FOREVER OPEN INFRASTRUCTURE ACROSS ALL TRANSPORT MODES
USERS, SAFETY, SECURITY AND ENERGY IN TRANSPORT INFRASTRUCTURE

USE-iT FOX

INEA
Start date: 01/05/2015
Duration: 24 months

Deliverable D3.1

Preliminary report on safety and security based on investigation across modes and domains

Main Editor(s)	Isabela Mocanu (AIT), Peter Saleh (AIT), Paulo Machado (LNEC)
Due Date	31.12.2015
Delivery Date	31.12.2015
Task number	Task 3.1 Preliminary investigation on Safety and Security across modes and domains
Dissemination level	PU

Project Coordinator	Dr. Thierry Goger, FEHRL, Blvd de la Woluwe, 42/b3, 1200 Brussels, Belgium. Tel: +32 2 775 82 34, Fax: +32 2 775 8245. E-mail: thierry.goger@fehrl.org Website: www.useitandfoxprojects.eu

Contributor(s)

Main Contributor(s)	Isabela Mocanu, AIT Austrian Institute of Technology, Austria T +43 50550-6097, Isabela.Mocanu@ait.ac.at Peter Saleh, AIT Austrian Institute of Technology, Austria T : T +43 50550-6463, Peter.Saleh@ait.ac.at Paulo Machado, National Laboratory of Civil Engineering (LNEC), Portugal, T +351 21 844 3515, pmachado@lnec.pt
Contributor(s) **(alphabetical order)**	Jiri Ambros, CDV, Czech Republic Tadas Andriejauskas, VGTU RRI, Lithuania Tetvana Bondar, DNDI, Ukraine Rui Capitão, LNEC, Portugal João Paulo Cardoso, LNEC, Portugal El-miloudi El-koursi, IFSTTAR, France Jenny Eriksson, VTI, Sweden Conceição Juana Fortes, LNEC Portugal Sandra Gomes, LNEC, Portugal I.J. Iglesias, CEDEX, Spain Paulo Machado, LNEC, Portugal Álvaro Pereira, LNEC, Portugal Kiswendsida Abel Quedraogo, IFSTTAR, France Margarida Rebelo, LNEC, Portugal Ewa Zofka, IBDiM, Poland

Review

Reviewer(s)	1. Peter Saleh, AIT, Austrian Institute of Technology

Control Sheet

Version History			
Version	Date	Editor	Summary of Modifications
v0.1	<2015/10/29>	Isabela Mocanu	First Input
v0.2	2015/11/20	Isabela Mocanu	Incorporated comments and additional input from partners
V0.3	2015/12/4	Isabela Mocanu	Completed first draft
V0.4	2015/12/18	Alvaro Pereira	Inputs on Security
V0.5	2015/12/18	Isabela Mocanu	Completed final version

Final Version released by		Circulated to	
Name	Date	Recipient	Date
Isabela Mocanu	18/12/15	Coordinator	
		Consortium	
		European Commission	

Table of Contents

Abbreviations

Abbreviation	Meaning
ACS	Access Control System
CCTV	Closed-circuit television
CSA	Coordination and Support Action
EASA	European Aviation Safety Agency
EMSA	European Maritime Safety Agency
ERA	European Railway Agency
ERRAC	European Rail Research Advisory Council
ERTMS/ETCS	European Railway Transport Management System/ European Trail Control System
ERSO	European Road Safety Observatory
ETSC	European Transport Safety Council
ETSI	European Telecommunications Standards Institute
FEHRL	Forum of European Highway Research Laboratories
FORx4	Forever Open Road, Rail, River and Runway
FOX	Forever Open Infrastructure (X) all transport modes (Road, Rail, Water, Air)
ICAO	International Civil Aviation Organization
IMO	International Maritime Organization
ITS	Intelligent Transport Systems
OBU	On-board unit
SAMNET	Safety management system and interoperability for railway systems
SIDOS	Security in design of stations
TASS	Total Airport Security System
TMC	Traffic Management Centre
TRIP	Transport Research and Innovation Portal
USE-iT	Users, Safety, Security and Energy in Transport Infrastructure
VANET	Vehicle ad-hoc network
WSN	Wireless sensor network

List of Figures

List of Tables

Executive Summary

This report is a deliverable of USE-iT (Users, Safety, Security and Energy in Transport Infrastructure); a Horizon 2020 Coordination and Support Action (CSA) project managed by the Forum of European Highway Research Laboratories (FEHRL). The aim of USE-iT is to better understand the common challenges facing transport modes and in conjunction with stakeholders to produce a multi-modal research roadmap to develop technologies and approaches to addressing these challenges. In addition to a work package on management (WP1) and a work package on dissemination activities (WP5), USE-iT is divided into three technical Work Packages addressing important challenges facing all modes; providing better customer information (WP2); improving safety and security (WP3) and reducing carbon emissions and energy consumption (WP4). This deliverable presents the preliminary results of WP3, in which technologies and approaches that have the potential of enhancing safety and security across all transport modes were investigated.

