. It is worth noting that the system has been made with a view to minimize the operator involvement in the general-use of subscribed vehicles. For such vehicles it is possible to define any time ranges, i.e.: days of the week, working days, not working days, hours, minutes, holidays, etc., freely configured by the system administrator.

ALPR cameras via fiber-optic networks transmit PAL video signal to an acquisition computer, which is responsible for image analyzes. After recognition, the message with identified license plate is transmitted to the database server. Registered vehicles movement through access points is handled automatically by the application on the database server – via TCP / IP and microcontrollers. Microcontrollers send signals to hydraulic pillars which unlock the way. Figure 3 presents a pillar with built-in camera for automatic license plate recognition. The pillar is equipped with red and green lights for signaling a driver possibility of movement.

Fig.2. The entry and the exit of limited traffic zone on Mariacka Street

Fig.3. Pillar with built-in camera for automatic license plate recognition equipped with red-green light signaling (on the left hand side lowered hydraulic pillar on the ground level)

For the direct supervision of the zone, installation of CCTV video surveillance cameras has been made. Surveillance subsystem serves to protect hydraulic pillars and other elements of the system infrastructure against acts of vandalism and road accidents. Recordings from the CCTV system provide further proof in guilt determination (e.g. attempts of enter during red light).

An intercom or video intercom may be the additional element supporting the work of the system allowing direct communication for a driver with the operator.
2.2 Location of the main access points of the system

The system consists of four access points localized on the Mariacka Street (two access points), the Stanisława Street (one access point) and the Mielęckiego Street (one access point). Each of the above mentioned passage is equipped with at least two hydraulic pillar operated via control unit supervised by the application server (for automatic passages) and system operator software.

Control center is located in the building of the Municipal Police, and communications between the different elements of the system is implemented by fiber-optic network. Figure 4 presents hardware allocated in the control center.

Fig.4. Hardware supervising the restricted traffic zone system in Katowice

The primary objective of the system is to regulate the movement to traffic-restricted area. The task is to limit entry to the zone for unauthorized vehicles and automatically authorize entry into or departure from the zone for authorized vehicles – located on the so-called „White list“. Control over hydraulic pillars is automatic (for vehicles permitted to travel in the zone) and semi-automatic or manual by the operator of the system.

There is also the possibility of combining data from ALPR cameras with optional short-range RFID readers. RFID readers are designed to support the users with temporal access to specific part of the zone, between consecutive entrances and departures (for example, for people with disabilities, suppliers, temporary hotel guests, etc.).

The system operator has an overview over the situation of entry and exit from the area, made possible by means of an additional monitor of the CCTV surveillance system. After granting the appropriate permissions, the operator also has the ability to add vehicles to eligible groups. Thus, during next entrance or exit from the zone the vehicle is handled automatically. The operator panel in the Web interface is presented in fig. 5.

2.3 Software for supervision of Limited Traffic Zone system

Software for supervision of Limited Traffic Zone system provides full functionality of supported vehicles or groups of vehicles on:

- accurate reading of license plates of all patterns allowed in European Union (including square shape format and obsolete black license plate in good lighting conditions);
- the ability to detect vehicles without license plates;
- access to system archive data with the ability of criteria definition for records selection and aggregation;
- the ability to define groups of registration numbers;
- available operation modes:
  - automatic – pillars are automatically lowered after proper identification of license plate of authorized vehicles,
  - semi-automatic – the system suggests the operator a requirement for a specific group of vehicles of conditional entry to the zone,
  - manual – the operator manually controls movements of pillars;
- possibility of remote diagnostics of the system;
- the ability to generate manual reports, create automated reports and statistics on the performance of the system in each application mode, cross-group and cross-temporal;
- the ability for the operator to manually edit vehicle license plates numbers identified by the system;
- the ability to define time ranges, in which the vehicles or groups of vehicles are granted permission to enter and exit a specific area;
- reports on each access point load (number of vehicles that pass) in different modes: daily, weekly, monthly, yearly and other including user-defined;
- the ability to create statistics about the operators of the system labor – including reporting on registration numbers of vehicles which have been granted access in manual mode;
- software interface in Polish;
- acoustic system provided for operators for a specific events;
- use of MSSQL Server database or equivalent (e.g. Oracle);
- work in a client-server mode;
• access to the system with an unlimited number of computers using a Web browser;
• the ability to secure access to applications via a USB dongle PKCS#11 (access token);
• integral part of the software is a module of travel time.

