

INTEGRATED SYSTEM FOR SAFE TRANSPORTATION OF CHILDREN TO SCHOOL - WITH THE USE OF INTELLIGENT TRANSPORT SYSTEMS (ITS)

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Abstract

The aim of the paper is to present the main guidelines of the Safeway2School European research project. The project's primary objective is to determine the safest route for school buses that transport children to school, through low traffic density areas, avoiding black spots. The project anticipates the use of Intelligent Transport Systems (ITS) in the process of children transportation. Within the project the Route Planning System, Rerouting System and Warning System will be designed and developed for school buses as well as for all surrounding vehicles. Project aims at designing the route for school buses and also the alternative route (in case the bus has to be rerouted due to traffic congestion or traffic incident) in order to maximize the safety of transported children with the use of localization and route planning tools, on-board safety systems and sensors in vehicles and road infrastructure. It is also crucial to design the network of „intelligent” bus stops (child-bus stop-bus communication) and equip the pilot group of children with special tags. The target group of the project consists of school bus drivers, children (pupils 6-16 years old) and their families, but also the road infrastructure authorities, car manufacturers, other road users and representatives of public administration. Within the project the training programs for school bus drivers, children, parents and other drivers will be elaborated. The aim of such activities is to result in unification of guidelines, training schemes and regulations concerning safe transportation of children to school. For the pilot realization of the above mentioned systems and training programs four European localizations have been chosen: Sweden, Austria, Italy and Poland. At the end of the project realization an evaluation of usability and effectiveness of applied technologies, as well as the level of system user's acceptance will be conducted. The project was submitted to the European Commission within the 7th Frame Program. Motor Transport Institute is the Polish project executor.

Keywords: *road traffic safety, road traffic safety guidelines children transportation safety, intelligent transport systems*

1. Introduction

School bus transport is an underinvested area in many European Union countries. This kind of transport should be a priority for all societies, since it concerns one of the most vulnerable road users - children. It should also be considered not only in terms of travelling by bus, but also from door to door perspective - from the moment a child leaves home until it reaches school's door.

Even though crash statistics show the number of accidents involving children, they often lack school bus transportation accidents, e.g. before the bus arrives and after it departs from the bus stop, even though riding a school bus is children's main travelling activity during school year. Different studies show that highest risk for a child to be injured or killed in a school bus related crash is when getting to and from the bus stop and while waiting at the bus stop.

In most countries there are no systems for school bus route guidance or route planning. These systems are crucial for driver support system, but also in terms of optimization the bus route in order to cut CO₂ emission. There is a need for a system that supports the driver of the bus, which would inform where to go, where are the bus stops located and when children should enter or exit the bus.

It is also important to increase the visibility and awareness for other road users (e.g. car drivers) with a unified marking and signing in the EU. This aims at decreasing speed or stopping

completely when passing a school bus. Intelligent transport systems (ITS) have the potential to increase traffic safety, limiting the dangerous situations leading to decreasing the number of road accidents.

The Safeway2School project will use different national initiatives and best practices to give solutions to the problem with a holistic approach. It encompasses the development and implementation of several tools aiming at increasing the safety of children, which will lead to lower death toll and number of injuries. In addition, the feeling of security among children travelling by a school bus, their parents and the bus driver will rise. The driver will be aware of the children coming to the bus stop, and children will know when the bus is arriving so they do not have to rush. Also parents will know if the child is on-board.

2. Polish background

In Poland each year around nine thousand children aged 0-17 are injured or killed in road accidents. In 2005, 2006 and 2007 the majority of road accidents casualties were noted in the age group of 7-14 years old. In this group of children consequently 4565, 4311 and 4274 children were injured and 114, 101 and 97 were killed. In the age group under 6 years old in the consecutive years 1526, 1446 and 1480 children were injured and 59, 50 and 59 were killed. In the group of children 15-17 years old 3388, 3156 and 3527 were injured, 165, 150 and 180 were killed in road accidents. In the age group of 7-14, road accidents' victims (killed and injured) are mainly pedestrians, the second most endangered group constitutes car passengers. As in other EU countries there are no special statistics available concerning accidents during travel to and from school. The total number of children (pupils attending school 6-16 years old) in Poland equals 3601627 (2008), number of children travelling constitutes 20% of all children attending school.