Transport and mobility represent one of the most important elements 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 and secure transport across all modes is paramount.

In WP3, a literature review was performed to identify best practice approaches that have the potential to cross over from one transport mode to another. A significant number of technologies and approaches with capabilities to improve transport safety and security were identified and categorized in areas and concepts, as shown below:

Area	Concept
Safety of people & Safety of goods	Accident reduction measures
	Human factors and education
	Infrastructure ITS
	In-vehicle technologies
Security of people & Security of goods	Measures to prevent criminal activity
	Measures to reduce opportunities for criminal activity
	Transportation safekeeping
	Surveillance

A detailed description of these technologies, along with barriers and opportunities for cross modal application can be found in Appendix A. The next step in the project is to discuss the technologies with key stakeholders from all modes in order to identify potential research topics that could benefit more than one mode. This will be done through:

- A stakeholder workshop to be held on 21st January 2016 in Brussels
- A questionnaire sent out to stakeholders in December 2015

The information gathered will be summarised in the next WP3 deliverable. The research topics from WP3 will be incorporated into the final USE-iT research roadmap, together with the outputs from the other WPs. This 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 deployments.

1 Introduction

Users, Safety, Security and Energy in Transport Infrastructure (USE-iT) is a Horizon 2020 Coordination and Support Action (CSA) project with duration of two years, managed by the Forum of European Highway Research Laboratories (FEHRL). The project addresses MG. 8.2-2014, next generation transport infrastructure: resource efficiency, smarter and safer of the Horizon 2020 Work programme 2014-2015 in the field of smart, green and integrated transport. In parallel with USE-iT, the Forever Open Infrastructure Across (X) all Transport Modes (FOX) project supports many of the same objectives and there are significant synergies, not least in generating significant stakeholder involvement from road authorities, infrastructure owners and operators across the EU and beyond.

Both projects are expected to contribute to FEHRL's FORx4 (Forever Open Road, Rail, River and Runway) initiative which aims to develop a common European transport infrastructure promoting mode neutral transport.

USE-iT builds on the FORx4 methodology in which the four transport modes (road, rail, water and air) were merged with the four shared domains (infrastructure, technology, governance and customer) to form a holistic transport system for the future. The methodology is shown graphically in Figure 1 and the domains are explained in

Table 1.

Figure 1 FORx4 programme (FEHRL, 2013)

Table 1 Descriptions of the domains (FEHRL, 2013)

Domains	Description
Infrastructure	The transport network formed from Europe's routes and interchanges, which includes the changes required in construction and maintenance, and the specifications used.
Technology	The information, communications, sensor and power systems that will support the future transport network.
Governance	The management, operations, investment and appraisal of the network.
Customer	The understanding of a customer's motivation for travelling and choice of mode in order to implement policy interventions to support political objectives.

USE-iT examines common challenges across these domains and modes, identifying potential areas for transferring good practice and potential future areas for collaborative research. Moreover, the objective of USE-iT (Users, Safety, Security and Energy in Transport Infrastructure) is to **better understand the common challenges experienced across transport modes, bring representatives of transport modes together to share experience and skills and to develop a set of common research objectives.**

The project will draw upon the experience gained from the Joint European Transport platform with the focus on infrastructure operations, and will also focus on research objectives presented in the Forever Open Road programme and the work of the FORx4 - Forever Open Road, Railway, Runway and River – A Cross-modal transport initiative for research initiated by FEHRL (Forum of European Highways Research Laboratories).

Deliverable 3.1 presents the initial results of the literature review on ensuring and enhancing safety and security across all transport modes, as part of Task 3.1 (a) and (b). The data gathered in this project phase will be used as the basis for the first project Workshop (Task 3.2) in January 2016.

2 WP3 Goals and Objectives

The aim of WP3 Safety and Security is to gather knowledge and understand how operators and owners of transport infrastructure can enhance and reinforce safety and security operations and procedures across transport modes, through exchange of knowledge, share of experience and strong cooperation and to determine the common research challenges.

Safety and security measures differ across the four transport modes in terms of methodology, implementation and enforcement. However, there is great potential for many complementary research actions, due to, for example, technological overlaps in infrastructure requirements. Nevertheless, the work performed in this work package is performed separately, but in parallel, for the assessment of safety and security operations, respectively.

2.1 Background

Transport and mobility represent one of the most important elements 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 and secure transport across all modes is paramount. While aiming at similar goals (safekeeping people and freight), safety measures and security procedures differ in their requirements, implementation and operational burden across all transport modes.

2.1.1 Transport safety

In broad terms, transport safety refers to employing methods and measures for reducing the risk of a person using a transport mode for being killed or seriously injured. Various safety agencies such as, European Aviation Safety Agency (EASA) or European Maritime Safety Agency (EMSA) contribute to ensuring and advancing safety in all transport modes (European Commission, 2015).