Image of example vehicle from waiting to enter the restricted traffic zone and observed in IT system is presented in fig. 7.

Fig.6. Image of example vehicle waiting to enter the restricted traffic zone

The software enables full management of groups of vehicles, including full management and definition of new groups such as:
• a group of vehicles permitted to enter the designated area – operated by issued IDs;
• a group of vehicles defined separately for each entry / exit;
• a group of sought vehicles;
• a group of temporary vehicles such as wedding or other event service, medical transport;
• a group of vehicles permitted to enter the zone, a separate list for each entry / exit.

Panel for groups’ management is presented in fig. 7.

Fig.7. Groups and license plates belonging to subscribers

3. Conclusion

The article presents the latest developments dedicated to automatic supervision of limited traffic zones introduced in Poland and abroad. Based on example implemented in Katowice by Telsat ultra-modern system for automatic surveillance and control of restricted traffic zone has been presented. The openness of the system and ease of adaptation to a particular task allow to take full advantage of the system, its capabilities, continuous development and adaptation to the demands of investors. It is worth noting that the system has been awarded the title of Lider of the ITS in 2011 for contractors – PHU Telsat for Best Product and prize for the Investor – Katowice City Hall – In the category of Best Deployment. This demonstrates the high level of innovation and effectiveness of the developed solution.

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The Innovative 3G Technology in the Variable Message Signs

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ABSTRACT
This article presents the innovative 3G technology used in the VMS (variable message signs). The 3G optics is an advanced lenticular solution that allows an effective mixing of three colours (RBG) without the effect of the colour change depending on the viewing angle. This technology is in opposition to the previously used systems with the separated light beam distribution for the red, green and blue colour. The work describes in detail the functional and technical performance of the new VMS technology and summarizes the characteristics of the parameters obtained from the previously used light beam distribution technology. An important element of the study is to present a measures of performance and efficiency associated with the power consumption, light output, light distribution, visibility, legibility, reliability and durability. Particular attention was paid to the evaluation of the VMS optical performance efficiency. In addition, in the presented work were shown examples of the installed 3G VMS, as well as examples of graphic and text messages displayed on 3G signs.

KEYWORDS: variable message signs, LED optics, 3G signs

1. Introduction

1.1 The Use of the RGB Model in Road Variable Message Signs

The RGB LED technology allows to display any colour from a palette of 256 colours, however, the basic range of colours used in road signs are: red, yellow, green, blue and white. In case of using the LED technology, the colour of the emitted light depends on the width of the energy barrier of used semiconductor material and in practice, at the present moment, does not cause any major problems to obtain the desired light colour. Only white colour is achieved by additive colour mixing or using a special phosphor changing blue (or UV) LED light on a white light radiation. The method of mixing colours (additive mixing) is carried out by placing in a housing 2, 3 or 4 LED of different colours. It is worth noting that in the road application colour rendering index is not applicable.
1.2 Formal Requirements for Variable Message Signs

The basic formal requirements for the VMS signs are specified in [8]. The basic parameter of the RBG VMS is the colour space, which is described with the chromaticity coordinates. The chromaticity chart for the class C2, is shown in the fig. 2.

Taking into consideration the limitations of the RGB LED technology, it is very important how the VMS manufacturer can deal with ensuring uniformity of the colour, in relation to those required by the standard 10 years of operation time. The classic RGB LED technology and LED aging effect leaves existing applications in Poland much to be desired in this respect.