As far as transportation by school bus is concerned some children are transported by a provided school bus, others travel to school by the regular public transport. The criteria for school transportation differ among countries and there are also major differences concerning their signing.

In Poland, around 700000 children between 6 and 16 years of age travel by school buses. Act on Education states that safe transportation and guidance should be provided for children who live in a distance longer than 3km (6-10 yrs of age)/ 4 km (11-16 yrs of age) from the nearest school. A guide/assistant should be present on board of each school bus. A special government funded program is used to purchase school buses. New buses purchased by the Ministry of National Education are equipped with safety belts and signing/markings, and are also adapted for transportation of children with disabilities. Another option for local authorities is to buy either used buses and transform them into school buses (signing/markings) or select the transportation service through a tender offer. In these options it is not always possible to adapt the buses to transport children with disabilities. Vehicles transporting an organized group of children or youth under the age of 18 should be marked in front and back with a plaque of yellow colour with a black symbol of children. School buses in Poland are orange coloured (only the ones purchased by the Ministry), marked in front and back with rectangular white plaques with black school bus text on it. Drivers of school buses have to go through special training, carried out by the Police. School bus drivers can give orders or signals to other road users. Other drivers approaching a school bus are obliged to stop if the stop sign on the bus is turned on. A guide/assistant should be present on board of each school bus, but there are no regulations as far as their training is concerned. However, they should have a certificate of first premedical aid training. Local authorities assign teachers or retired teachers to assist on school buses (special purchased buses). New buses and the older ones (leased from the transportation companies) meet all the requirements as far as exhaust emission limit is concerned for this type of vehicles.

3. Project's objectives and target groups

Project Safeway2School aims to design, develop, integrate and evaluate technologies for providing a holistic and safe transportation service for children, from their door to the school door and vice versa, encompassing tools, services and training for all participating key actors. Safeway2School project's main objectives are:

- to develop the optimal route planning for school buses, to guide them through low intensity traffic areas, and to avoid so called black spots,
- to develop the optimal real-time route guidance, considering the traffic data, but also the estimated arrival time of children at the bus stops,
- to develop intelligent bus stops' chain which takes into account children's and school buses' location, and transmits relevant information and warnings,
- to develop a secure and reliable system of school bus position tracking and monitoring,
- to develop parents' notification system, informing them whether children are on-board the school bus,
- to integrate safety enhancement applications with regard to speed monitoring and safety belt usage for school buses while travelling,
- to develop warning systems for surrounding vehicles while a school bus stops in the designated area and children are waiting, entering or exiting the bus,
- to develop suitable training schemes for main actors of the project: school bus drivers, children, their parents and other drivers,
- to carry out socio-economic analysis, and therefore to identify optimal business plans, legal schemes and organizational incentives for fast adaptation and market penetration of project's system.

Target groups for which the project is designed are as follows:

- school bus drivers,
- students/children aged 6-9, 10-12 and 13-16 (with and without disabilities), when they are travelling alone from/to school bus (however some applications - e.g. safety belt use - are required for all ages),
- families of the children,
- infrastructure (e.g. bus stops or bus fleet operators),
- car manufacturers,
- authorities (legislators, municipal and school authorities),
- other drivers (e.g. of surrounding traffic vehicles).

The project's purpose is to combine a wide range of ITS technologies regarding localization, route planning, route guidance, vehicle to vehicle (V2V), vehicle to infrastructure (V2I) and on-board systems and sensors, as well as short-range and GPRS communications, etc. All these solutions aim at providing a holistic approach to safe transportation of children from door to door perspective.

The project concept has the following attributes:

- no new telematic systems research,
- wide application of already existing V2I, V2V, ISA (autonomous), etc. sensors/systems,
- emphasis on integration to deliver applications,
- innovative research on HMIs (human machine interactions) for all,
- realistic Use Cases for different environments, regarding different organisational, cultural and environmental conditions in children transportation around Europe (performing pilots in Austria, Italy, Poland and Sweden covering North, Central, South and Eastern Europe),
- accompanying socioeconomic research and training initiatives, towards realistic and short-term implementation.