Statistics show that, overall within EU, the number of fatalities caused by transport accidents fell by 40.8% for men and 43.8% for women, between 2004 and 2012. In general, transport accidents accounted for 0.6% of total deaths in 2012 (Eurostat, 2015).

To get an overall picture of safety in transport, Table 2 presents a comparison of safety, using a travel scenario hypothesis – the risk of fatality for a passenger travelling over a given distance using different transport modes (ERA, 2014). It must be noted that the estimated risks are subject to wide variations, as one single accident could result in a high number of fatalities (especially in the case of an airplane incident).

Table 2 Fatality risk of passengers using different modes of transport (EU-27 in 2008-2012) (ERA, 2014)

Transport mode used by user	Fatalities per billion passenger kilometres

Airline passenger	0.06
Railway passenger	0.13
Bus/Coach occupant	0.20
Car occupant	3.14
Powered two-wheelers	48.94

Road transport accounts for the majority of fatalities in transport. In 2013, approximately 26.000 fatalities occurred and more than 1.3 million people were injured due to road traffic accidents. Nevertheless, it is estimated that between 2004 and 2013, the number of road accident fatalities in EU has decreased by 45%. Figure 2 shows the trend in road accident fatalities between 2004 and 2013 (ERSO, 2015).

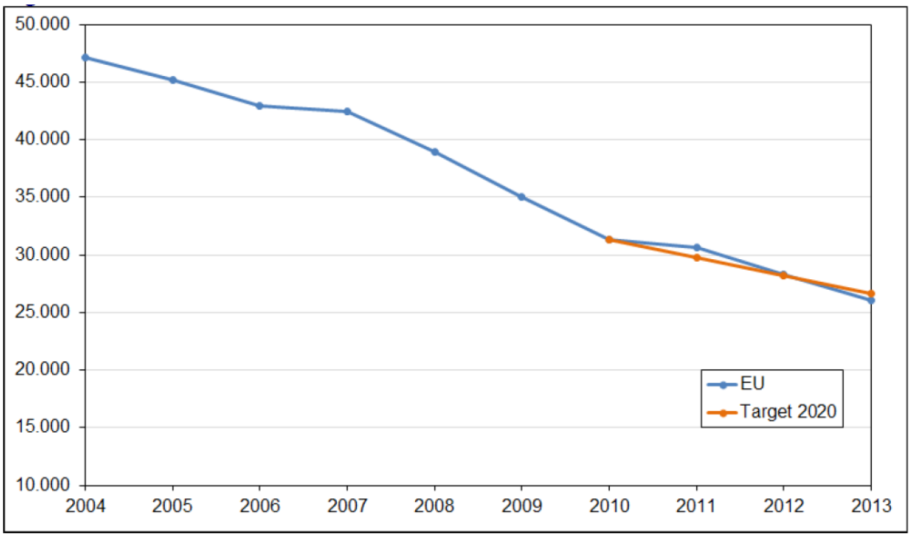

Figure 2 The number of road accident fatalities in the EU, 2004-2013 (ERSO, 2015)

By comparison, the number of fatalities and the number of passengers in air transport are shown in Figure 3, as reported by the European Aviation Safety Agency (EASA). In 2014, 16 fatal accidents involving commercial airplanes occurred, which is lower than the average number of fatal accident for the previous 10 years. Unfortunately, 2014 has reversed the decreasing trend in the number of fatalities occurring in air transport. As noted previously, a catastrophic accident can result individually in hundreds of fatalities (EASA, 2015).

