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Cross-modal challenges and opportunities in transport safety

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Abstract

This paper presents the safety-related results of the project USE-iT (Users, Safety, Security and Energy in Transport Infrastructure), a Coordination and Support Action funded within the H2020 framework programme, where the aim is to better understand the common challenges facing all transport modes. The project targets aspects of providing better customer information, improving safety and security and reducing energy consumption. To this end, technologies, methodologies and approaches with capabilities to improve transport safety and with cross-modal implementation potential were identified through a comprehensive literature research. Based on three rounds of stakeholders' consultations, which included workshops, interviews and questionnaires, a set of safety-related challenges along with the opportunities with the highest multi-modal potential to address them, was identified. This work is followed-up by the development of a cross-modal research roadmap with selected opportunities for addressing the identified challenges in the topics of user information, safety, security and energy reduction.

Keywords: safety, cross-modal, challenges, research roadmap

Introduction

Transport and mobility represent one of the most important components of any economy and society. Moreover, global transport across all modes has a direct impact on the quality of life of people and their traveling. For this reason, not only ensuring but enhancing safe transport is paramount.

Historically, transport modes have developed in competition with each other leading to large gaps between the modes themselves, their management and their development needs. However in recent years, concepts such as inter-modality, cross-modality and interoperability, as well as topics like land use planning and sustainable mobility have brought the need of increased cooperation in the transportation sector. Furthermore, a closer look at the European transport system reveals common challenges such as resource efficiency, environmental friendliness, safe and seamless transport for the benefit of people, the economy and society [1].

This paper presents a part of the results of the USE-iT project (Users, Safety, Security and Energy in Transport Infrastructure), a Coordination and Support Action (CSA) funded by the European

Commission (EC) within the H2020 framework programme. The overall aim of USE-iT is to better understand the common challenges facing all transport modes and, in conjunction with international stakeholders, to produce a multi-modal research roadmap with technologies and approaches for addressing these challenges. The project refers to three important topics: providing better customer information, improving safety and security and reducing carbon emissions and energy consumption. This paper addresses only the aspects related to increasing safety in transport. To this end a vast number of technologies, methodologies, approaches and best practices with capabilities to improve transport safety were identified through a comprehensive literature research performed across all modes. The aim was to identify the technologies and approaches not only that enhance safety, but that have the highest potential for applicability in multiple transport modes. Based on three rounds of stakeholders' consultations, which included workshops, interviews and questionnaires, a list of research opportunities with the highest cross-modal potential to address challenges in transport safety was identified. The opportunities are predominantly from the infrastructure and technology domains, with significant influences from a governance and user perspective.

The paper contains two major parts. The first part comprises a description of the methodology, which consists of the literature research and the three stages of stakeholder consultations. The second part is devoted to the identified cross-modal safety opportunities and their description in terms of benefits, challenges and steps for cross-modal implementation.

Methodology

The methodology was two-fold: first, a state of the art literature review was carried out across all transport modes to identify the technologies, techniques, methodologies and approaches that had the highest potential to increase safety, as well as to be transferred from one transport mode to another. Out of the initial 110 identified topics, 30 were distinguished as having cross-modal potential and were classified into specific concepts. Topic examples include: Vision Zero, education for maritime safety, ERTMS (European Railway Transport Management System), Single Window, e-Call, alcohol interlock, automation in work zones, truck platooning and many others [2].

The topics were then analysed in detail, evaluated and validated for their potential of cross-modal implementation by carrying out three rounds of stakeholder consultations. Firstly, an online survey with key questions was developed and sent to more than 300 stakeholders to collect data on how safety is achieved across different transport modes, as well as to gather first views on potential cross-modal cooperation. A total of 83 stakeholders from different countries and transport modes completed the questionnaire. Then a workshop was held in Brussels in January 2016 to present the first identified technologies, methodologies and approaches and gather feedback on potential barriers and opportunities related to their transferability across different transport modes. Approximately 20 external stakeholders (including EC officials) were present at the workshop, covering all transport modes as well as various roles within the industry, R&D community, policy, etc. Stakeholders also provided further input in the form of unidentified topics with cross-modal potential. The feedback and input were used to perform a first selection of the most promising topics that was further consolidated

with a scoring system commonly developed in the project. All topics were qualitatively assessed in terms of potential to increase safety, transferability, efficiency, ease of implementation and co-/dis-benefits.