Another important technical parameter, from the point of view of the 3G technology, is the angle of the light beam distribution.

The choice of the light beam class distribution depends on factors such as class and width of the road, speed and capacity of human perception, especially in terms of readability of the graphic contents. The importance of the directional intensity of the radiation source and the light intensity at the point at which the recipient is able to read, for example a text message, cannot also be ignored. The larger the angle of the distribution, the greater the current must be used to power the LED in order to provide a fully readable information. This is strongly associated with the phenomenon of faster degradation of LED. An effective solution is to use optoelectronic systems which allows to focus the light beam emitted by the diodes.

2. LED Current as a Factor Determining the Efficiency and Reliability of the VMS

Light-emitting diodes produce monochromatic light, which follows directly from the principles of their operation. The intensity of the light is not too great when the source is a single item. Hence, the useful efficiency in real environments requires a parallel structure, in a functional sense, taking into account the use of many small parts to achieve proper illumination, effective in the realities of the road and its surroundings. In the physical sense (for interpretation in the form of a complex object) we are talking of course about the serial structure, because proper work requires the operation of all the constituent elements (LED). It can be considered in the form of the so-called mixed structure (serial-parallel), for which some elements function as a parallel object and redundancy allows the part of LED to be crashed, while maintaining a “full” functionality of a complex object. We can see how it can work in practice in reality of our roads when trying to determine, which has been encoded in a graphical puzzle, when only a part of the traffic sign is visible. If the objective function is to increase driver alertness, the effect can be achieved. However, in the meaning of the sign efficiency, it is not acceptable, and an attempt to define what percentage of defective parts can be tolerated may not necessarily be effective. The damaged LED distribution is important, and in this case it is quite difficult to define. Far better is to take efficiency of all the LED elements, treating the VMS sign as a serial object.

In this case, using the analysis presented in [1] may determine that the reliability of a complex object is expressed by the product of the probabilities of failure of individual elements, as it is legitimate to assume that the elements are independent.

The use of a lower reliability devices, for the reduction of purchase cost, is just as effective as throwing a rotten meat, fragrant otherwise, to the soup. It is worth to trace presented in the cited literature [1] examples to convince (mathematically) the reasonableness of such action. Assuming that the manufacturer of the equipment will also be the service provider, it can be assumed that the used components are of the appropriate quality.

Regarding the incandescent lighting elements, the failures are usually considered in a catastrophic way in the form of “turn on or not”. For other types of items, it is assumed that the damage can be a parameterized, but the deterioration of the properties over a defined percentage is also regarded as catastrophic failure. The good example is buying “energy-saving” light bulbs with an average operation time labelled on the packaging. After a surprisingly short time bulbs begin to “fade”, creating an intimate atmosphere in the room. The similar situation occurs with the LED. In contrast to the light bulbs at home, in the VMS signs the current supply of the LED elements can be changed. The result is, of course, the changes in the intensity of light, but by treating the problem in the right way, we can optimize the multidimensional problem.

The light output of the LED decreases gradually. In this case, a substitute for a parameter called the lifetime of the object, which
is an approximate estimator of its properties [1], is used as the
term of the operating time. This is a descriptor for a similar logical
sense, except that the change in the intensity of emitted light to
the 90% of the initial capacity is interpreted as a failure in order to
eliminate the object of use.

Therefore, if (for example) a standard [8] requires that the device
keeps its durability, when exposed to a corrosive environment, for
a minimum 10 years, the selection of the components of a complex
object is essential, because the use of the “n” elements (in simple
terms) also “n-times” reduces the unit life related to a single element.

The lifetime of the object can be adjusted by the user, depending
on the level of his technical culture. An example of this can be a
daily use of a car. Indefensible is the thesis that one driver gets
the same “successful” version of the engine and the engine of the
second driver is frequently damaged. Experienced or trained user
knows that a certain speed range allows an efficient and economical
driving while other is just effective. Similar situation is with the
light-emitting diodes. Selection of parameters for their actions can
have a significant impact on the sustainability.