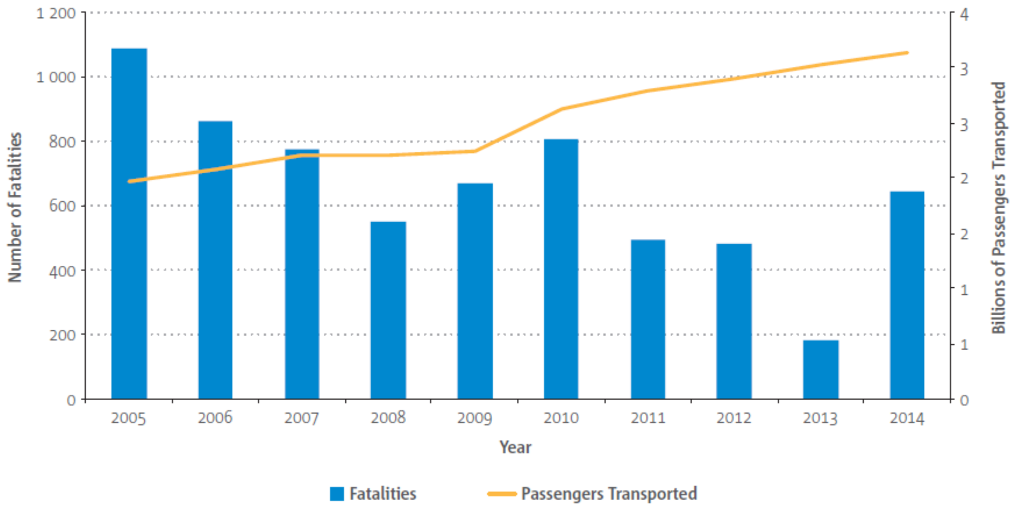

Figure 3 Number of worldwide fatalities involving passenger and cargo operations with the number of passengers transported, maximum take-off mass above 5700 kg (EASA, 2015)

The number of fatalities in maritime transport is shown in Figure 4, as reported by the European Maritime Safety Agency (EMSA). In 2014, a total of 3025 accidents occurred in European territorial seas and internal waters, which resulted in 136 fatalities. A significant increase could be observed for 2014 (EMSA, 2015).

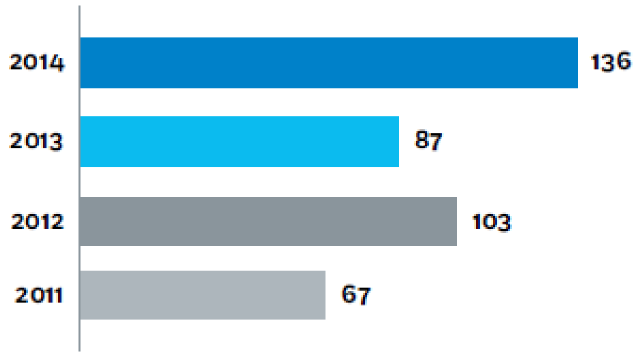

Figure 4 Number of fatalities in European territorial seas and internal waters (EMSA, 2015)

More than 2000 significant accidents occur each year on the railway system of the European Union. Figure 5 shows the number of fatalities and serious injuries in rail transport, for the period 2007-2012, as reported by the European Railway Agency (ERA). As it can be seen, the number of accidents has been decreasing steadily over the last years (ERA, 2014).

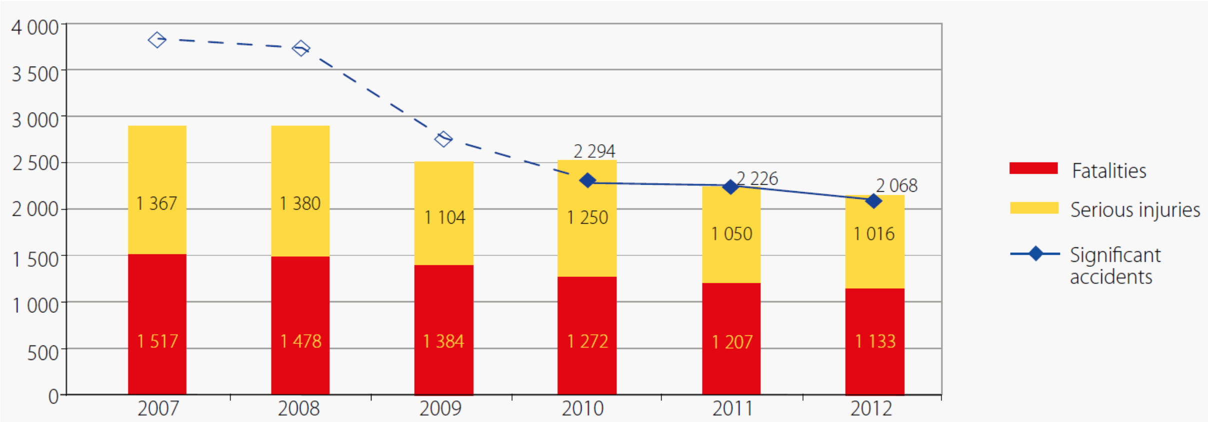

Figure 5 Significant accidents and resulting casualties for EU-28 (2007-2012) (ERA, 2014)

As seen in the presented statistics, transport safety has increased steadily in the last few years. Nevertheless, the European Commission presented in the "Roadmap to a Single European Transport Area" (European Union, 2011), a list of initiatives towards an efficient and integrated mobility system, which includes a series of actions for increasing safety across all transport modes. The actions refer, but are not limited to:

- deploy road safety technologies
- focus on training and education of all road users
- improve the collection, quality, exchange and analysis of data in civil aviation;
- ensure the implementation of the EU aviation safety strategy across all aviation domains
- develop SafeSeaNet into the core system for all relevant maritime information tools needed to support maritime safety
- enhance the certification and maintenance process for safety critical components used to build rolling stocks and railway infrastructures.