Safeway2School aims to promote the development of safer and more secure door to door school transport for children within the EU. The project aims to promote the development of:

- more detailed and coherent crash statistics of school transport accidents within the EU,
- school transport safety increasing systems and technology (driver support systems, bus stop inventory and route planning tools, bus marking and signing, intelligent bus stop marking and signing),
- uniformed guidelines, training kits and policy recommendations of school transport within the EU.



Fig. 1. Safeway2School approach towards the safe transportation of children to/from school (Source: Safeway2School Project Proposal)

The above figure illustrates the scheme of project's solutions from the moment a child leaves home until it enters school. It shows the following stages of the trip to and from school including all safety features and devices, and also the preparation stage before a child leaves home.

4. Project's Use Cases and workplan

There will be 3 different systems developed within the frames of the Safeway2School project.

Use Case 1 - Safest route planning

The Route Planning System is designed to calculate the route based on safety criteria for buses and also children's way to and from bus stops (avoiding unsafe passages and waiting areas for children). The route will be calculated based on traffic data (e.g. on black spots) in order for the bus to reach all stations going through areas of slow traffic, avoiding complex and dangerous intersections. In order to evaluate thoroughly safe bus stops and ways to and from the bus stops the project's Inventory Tool will be used (also based on safety criteria). The safety criteria, grounded on state-of-the-art and crash statistics from different EU countries, will be developed within the project. The System during planning the safest route will also concentrate on reducing CO2 emission as much as possible. The bus driver will have the final route presented while driving as a part of a driver support system. The Safeway2School Route Planning System will use relevant know-how from other EU projects.

Use Case 2 - Rerouting and monitoring

The Rerouting System developed within the project will change the bus route, mainly to save time but also to cut CO2 emission. The System will operate in case of traffic problems or when a child is not present on the bus or at the bus stop. One of the requirements to use this System is to provide special tags which will be carried by the children. There has to be also a chain of intelligent bus stops, with the possibility of getting the signal from the tags and act as nodes between them and the school bus. The bus stops should be equipped with flashing lights warning other vehicles in the area. The children’s tags also provide an arrival notification to parents and schools by mobile phone information (sms). In case of any changes in schedule of the bus children and parents will be notified by sms. This will be done by project’s Dynamic Information System.

Use Case 3 - Warning other drivers

The Warning System will be developed in a way to be used both on the bus and at bus stops. The intelligent bus signs (designed within the project) and intelligent bus stops will send signals to other drivers to inform them to reduce their speed and to be more alert since children are present in the area. The system will only signal when children are actually present. The Use Cases will be potentially enriched with other systems.