2.1 The Current Dependence

The basic parameter for the operation of the LED is the supply
current. Voltage across the diode is a postponed value inherently
related to its structure (known from basic electronics diode
characteristics show quite small vertical or horizontal deviations,
depending on the direction of polarization). Controlling the
amount of the current directly affects the intensity of the light
source (light). Just as higher engine speed in a combustion engine
trigger the more power, the similar rotations reduce the trouble-
free operation, so the higher LED current will give “more light”,
but at the expense of reducing the desired longevity. Figure 4 well
illustrate this dependence.

2.2 The Temperature Dependence

It is well known that the current flow results in generating heat –
the Joule-Lenz law. An increase in the current value, in accordance
with the quadratic relationship, is reflected in the increase of the
thermal energy.

Although the ratio of 1.5 is spectacular, we should focus, in
accordance with the ideas articulated above, at the 90% of the
original optical quality. In this case, the different values (rather
schematically indicated on the x-axis) for the lifetime of the object
are still visible. If the reduction of the light intensity does not
substantially affect the functionality of the sign (like taking “the
foot slightly of the accelerator” does not affect the comfort
and efficiency of the car), then for obvious reasons the supply current
should be reduced.

2.3 Verification of the Supply Current of the
VMS RGB

The current supply of the so-called classical SWARCO FUTURIT
RGB LED (Fig. 7a), with reference to the nominal current, oscillates
at about 16-17% for the colours red and blue, and 7-8% for the green
colour. Detailed values are shown in the Figure 6.
3. Innovative 3G Technology

The 3G Optics Lens is an advanced solution that allows an efficient mixing of three colours (RGB) without the effect of changing colour depending on the angle of observation. This technology is the opposite of already used separated beam distribution systems for red, blue and green. The 3G technology allows to significantly reduce the power consumption of the VMS device, minimizing the “aging” effect in the life cycle of the object, increasing the MTBF (mean time between failures) and reducing costs of maintaining and servicing.

In the figure 7 are shown a classic RGB matrix and the 3G optics. In the classic system, each of the three LED (red, green, blue) has its own lens system (in the illustrated example lens have rectangular shape), whereas the 3G optics has been implemented with a lenticular system in the form of single circular lens.

Application of a common optical system for the three colours has been possible with the use of LED SMD (surface mount device). Full colour in the LED SMD (Fig. 8) was created by placing 3 LED in a single housing. LED SMD is characterized by a small size (in this case 3.2 mm x 3.2 mm), high optical efficiency, low power consumption and long operation time.

Table 1 presents the values of the forward (nominal) current for each colour. The highest value (50mA) has a red diode, while for the green and blue colours current is 35 mA.

Table 1. SMD RGB (Nichia STS-DA1-0125)

<table>
<thead>
<tr>
<th>Colour</th>
<th>Forward current (nominal value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blue</td>
<td>35 mA</td>
</tr>
<tr>
<td>Green</td>
<td>35 mA</td>
</tr>
<tr>
<td>Red</td>
<td>50 mA</td>
</tr>
</tbody>
</table>

The 3G optical system (Fig. 9) consists of a focusing lens, front lens and LED housing. The optical system focuses the emitted light beam, providing the optimum use of light and preventing from the phantom effect, which is created as a result of sunlight illumination. With the 3G technology one achieves following technical functionality:

- Luminance: meet the requirements of the class L3 (*) EN 12966-1:2005 + A1: 2009 for all colours - a value is at least 25% higher than the required minimum values. The derived class of luminance for the 3G allows an excellent content readability even for long distances, regardless of the position of the sun.

- The ratio of luminance: far exceeds the requirements of the R3 class of the standard [8] for all colours - providing high content readability even in the most adverse environmental conditions, in particular when the sign is exposed to a direct, blinding sunlight (high resistant to the phantom effect).