2.1.2 Transport security

Transport security refers to the measures and methods that are employed to ensure that a person traveling can do so without fear of being a victim of a deliberate attack, a freight transport will be delivered without interference and that the transport infrastructure is not attacked. Transport security can cover crimes, robberies, piracy, terrorist attacks, etc. Agencies such as the International Civil Aviation Organization (ICAO) and International Maritime Organization (IMO) deal with ensuring security across all transport modes (European Commission, 2012). According to TRIP (http://www.transport-research.info/) «transport security includes actions for infrastructure protection, improvement in crisis management, intelligent maritime and land border surveillance, and interoperability of systems.»

Terrorist events that occurred during the first decade of the 21th century have placed the topic of security at the top of the EU priorities, also in what concerns the transportation sector. These unfortunate events took place within Europe and all over the World. It must be noted however that hundreds of other unknown to public attempts have been stopped by authorities, mainly through

intelligence led police efforts and through the enforcement of several prevention measures, among others.
Closely related to internal daily threats (i.e. usually, crimes of low or middle range of disruptive impact, like vandalism, graffiti, theft, robbery, aggression) and external threats (i.e. mostly terrorist attacks with a high range of disruptive impact), there is the changing pattern of European citizens' mobility and freight, which deals with an increasing number of people and goods transported (see Figure 6) and can be considered as a key challenge to reinforce security priorities.

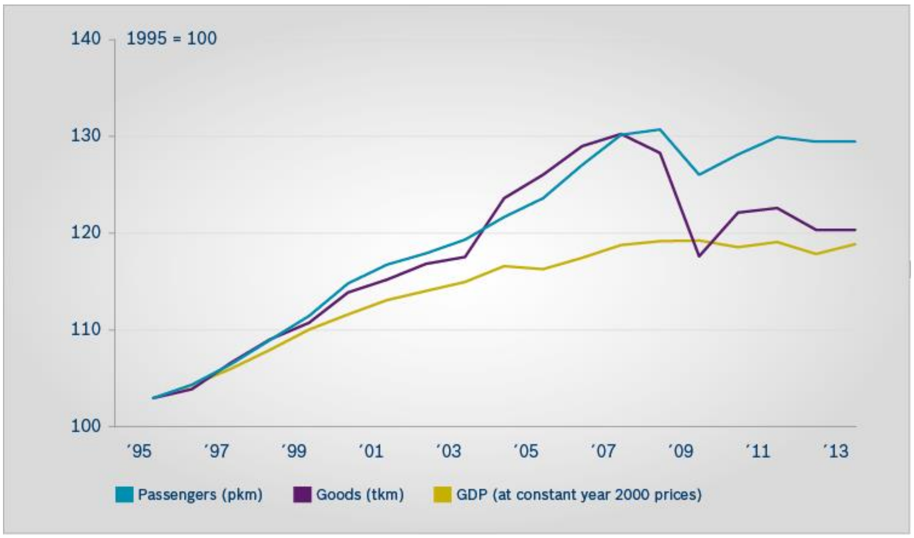

Figure 6 Transport growth EU-28 – Passengers, Goods, GDP 1995-2013 (Schade, 2013)

The European Commission recognizes that transport security is a very sensitive area and it involves very complex challenges. Moreover, transport security is a pressing theme on the EU's agenda where a comprehensive approach of policy, legislation and monitoring of air and maritime transport security should be consolidated and passenger security screening methods need to be improved in order to ensure high security levels with minimum hassle (European Commission, 2011).
In aviation and maritime sectors, the work has already commenced and should be continued with developing specific measures on security at the EU level. The benefits could include: 1) higher overall level of security for citizens in the EU, 2) lower levels of criminal activity and unlawful acts with consequential cost savings, 3) simplification for transport operators by having common security requirements; 4) simplification for security providers (equipment and personnel) (European Commission, 2012).

Similarly to safety, European Commission presented in the "Roadmap to a Single European Transport Area" (European Union, 2011), a list of initiatives towards an efficient and integrated mobility system, which includes a series of actions for increasing security across all transport modes. The actions refer, but are not limited to:

- the development of an EU-wide security systems to be used for air cargo

- promote the development of detection technologies that are effective as well as non-intrusive on privacy (e.g. body scanners, explosive detectors, etc.)
- focus on urban security issues
- heighten the security level along the supply chain without intruding on the flow of trade;

2.2 Objectives and methodology

The specific objectives of WP3 are:

- understand the state of the art in Safety and Security across all four transport modes;
- determine opportunities for the transfer of knowledge and working practices across modes;
- develop common future research objectives covering at least two modes;
- bring together infrastructure owners, operators and other stakeholders from across all transport modes to facilitate knowledge transfer in the areas of Safety and Security and develop a network for future cooperation;
- develop a roadmap describing the research challenges and implementations steps to achieve a greater cooperation and co-modal operations in the area of Safety and Security;