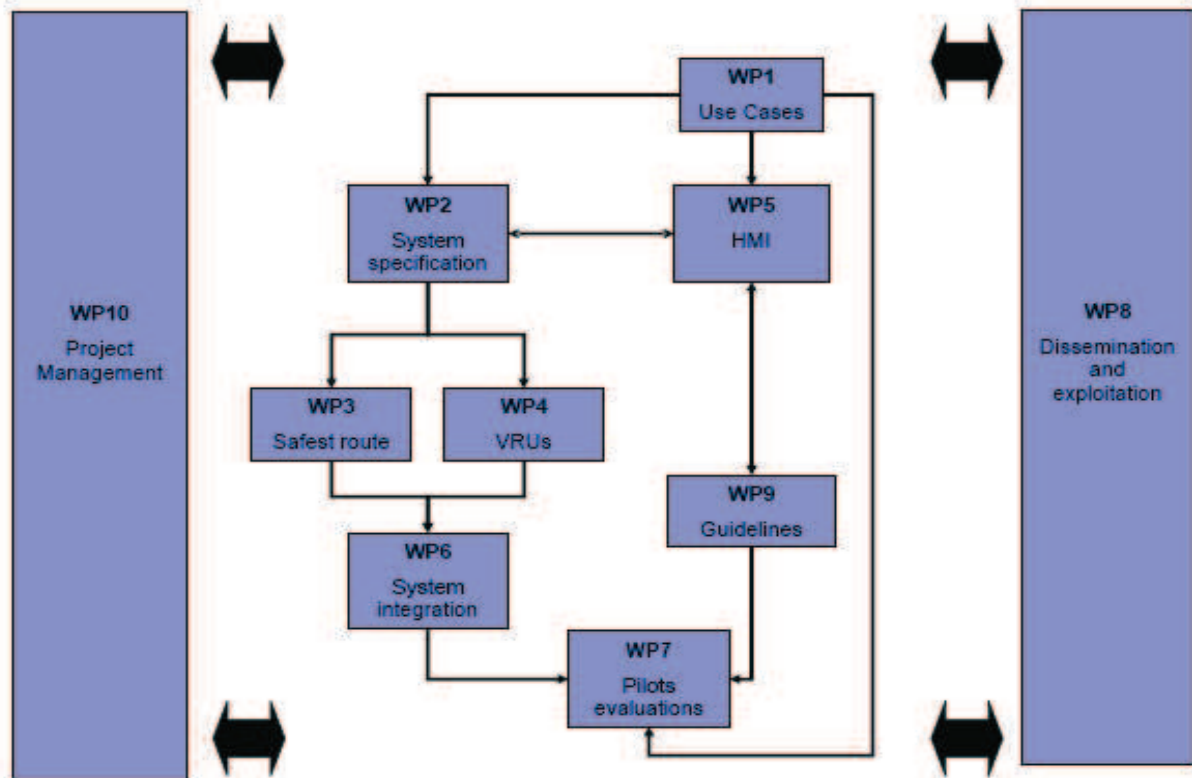


Fig. 2. Safeway2School strategy and workplan (Source: Safeway2School Project Proposal)

Fig. 2 illustrates the workplan of the project and connections between WPs. All required information of school transportation by bus within the EU will be collected in WP1 (Use cases). Based on this information, use cases will be drawn, which will be tested in WP7 (Pilots evaluations). The information from WP1 will also be used in WP5 (HMI - Human Machine Interaction), where the most suitable design will be selected for different systems developed within the project. The information gathered in WP1 and the design principles from WP5 will be used to design architecture and specification of the systems in WP2 (System specification). Also in WP2 risk, security and privacy issues will be dealt with. The system specification is the base for the

actual development of the systems in WP3 (Safest route) and WP4 (VRUs - vulnerable road users). All developed systems will be integrated and verified in WP6 (System integration) and tested in the use cases in WP7. Management is handled in WP10 (Project Management), whereas dissemination and use in WP8 (Dissemination and exploitation).

Poland is responsible for carrying out training stage in WP9 (guidelines), and will also participate in WP1, WP7 (as a pilot site) and WP8.

5. Safeway2School architecture

The Safeway2School architecture is presented in Fig. 3. The stress should be put not only on the trip inside the school bus. It is also important to implement safety criteria concerning the way to/from the bus stop and presence at the bus stop. Therefore, training for bus drivers and children should be carried out. It is also important for passing vehicles to reduce their speed and be more alert when children are around the bus stop or when a school bus is passing.