- The angle of light distribution: B6 meets the requirements of the standard [8] for all colours - a value is at least higher by 25% than the required minimum values. The 3G minimizes the effect of changing colour depending on the angle of observation.

- Uniformity: meeting the requirements of the standard [8] for all colours – in order to achieve the standard, in average, the values are at least lower by 80% than the required maximum values was used.

- Lifetime: high quality optical performance has been achieved through the use of only 15% (supply current in relation to
the nominal current) of the LED light brightness. This clearly extended the durability of the LED components and other sign components to about 20 years of operation. During the whole period there is no sign of the optical performance degradation or the phenomenon of non-uniformity of colour. The use of low power consumption strongly affects the economics of operating and maintaining.

### 4. Measures of the Optical Performance

All of the features above are integrated and taken into account in the formula for the OPE (Optical Performance Efficiency):

$$\text{OPE} = \frac{L_r \times I_m \times Bw \times pp^2}{a \times I^2 \times Lx}$$

where:
- $L_r$ – achieved luminance factor - see the test report of the Notified Body.
- $I_m$ [mA] – the maximum forward current - see the technical datasheet of user LED.
- $Bw$ – beam width in accordance with standard [8] - see the research report and table 2 (BW).
- $pp$ [mm] – spacing between elements (pixel pitch) as defined in the standard [8].
- $a$ – number of light element, the LED of the same colour per pixel.
- $I$ [mA] – the supply current to ensure compliance with the requirements for the luminance and luminance factor – see the CE-certificate research report.
- $Lx$ – factor depending on the class of luminance obtained in accordance with standard [8] - see research report CE-certificate and table 3 (LX).

**Table 2. Table conversion of the beam width (BX) [9]**

<table>
<thead>
<tr>
<th>BX</th>
<th>B1</th>
<th>B2</th>
<th>B3</th>
<th>B4</th>
<th>B5</th>
<th>B6</th>
<th>B7</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.005</td>
<td>0.007</td>
<td>0.010</td>
<td>0.020</td>
<td>0.015</td>
<td>0.030</td>
<td>0.120</td>
</tr>
</tbody>
</table>

**Table 3. Table conversion of the LX factor [8]**

<table>
<thead>
<tr>
<th>LX</th>
<th>L1</th>
<th>L2</th>
<th>L3</th>
<th>L3*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>0.5</td>
</tr>
</tbody>
</table>

An example of the calculation of the OPE for freely programmable RGB matrix, with pixel pitch 20mm, L3*, R3, B6, C2 shown in table 4

**Table 4. An example of the OPE calculation**

<table>
<thead>
<tr>
<th>Colour</th>
<th>W</th>
<th>Y</th>
<th>G</th>
<th>R</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>L3</td>
<td>18.4</td>
<td>11.8</td>
<td>6.0</td>
<td>6.8</td>
<td>2.0</td>
</tr>
<tr>
<td>L6</td>
<td>120</td>
<td>85</td>
<td>35</td>
<td>50</td>
<td>70</td>
</tr>
<tr>
<td>BW</td>
<td>0.03</td>
<td>0.03</td>
<td>0.03</td>
<td>0.03</td>
<td>0.03</td>
</tr>
<tr>
<td>pp</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>a</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>I</td>
<td>12.9</td>
<td>9.57</td>
<td>2.1</td>
<td>5.95</td>
<td>2.33</td>
</tr>
<tr>
<td>Lx</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
</tbody>
</table>

$$\text{OPE} = \frac{318 \times 263 \times 1143 \times 231}{5.95 \times 2.33 \times 0.5 \times 0.5 \times 0.5 \times 0.5 \times 0.5}$$

Table 4 shows that the highest value of the OPE index was calculated for the green colour, and the lowest for the colour white.
5. Cost Comparison

An important aspect of these technologies is to compare the cost of purchase, operation and maintenance of signs. For comparison purposes signs with the matrix size of 1300x1300 mm were selected. The estimated cost of the sign are shown in figure 13. According to fig. 13 sign with the RBG 3G technology have the highest purchase price (over 20% higher in relation to the RGB technology with the front shield and 64% higher compared to the pre-defined characters).