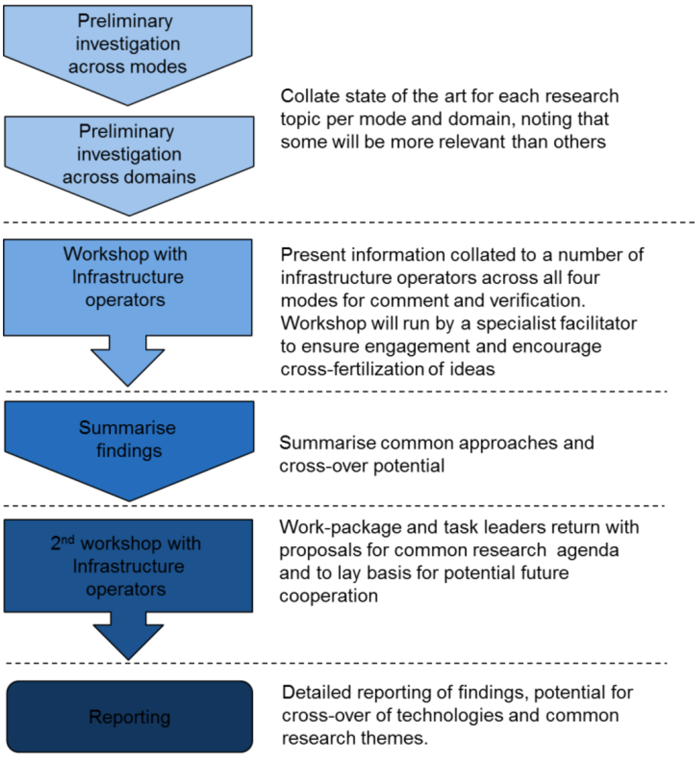

Figure 7 USE-iT - common methodology (own source)

The goal is to determine the best practices that can be exchanged between infrastructure representatives across all modes, develop and achieve an open line of communication and cooperation that can be extended beyond the duration of the project.

The methodology of WP3, similar to all WPs within USE-iT, is shown in Figure 7 and explains the five steps that will be taken to reach the project outcome:

- collate state of the art for safety and security, per mode and domain, noting that some will be more relevant than others;
- present initial findings to a number of infrastructure operators and other stakeholders across all four modes for feedback and further input;
- summarize common approaches and cross-over potential
- develop proposals for a common research agenda and lay the basis for potential future cooperation
- report final findings, potential for cross-over of technologies and common research themes

3 Preliminary investigation across modes and domains

This report summarises the findings of the preliminary investigation into the different technologies and approaches that ensure or enhance safety and security and could be transferred from one transport mode to another (Task 3.1 (a) and (b)). These technologies will be examined in more detail with input from key stakeholders in subsequent tasks.

3.1 High Level State of the Art review of existing technologies in safety and security

3.1.1 Methodology

A state-of-the-art literature review was carried out across domains and modes. In order to develop the scope and the scale of the search, definitions for safety and security, across each mode respectively were proposed. Table 3 shows the common definitions that were reached, based on combining all inputs, as well as on expert assessments.

Table 3 Definitions of safety and security across transport modes

Safety and Security /mode	Definition
Road safety	Safety refers to the concept of preventing fatalities and injuries caused by incidents and/or accidents (defined as undesired events) (International Transport Forum, 2008)
Rail safety	Safety aspects are related to accidents and incidents occurring on the working railway due to failures occurring in one or a combination of those: railway infrastructure, rolling stocks, equipment and operations or due to unintentional external factors (e.g. hazardous weather events) (Favo & Semerano, 2013)
Water safety	Safety refers to all the harmful actions, in which the human will is not involved, leading to damage or destruction of maritime and port infrastructures or vessels as well as port operations (Urbanski et al, 2009)
Air safety	Safety refers to all the harmful actions in which the human will is not involved. (Huang, 2009)
Road security	Security refers to accidents and incidents occurring due to external intentional threats. Examples of risk targets may include: personal vehicles, dangerous goods cargo, connecting infrastructure, traffic management centres, etc. (European Commission, 2012)
Rail security	Security aspects are related to accidents and incidents occurring on the working railway due to external factors emanating from human actions (vandalisms,

	terrorist acts, etc.). (Favo & Semerano, 2013)
Air security	Security refers to any voluntary human actions whose aim is to harm (European Commission, 2015)
Water security	Security refers to human, voluntary, actions aiming to endanger lives and goods as well as to disrupt usual procedures in maritime and port areas (Urbanski et al, 2009).

Furthermore, key words were used to search various databases for internationally published documents, like journal papers, project deliverables and reports, conference papers, etc. The search resulted in an Excel spreadsheet that contained all bibliographic references relevant for safety and security for each mode. The list was completed with input from the project partners. Figure 8 shows an overview of the different type of documents consulted in these tasks.