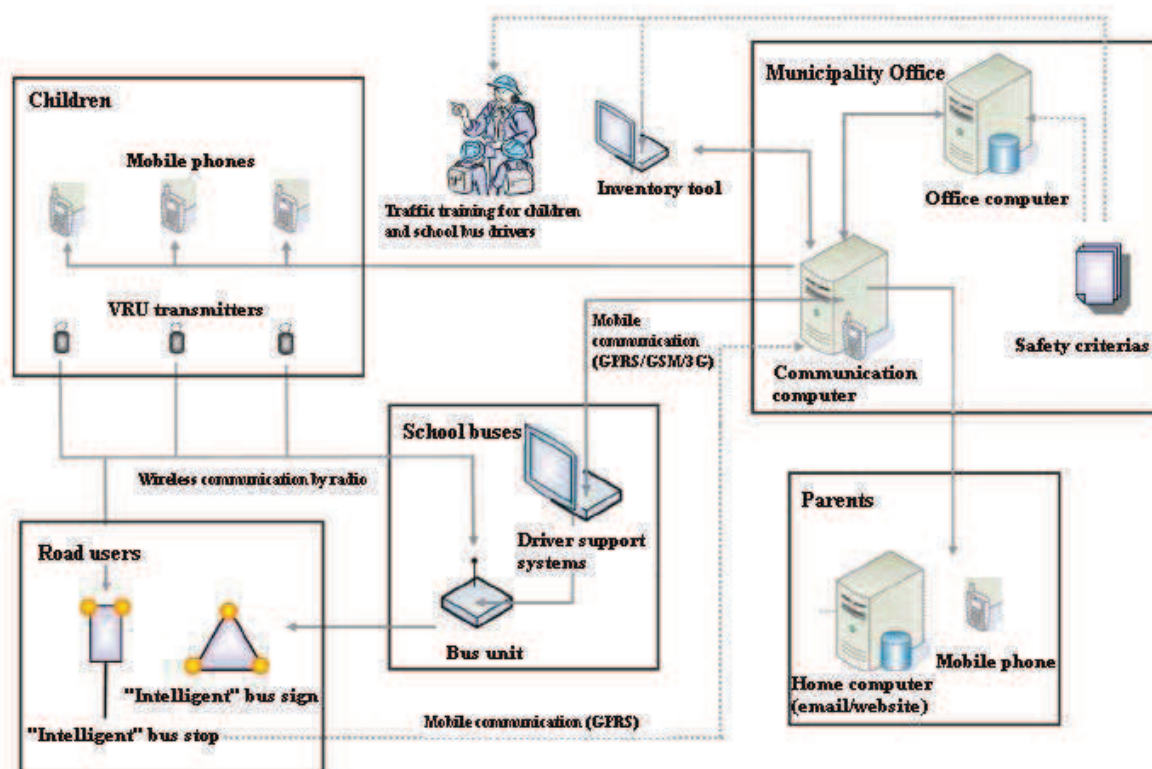


Fig. 3. Safeway2School architecture scheme (Source: Safeway2School Project Proposal)

The route of the bus should be determined in such manner to avoid unsafe bus stops and to make sure that the way to/from the bus stop is also secure for children. The strategic level will also include training schemes for children, parents and bus drivers. The tactical level encompasses rerouting systems regarding traffic situation but also information if a child is going to school by bus on a given day. This system will collect information from children via transmitters, by mobile phones or by web applications. Parents can log in to the system. Traffic information will be updated in the system with help of web applications. The system based on this information will make a new route which will be presented in the bus to the driver's decision support system (DSS). Information will also be sent to children's/parents' mobile phones. The DSS will be connected to a server that will disseminate the information. A system on the operative level is designed to make road users more alert about children being on the way to and from the bus stop or waiting at the bus stop. It will send information to the surrounding vehicles only if children are around. It can be achieved via transmitters carried by the children and also with warning signals

(visual/audio) at the bus stop. There will be a system that with the help of the specially designed sign will make drivers more aware of risky situation. The sign will start and stop automatically with help of the route guidance system and the GPS position of the bus stop.

6. Pilot experiments

The Pilot experiments will take place in four different European localizations - Austria, Italy, Poland and Sweden. There will be one additional driving simulator experiment carried out in Germany, which will focus on the design of the bus sign. The Pilot sites have been selected to have input from different parts of Europe (north, east, central and south). During the selection process differences in the systems of school transportation were considered, since in some countries the public transportation is used and some have special purchased buses with or without an assistant on board. The Pilot sites will implement different parts of the Safeway2School concept and the system and concept will be evaluated. The aim is to run experiments that include not only one single part, but several parts in order to evaluate the effect of the holistic approach. The Pilot experiments will all be based on the same technical solutions.