The second stage consisted of a round of in-depth stakeholder interviews with safety experts from different countries (i.e. England, Austria, Portugal, Spain, Sweden, Ukraine, France, Lithuania and Czech Republic), transport modes and types of organisations (i.e. research providers, transport operators, universities, government, national authorities). Interviews were held both face-to-face, by phone or email and comprised a range of questions, including a prioritization of the thus far identified safety topics, as well as potential implementation issues, research gaps and cross-modal opportunities. Almost 40 expert interviews were conducted with high-level stakeholders. Following the interviews, the list of safety topics was revised and streamlined one more time.

The third stage of consultations consisted of a second workshop held in Brussels in September 2016, in which the current results and findings were presented in the form of posters and handouts. The workshop focused only on the streamlined list of safety topics and more specifically on identifying the relevant steps to implementation and the research gaps in addressing the cross-modal safety challenges. The stakeholders' feedback was once again incorporated into the current work, yielding the final list of cross-modal research topics related to safety.

Common safety research challenges and opportunities

The three stages of stakeholder consultations yielded a final list of safety topics with the highest potential to address cross-modal safety challenges. The topics are described in terms of:

- Benefits for cross-modal implementation – a description of the benefits that would arise as a result of the implementation of the specific technology / method / approach across transport modes
- Challenges for cross-modal implementation – a description of the challenges that would need to be overcome in order for the specific technology / method / approach to be implemented across transport modes
- Steps to implementation – the necessary actions that need to be taken to reach implementation into a specific transport mode

Challenge 1: Availability and sharing of high quality data across transport modes

Currently, there is a lack of in-depth cooperation between agencies and authorities of different transport modes. As mobility becomes more and more cross-modal, a database with highly detailed information across all transport modes (e.g. incident data, fatalities data) could have potential to increase safety. This is especially relevant for locations and subsystems where more than one transport mode converge, such as railway level crossings for example. In these cases, safety improvements may be reached if a system's approach – encompassing both modes – is applied. Common data formats and protocols should be developed and agreed upon.

Benefits for cross-modal implementation include:

- Possibility of cross-modal assessments of potential risks and criticalities
- Stronger cooperation between authorities across transport modes
- Faster and stronger reaction time to a cross-modal incident through better cooperation and notification of authorities
- Support for more efficient, interlinked/routing – development of multi-modal applications

Challenges for cross-modal implementation include:

- Difficulty to combine different types of data from multiple modes of transport
- More focus should be on data quality rather than on the quantity of the data
- Difficulty to ensure data privacy and data security
- Requirement for regular updates of databases, translating into significant amounts of administrative work for maintenance purposes
- Need for establishing liability rules and data ownership
- High risk for data manipulation, cyber-attacks, malfunctions

Implementation steps include:

- Development of a common agreement between different interacting transport modes on the methodology, format, type, usability of data
- Agreement on a standardised data format, the frequency of data exchange, data exports/imports and regular updates
- Development of a common interface and procedure for the data collection and data management procedure
- Agreement on the main responsible body for data collection, database maintenance, etc.

Challenge 2: Improving safety performance at national levels

Setting safety targets at regional/national level is a method that has been proven to increase road safety performance. A similar methodology could be applied to, for example, waterborne transport, where according to ETSC (European Transport Safety Council), there are no general safety related strategies [3]. A safety management system could also enable data collection, which would help establish a "transport safety observatory".

Benefits for cross-modal implementation include:

- Support in setting a timeframe for specific measures to decrease fatalities and severity rates
- Possibility of combining safety targets with economic and environmental milestones to achieve secondary benefits
- Inclusion of new paradigms such as the Safe System Approach in order to incorporate all causing circumstances
- Contribution to societal needs and challenges towards a more safety-oriented culture
- Implementation of motivation actions, in the form of specific incentives

Challenges for cross-modal implementation include:

- Financial limitations and barriers to resources
- Institutional cooperation between the transport modes; only theoretical cooperation exists, as everyone works decentralized with their own interests
- Need for clear policy for the implementation, monitoring, management, enforcement, penalisation, keeping track of the advancement of each measure
- Need for keeping in line with European and global strategies for safety management

Steps to implementation include:

- Development and evaluation of the new strategy concepts
- Development of specific milestones and aims – which are measurable and can be evaluated
- Publication in different styles (e.g. factsheet, smartphone application, website) and promotion across different media channels (e.g. TV, email, social media groups)
- Development of a plan for updating, evaluating and monitoring the strategy and its milestones
- Development of a tool kit for proper implementation and application (e.g. enforcements, funding, incentives)

Challenge 3: Safety education and human factors

Human error represents the primary cause for accidents [4]. Increasing safety through education has a very high potential. "Drivers" in air, water and rail transport modes are professionally trained, while the training of road drivers cannot be considered so. However, with the coming and implementation of new in-vehicle systems and moreover vehicle automation, the process of acquiring a driver's license should be updated (e.g. the handover process from the vehicle to the driver, especially in a critical situation should be included in the training). Regular trainings in vehicle (i.e. train, air, vessel and car) simulators could help improve driver skills to the required level.

Benefits for cross-modal implementation include:

- Ensuring optimum and safe change in all transport modes due to new developments, while increasing acceptance and usability
- Decrease in malfunctions, errors and risks caused by human errors
- Upgrade in on-going education procedures (e.g. new driving licence acquiring process, early age education, elders' education)
- Optimisation of modal split due to human behavioural changes

Challenges for cross-modal implementation include:

- Limited time and financial resources
- The infrastructure to deliver simulator training is expensive and resource intensive
- Establishing the chain of resources and benefits, as well as the involved entities and their roles (e.g. who pays and who benefits)
- Keeping up with new types of media and new ways to educate (e.g. online certificates vs. real

simulations, etc.)
- Establishing frequency and update schedule of education plans and activities
- Taking into account new vehicle technologies and developments (e.g. new Human-Machine Interfaces)

Steps to implementation include:
- Development and evaluation of the proposed education and training methods or procedures
- Development of specific milestones and aims – which are measurable and can be evaluated
- Agreement on common certificates of accomplishment, recognised issuing bodies, availability period, geographic extent (i.e. national or European)
- Development and publication of relevant materials in different styles (e.g. factsheet, smartphone application, website) and promotion across different media (e.g. TV, email, social media groups)
- Development of a tool kit for proper implementation and application
- Development of a plan for updating, evaluating and monitoring training procedures

Challenge 4: Driver state monitoring

Human error represents the primary cause for accidents in transport. Therefore the evaluation of drivers' fitness, combined with appropriate mitigation measures could increase safety, e.g. monitoring the driver's state through systems such as alcohol interlock and fatigue warning. For example, it was found that alcohol and drug use is an increasing cause of maritime accidents [5]. Currently, alcohol interlock can be used to prevent unfit road drivers from starting their cars. A similar system could be implemented in maritime transport. Fatigue warning systems can control the vigilance of a driver and demand feedback at certain intervals. This system, researched for rail transport, could be applied to other modes such as road and water.

Benefits for cross-modal implementation include:
- Increasing safety and decreasing the risk of human error, reducing the number of fatalities
- Increasing awareness and decreasing reaction time, while tackling the effects of fatigue
- Improvement of cross-modal traffic management
- Contribution to a more safety-oriented culture

Challenges for cross-modal implementation include:
- Limited financial resources for implementation
- Not all driver monitoring systems are proven; more research on this subject is needed
- Low user acceptance in all transport modes
    - In rail transport, safety levels are already quite high, therefore investment interest is low
    - In air transport, the level of complexity in aircrafts is already high
    - Road vehicle manufacturers are customer-focused and therefore a system which is not

popular with drivers is not seen as an economic-beneficial investment

- Need for technical, procedural and legal clarifications towards implementation
- Need for business models

Steps to implementation include:

- Definition of system technical requirements and specific needs for each transport mode
- System development with mode-specific technical adaptations
- Definition of an integration procedure into existing in-vehicle operating systems
- Testing and rollout phase of systems
- Training of system users

Challenge 5: Cross-modal interaction in a safe and efficient manner: Cross-modal V2V communication

Cooperative traffic systems share information using Vehicle to Infrastructure (V2I) and Vehicle to Vehicle (V2V) communications. In so doing, the systems can give advice or take actions with the objective of improving safety, while also contributing to sustainability and efficiency [6]. One potential application would be a cross-modal communication between vehicles – cars and trains, especially at level crossings. The car could not only receive warnings regarding a passing train, but could also automatically brake before a level crossing, with the help of in-vehicle systems at various levels of vehicle automation.