Next step is to compare the costs of operation, maintenance and repairs (table 4).

Table 4. Summary of other sign expenses

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Predefined</td>
<td>40</td>
<td>17</td>
<td>74,46</td>
<td>at least 12 years</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td>RGB 3G</td>
<td>100</td>
<td>30</td>
<td>131,4</td>
<td>at least 12 years</td>
<td>400</td>
<td>1200</td>
</tr>
<tr>
<td>RGB with front shield</td>
<td>1250</td>
<td>375</td>
<td>1642,5</td>
<td>5 - 7 years</td>
<td>400</td>
<td>1800</td>
</tr>
</tbody>
</table>

In regard to the annual operating costs, the use of the sign made in 3G technology is more than 12 times cheaper than the sign with the front shield. This is due to the power consumption of the sign with the front shield, which is over 12 times higher. Cost of operation is the lowest for the pre-defined sign, with the value of less than 100 PLN per year. Servicing costs are more or less at the same level for each technology. Worth noticing are repairs after the warranty, which for the 3G and sign with front shield cost respectively: 1200 and 1800 PLN. An important element is that the estimated life of the sign with front shield is almost two times lower than for the 3G and predefined technology.

6. Contents Examples – the 3G Matrix

The basic range of colours (red, yellow, green, blue, white) which can be emitted in road signs are shown in figure 15.

The 3G technology also allows to display the freely programmable, full-colour test messages and graphics. Examples of messages are illustrated in figure 16.
8. Conclusion

Choosing the technology of variable message sign can be reduced to four basic points:

- The choice of technologies depending on needs - the choice between cost attractive predefined signs, and fully programmable RBG technology.
- Consideration of the sign operation and maintenance cost - technology selection not only in terms of the initial purchase cost, but also taking into account the indirect costs arising from the exploitation process.
- Consideration of the sign durability and reliability - selection of technology for proper operation during the specified time period. The proper operation is understood as maintaining appropriate lighting parameters.
- Selection of certified signs with a complete report of the test – sign should fulfil the standard [8] and manufacturer should present the results of measurements required for the specific functional classes. Test should be made by a notified research body.

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Notice: For colour version of the figures please contact the authors.
European ITS framework architecture for transportation planning support

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ABSTRACT
This paper gives an overview on some chosen aspects of transportation planning process and decision making. This article aims to show how FRAME Architecture can be seen as a decision support tool for transportation planners, transportation engineers, IT engineers and decision making persons.

KEYWORDS: ITS Architecture, European Framework ITS Architecture, FRAME, Systems Engineering, system requirements, strategic planning

1. Introduction
The use of information and communication technologies in road transport has progressed remarkably during last 40 years. Intelligent Transportation Systems are seen as a power tool to provide sustainable growth. ITS Systems have become more effective, that's why are widely deployed. The more advanced this systems are the more difficult to manage them in a cost-effective way, especially in the context of maintenance. Today's systems mostly are not open and do not provide geographic continuity and interoperability. Solution for this problem is strategic planning which allows to control and easily plan the spendings. This approach is based on European Framework ITS Architecture – FRAME, which can be use as a model of any ITS System and a guide for decision makers, contractors and system engineers. FRAME is expressed in terms of user needs and functional requirements gathered into consistent groups. FRAME offers also support for organizational issues, cost/benefit analysis, risk analysis, communication requirements, deployment programme, component specification and for defining the system boundary.