The Safeway2School is addressed to different stakeholders (municipalities, children and parents, school bus drivers and road users). At each site a focus on two or more of the stakeholders will be made. In Austria and Poland the road users (car drivers) and children/parents will be the subject of the evaluation. In Italy and Sweden there will be a focus on the bus driver and the children/parents but also on the municipalities and authorities, in order to use safety criteria with a help of a tool and integrate this information to the route guidance system.

All Pilot sites will include aspects related to speed reduction among road users when children are entering/exiting the bus or are waiting or going to and from bus stops.

In the Pilot experiments intelligent bus stops will be tested regarding communication with the warning unit but also with the bus and/or with parents. At two of the pilot sites routing and rerouting will be examined as well, which will enable the bus driver to avoid unsafe areas, but also to reduce the travel time and length and CO₂ emission since the bus does not have to go the same route each day if the children are not present.

The Pilot in Poland is aiming at car drivers who pass a stopped bus when children are getting on or off the bus. At the Polish site the trainings' results will be evaluated regarding safety routines for bus drivers and children. Additionally car drivers' visual pattern will be tested by measuring eye movements when approaching an intelligent bus stop. Based on the legal regulations concerning the obligation of a car driver to act with special attention and if necessary to stop behind the school bus, the pilot should highlight the real situation. A new sign, which will be fixed to buses, indicating that children are either getting on or off the bus will be designed within the project and its effectiveness in real life will be tested. The speed of passing cars will be recorded by radars installed around the bus stops. Also data from visual observations will be collected for the analysis of the drivers' behaviour, children's behaviour when getting on/off the bus, the number of children, their age, etc. Other factors will also be considered (pedestrians and vehicles flow in the bus stop area, density of traffic, etc.).

The experiment in Poland will last for at least three months involving 4 equipped buses (2 with signs and 2 without signs). Trainings on safety conduct concerning entering/exiting and waiting or walking to/from the bus stop for children but also for bus drivers will be performed. Visual observers will also be involved in the project. They will be present once a week at the site to collect data. It is also planned to use an acoustic signal to catch the attention of the children while they are waiting at the bus stop and the bus is approaching (for this activity it is necessary to have an approval from the appropriate authority). Also the bus may send an acoustic signal while children are getting on/off the bus. The interaction between the alertness of the children and the cars slowing down/stopping behind the bus may be investigated. Data from buses with the new sign will be compared to buses without the new sign.

The Pilot in Poland will encompass the following elements:

- 2 buses equipped with radar and the new warning sign (specially designed within the project),
- 2 buses only equipped with radar,
- 2-4 intelligent bus stops,
- training-kit for the bus drivers and children travelling by school buses,
- 1 instrumented vehicle with eye-movement equipment,
- special tags for children using the intelligent bus stop.

7. Summary

The safe and secure transportation of children to and from school is an issue which should be given more attention on the European level. The diversity of systems and practices in different regions of Europe requires unification and standardization of warning signs and sounds, training schemes, guidelines, and policy recommendations. Safeway2School will use the best national experiences and best practices and introduce technological innovations in a holistic way. The goal is to satisfy different conditions in each country. Therefore the project will encompass 4 different Pilot sites: in North Europe - Sweden, Central Europe - Austria, South Europe - Italy, and Eastern Europe - Poland.

The project integrates the already existing technologies but also new products/services to enhance the safety and security of children travelling to/from school. There are several innovative concepts such as: Safest route planning, routing and re-routing, avoiding complex, high speed and unmarked roads. Safeway2School includes the following ITS solutions: surrounding traffic information and warnings by signs and sound signals (located on the bus or bus stop and even telematically transmitted to surrounding vehicles equipped with special devices), on-board integrated safety system functionalities (controlling e.g. safety belts, speed adaptation), intelligent bus stops, intuitive, safe and low-cost interfaces for drivers, children and parents.

The monitoring process will also strengthen children's security. Several technologies increasing safety and security of the road users are already being applied in other transportation fields. They should also be introduced within the school bus transportation system and protect the most vulnerable road users - children.

There is still much to be done within the school bus transportation area. Safeway2School aims to develop measures to increase safety and security in bus transportation to school, focusing on the route to school, not only the mode used.

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