Benefits for cross-modal implementation include:

- Increasing safety and decreasing the number of incidents occurring at road-rail level crossings
- Decreasing the risk of human error, reduction in the number of fatalities and severity rates
- Improvement of vehicle safety performance, facilitating the application of the safe system approach to crossing nodes
- Improvement of cross-modal traffic management

Challenges for cross-modal implementation include:

- Limited financial resources for research, testing and implementation
- Need for more research to link communication channels across 2 transport modes, not only in terms of infrastructure but also in terms of vehicles' communication
- Need for technical and procedural clarifications towards implementation
- Need for investigation of legal prerequisites and definition of standards related to implementation of a cross-modal system

Steps to implementation include:

- Definition of system technical requirements (e.g. data formats, communication channels) and specific needs for each transport mode as well as for establishing compatibility between the two transport modes

- Development of regulatory aspects regarding data protocols, data privacy and liability
- System development with mode-specific technical adaptations
- Definition of an integration procedure into existing in-vehicle operating systems
- Testing phase and rollout of system
- Training of system users

Challenge 6: Automation in the context of multimodal transport

Automation in transport has a high potential to primarily increase safety, but also influence efficiency, travel time and overall mobility. Automation in road transport is still under development at various levels (e.g. fully autonomous vehicles are still in the future); nevertheless, best practices can be applied and taken from other modes [7]. For example, work areas are still a cause for many accidents and automation could bring benefits not only in roadworks but also in rail maintenance work.

Benefits for cross-modal implementation include:

- Increasing safety, by minimising or eliminating the human error factor involvement
- Reduction of driver stress and workload and driver costs
- Provision of self-car mobility for non-drivers
- Improvement of overall transport safety performance by becoming more technologically secured
- High potential to learn and exchange ideas between less and more automated transport modes (e.g. road and air transport)

Challenges for cross-modal implementation include:

- Need for clear business models
- Need for clarification and approval of real-life testing
- There is still a lot of apprehension regarding autonomous driving, i.e. humans should be ready to take over in critical situations even in an autonomous vehicle environment
- Need for development of take-over scenarios (i.e. driver – vehicle) in critical situations
- Need for further investigation of transport infrastructure requirements
- Regulatory aspects, definition of ownership of data and standards, liability and responsibility
- Security and data privacy concerns

Steps to implementation include:

- Technological research
- Clarification of testing specifications and regulations
- Testing and validation of specific key applications within each mode
- Development of regulatory aspects regarding data privacy and liability
- System development with mode-specific technical adaptations
- Definition of integration procedure into existing in-vehicle operating systems
- Testing phase and rollout of particular application

- Training of application users

Outlook and next steps

This paper has presented the safety-related results of USE-iT, where the aim is to better understand the common challenges facing all transport modes in user information, safety and security and energy reduction. A comprehensive literature review was performed to identify technologies, methodologies and approaches with capabilities to improve transport safety and that have a high potential for applicability in multiple transport modes. A set of over 30 topics were identified, which included automation, e-Call, alcohol interlock, cross-modal cooperative traffic systems and setting national safety strategies and were submitted to three rounds of stakeholders' consultations that comprised online surveys, international workshops and face-to-face interviews. The consultations resulted in a list of safety-related challenges and the opportunities with the highest cross-modal potential to address them. These have been discussed in terms of benefits, challenges and steps towards cross-modal implementation. The challenges are:

1. Availability and sharing of high quality data across transport modes
2. Improving safety performance at national levels
3. Safety education and human factors
4. Driver state monitoring
5. Cross-modal interaction in a safe and efficient manner: Cross-modal V2V communication
6. Automation in the context of multimodal transport

Only a brief insight into the outcomes of the project could be presented in this paper. All detailed results can be found in the USE-iT deliverables to be published online. The work will be followed up by the development of a set of common research themes crossing the topics of user information, safety and security and energy reduction in all transport modes, which will serve as input to a cross-modal research roadmap. The roadmap will represent an investment strategy for key infrastructure funders including European, national and regional public bodies and private infrastructure investors to be used in specific developments.

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