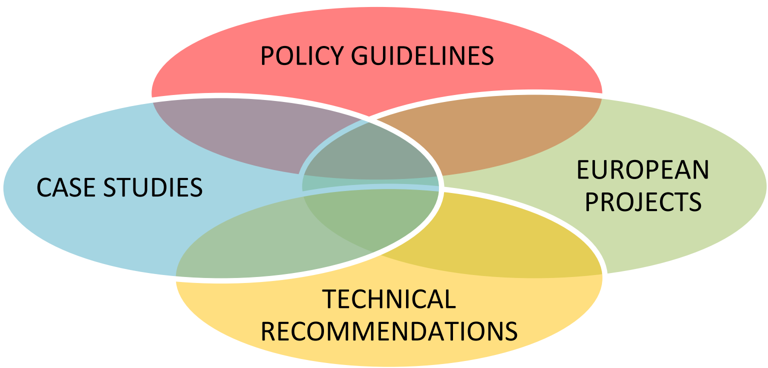

Figure 8 Overview of documents reviewed

The review of the literature yielded areas and concepts for both safety and security, presented in Table 4. It should be mentioned that the initial collection of references contained data that, although not relevant for this initial task, it will enrich the project's next steps.

The final step of the methodology was to assign specific literature to each project partner for review. A common USE-iT/FOX template was developed and used to describe the different technologies and approaches, by reporting their maturity and applications in the transport mode in which they perform. Moreover, the potential benefits as well as possible barriers for implementation of the technology/approach in other transport modes are detailed, where possible. The data in the templates form the basis of this deliverable.

Table 4 Areas and concepts in WP3

Area	Concept
Safety of people & Safety of goods	Accident reduction measures

	Human factors and education
	Infrastructure ITS
	In-vehicle technologies
Security of people & Security of goods	Measures to prevent criminal activity
	Measures to reduce opportunities for criminal activity
	Transportation safekeeping
	Surveillance

3.1.2 Overview of findings

A total of 39 technologies and approaches were selected, as being relevant for Safety and Security and distributed for review to the project partners, as shown in Figure 9.