2. Transportation Planning
Planning is an integral part of decision making process. Plans establish a context in which we anticipate when and where future developments will occur. With founding constraints, plans tell a region what it can afford, and what it cannot. Transportation planning is an important part of defining a vision for the future and of establishing strategic transportation investment and system operation directions...[1] for the defined area. Intelligent Transportation Systems are enhanced “traditional transportation” by means of ICT technologies. This technology addition requires new approach for decision making process support because of different lifetime of the projects, more number of stakeholders and necessary ICT knowledge required for more complicated problem solving. However, the basics of the planning process are the same for ITS and “traditional transportation” and in each case is to generate information useful to decision makers for the specific types of decisions they are facing. The scope of Intelligent Transportation Systems projects vary widely from national level to specific ITS services. That's why it is needed to have different kind of strategies for different types of planned implementations.

3. FRAME ITS Architecture

3.1 What is the FRAME Architecture
European framework ITS Architecture is the result from Framework Programmes funded be European Commission since 1998. For that time FRAME is continuously enhanced – with cooperative systems being added by the E-FRAME project (2008-11)[2]. FRAME Architecture covers the following areas of ITS[3]:
• Electronic Fee Collection – enables the acceptance of payment for services provided by other areas of ITS
• Emergency Notification and Response – enables the Emergency Services to respond to incidents.
• Traffic Management
• Public Transport Management
• In-Vehicle Systems
• Traveler Assistance
• Law Enforcement
• Freight and Fleet Management
• Support For Cooperative Systems

FRAME Architecture is intended to use within the European Union, that's why consists only user needs, and functional viewpoint to not mandate any physical or organizational structures on its users.

3.2 FRAME Architecture in European Policy

From many years European Commission is looking for the basis for deployment interoperable ITS services. As a result Action Plan (2008) and ITS Directive (2010) are the first written documents which aims to define the necessary measures to develop EU ITS Framework Architecture. Action 2.3 from the Action Plan and actions from the priority areas II: “Continuity of traffic and freight management ITS services” (action 1.1/1.5) and from priority area IV: “Linking the vehicle with the transport infrastructure” (action 1.1/1.2) from the ITS Directive. [4][5]

FRAME Architecture was funded from the beginning from European Commision budget and it seems to be natural consequences to be the biggest candidate for mentioned earlier EU ITS Framework Architecture. Action 2.3 from [6] aims to “define, adopt and support the deployment of a multimodal European ITS Framework architecture, based notably on the FRAME model and the results of E-FRAME project (2008-11)”. 

4. Results of FRAME ITS Architecture

FRAME architecture can be modeled the same way as systems in system theory or systems engineering. The inputs are the stakeholder aspirations and the output is the result of the FRAME transformation process[7].

Fig.1. FRAME as a system

Inputs are a structure consisting of a set of Stakeholder Aspirations $S = \{x_1, x_2, \ldots, x_n\}$. Outputs area collection of results from FRAME Architecture $R = \{S_b, D_p, O_i, C_s, C_r, C_b, R_a\}$, where: $S_b$ – System boundary, $D_p$ – Deployment programme, $O_i$ – Organisational issues, $C_s$ – Component specification, $C_r$ – Communication requirements, $C_b$ – Cost/Benefit analysis, $R_a$ – Risk analysis.

4.1 System boundary

System boundary is what is insight our system. System boundary consist of subsystems and modules. In Systems Engineering field these are called components. “A software component is a unit of composition with a contractually specified interface and explicit context dependencies only.[8] These interfaces creates a boundary of the system. Interfaces are defined by the physical data flows between our system and external entities called terminators/actors. Each terminator has its own responsibility which is outside the scope of defined system.

4.2 Deployment programme

Deployment programme often called mitigation strategies is the way how to get from legacy systems (if exists) to intelligent transportation vision. From the picture below it can be seen that the most important part is the interim which is the precisely defined transition based on the ITS architecture document. This document needs to be extended to software or hardware component specification which fulfill the requirements from the legacy systems and ITS Architecture document.

Fig.2. ITS Deployment programme

4.3 Organisational issues

ITS implementation frequently involves both public and private organizations, including local authorities, public transport operators, equipment manufacturers, service providers. Before service can be deployed successfully, their relative roles and responsibilities (financial and organizational) must be clearly established.[9] Organisational issues comes from system boundary and division the system into subsystems and modules (components). Each component is deployed and managed by specific organization which is responsible for developing and/or maintaining defined group of functionalities. These human entities are responsible for properly functioning of each part of the system and the consequences of not meeting defined service level agreements could be easily punished.

Another business is that “to achieve the main goal of deployment involves hitting a lot of subtargets – meaning not only the technology deployments but agreeing on who does what and working with the public authorities that will have to carry on the work after the project finishes, when there is no further funding”[10]. Organisational issues helps us to create good business models before the deployment starts.
4.4 Component specifications

Most contemporary Intelligent Transportation Systems exist in highly dynamic environments. Their requirements change frequently and they must be built or modified on challenging development schedules. These systems are mainly decentralized and built from modules called components. Every component has a component specification. Each component's specification defines the basic characteristics of the interfaces (inputs and outputs) and operations. Development of pluggable components is a key motivation of valuable design approach. That is, it should be possible to understand precisely what a component does based on the specification for the operations in its interfaces. It should be possible to replace one component by another that implements the same set of interfaces i.e. traffic controller software or hardware. It should thus be possible to reuse a component reliably with several different components in different contexts.

Fig. 3. Component with interfaces (UML 2)

4.5 Communications Requirements

Communications requirements defines requirements for physical dataflows within our system and between system and terminators. Physical viewpoint creates the framework for actual design of the system (such as location of the functions, location of the data and level of detail of the data, etc). Telecommunication choices are made through complex decision making process because of the necessary bandwidth and costs. Communications requirements are also linked to the appropriate standards. FRAME Architecture (physical viewpoint) shows us from where to where information goes.

4.6 Cost Benefit analysis

Benefit-cost analysis (BCA) is a technique for evaluating a project or investment by comparing the economic benefits with the economic costs of the activity. Benefit-cost analysis has several objectives. First, BCA can be used to evaluate the economic merit of a project. Second the results from a series of benefit-cost analyses can be used to compare competing projects. BCA can be used to assess business decisions, to examine the worth of public investments, or to assess the wisdom of using natural resources or altering environmental conditions. Cost benefit analysis should be an important tool for ITS decision makers. It is closely connected to the component specifications where estimated cost of each component may be established. Knowing our budget we can choose which components we can afford with the precise definition of the interfaces needed for further development.

Fig. 4. Component based C/B analysis

4.7 Risk analysis

Regarding to PMBOK plan risk management process is organised around five consecutive phases:

a. Identify risk - process is used to identify and gather all risks and there nature, which could impact the project. SWOT analysis is a part of this process.
b. Perform qualitative risk analysis - this process is performed quickly to determine as soon as possible which risks are the highest priorities on the project. It uses the probability and impact matrix (PIM) to prioritise and rank risks.
c. Perform quantitative risk analysis - assigns a projected value (usually this value is stated in terms of cost or time) to the risks that have already been ranked by the previous process.
d. Plan risk responses - this process, plan risk response is, plans for how each risk will be managed, and who will be responsible for them.
e. Monitor and control risks – is the process of implementing risk responses plans, tracking identified risks, identifying new risks, and evaluating risk process effectiveness throughout the project.

Plan risk management should take place early in the project because it will have a significant impact on all aspects such as scope, time, cost, quality, and procurement.

5. Conclusion

As shown in this article FRAME Architecture is a great tool for decision makers to plan ITS Systems in a more convenient and efficient way. The results from FRAME could be the part of Terms of Reference or high level specification of particular design. This paper showed that having ITS Architecture could not be an aim
as itself but the mean to an end. Risk analysis and Cost Benefit analysis could be used for strategic planning. System boundary and organizational issues may be used for dividing the responsibilities for each part of the system and the communications requirement, deployment programme and component specification should be applied to the all technical issues.

Bibliography