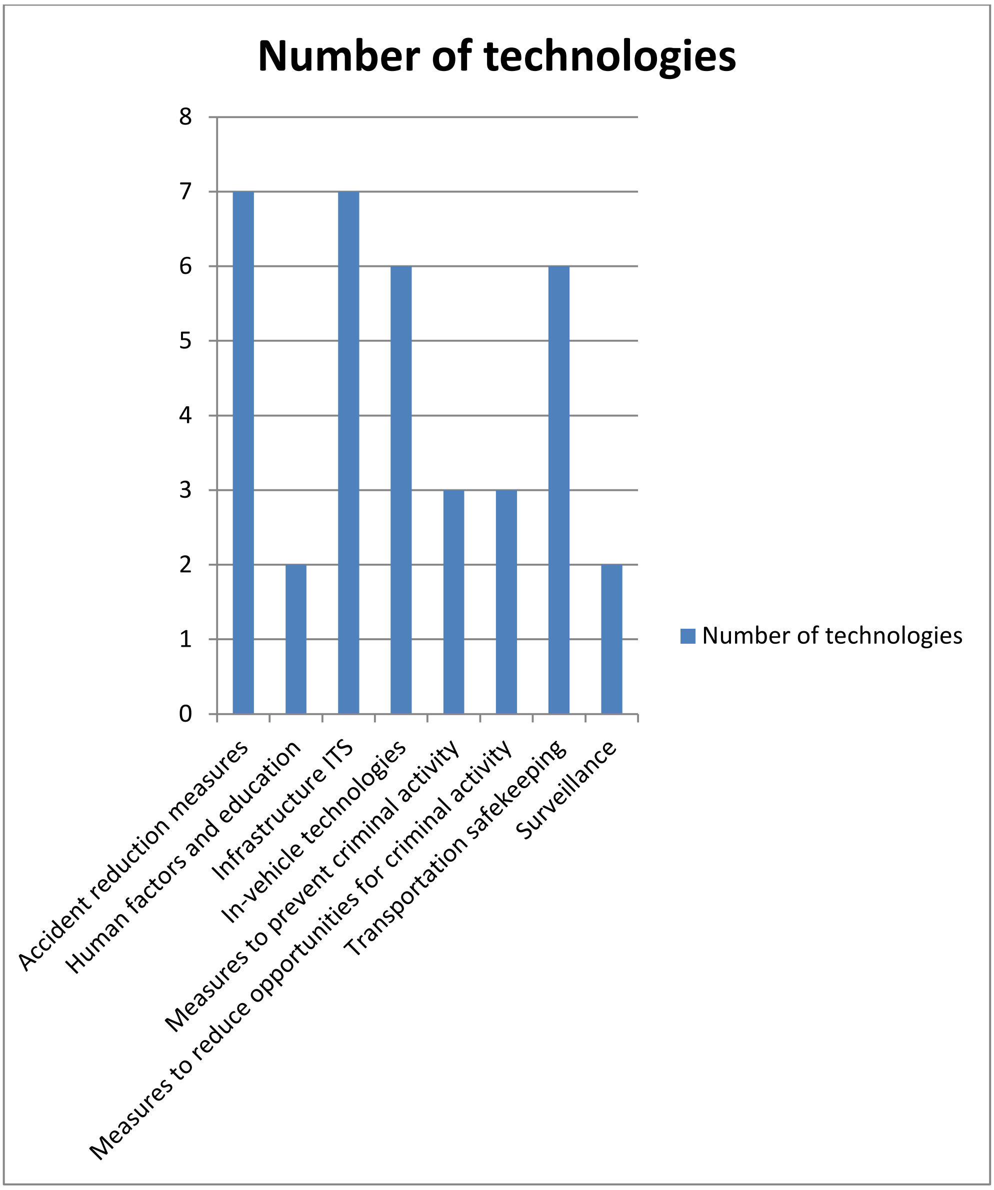

Figure 9 WP3 technologies by concept

The following section provides an overview and description of the areas and concepts of WP3, including a brief listing of the technologies included in each concepts, along with a case study example.
The templates containing detailed information on each technology and approach presented in the below sub-chapter can be found in Appendix A.

3.2 Areas and Concepts

3.2.1 Safety of people and safety of goods

Safety of people – by safety of a person, within the context of transport, it is understood the degree of freedom of a person (passengers, transport mode users, drivers/riders, etc.) to use any mode of transport, in a safe manner, without the risk of being involved in an incident or an accident that may result in death or injury.

Safety of goods – refers, in the context of transport, to ensuring that any goods, cargo, baggage, etc. is protected against any incident or accident leading to damage or destruction that is not caused by human will.

1. Accident reduction measures

This concept refers to the application of cost-effective measures and strategies to the existing transport infrastructure, particularly in the areas, sections, or sites with highly recognised accident risk. Although accident reduction measures apply to all transport modes, the concept is most significant for road transport, as it accounts for over 90% of all transport accidents (ETSC, 2001). Table 5 presents the technologies and approaches identified so far for accident reduction, with cross-modal applicability.

Table 5 Technologies and approaches for accident reduction

Technology/measure/approach	Domains	Transport mode in which it exists	Transport mode in which it could be applied
Vision Zero	Governance	Road	Air, Rail, Water
Intermodal Emergency Response Services	Technology	Road	Air, Water
Modular urban transport safety and security analysis (MODSAFE)	Governance	Rail	Road, Water
Network safety ranking and accident prediction	Governance	Road	Rail
Procedure for defining black spots on public roads	Governance	Road	Rail
Technique for carrying out road safety audits and inspections	Governance	Road	Rail

Implementation of safety management strategies	Governance	Road	Water

Case study – Vision Zero

All countries are advised to adopt and promote the "Vision Zero", an ambition that seeks to eliminate death and serious injury arising from the use of road transport

Vision 0 focuses on 4 key segments:

Infrastructure

- building roads and infrastructure what meet capacity and environmental challenges without compromising traffic safety; using the best experts for achieving the optimum network

Vehicle technology

- technology is crucial in improving driver, passenger and pedestrian safety; systems include: active or passive systems, alcolocks, automatic braking, cooperative technology, automated driving, etc.

Services and education

- public services and education are vital when it comes to implementing effective traffic safety solutions

Control and surveillance

- can include systems for monitoring traffic flows, weather conditions or other measures that quality as Intelligent Transport Systems

In addition, improving performance in the longer term may need: improved data collection, improving key institutional management functions, supporting R&D through knowledge transfer, funding effective safety programs, etc.

Technology applicable to transport mode:

Technology/measure possibly applicable to transport mode:

Opportunities and benefits from development and implementation:

A similar concept developed for rail, air and/or water could bring high benefits in terms of reducing fatalities, using new technologies to enhance safety.

Barriers to development or implementation:

The fatality rate in other transport modes is lower; therefore, the interest in setting safety targets similar to "Vision Zero" may be low.

2. Human factors and education

This concept refers to all the measures and services that ensure that drivers (including captains, pilots, conductors, etc.) of all transport vehicles receive the best information in the form of education, training, as well as reliable and up to date data regarding their travels. Table 6 presents the technologies and approaches identified so far for human factors and education, with cross-modal applicability.

Table 6 Technologies and approaches for human factors and education

Technology/measure/approach	Domains	Transport mode in which it exists	Transport mode in which it could be applied
Nautical port information	Governance	Water	Air, Rail
Education for maritime safety	Governance	Water	All

<u>Case study – Nautical port information</u>

Ship's masters, agents, charterers and other stakeholders in the shipping industry have an interest in obtaining reliable and up-to-date port and terminal information. The required nautical port information consists mainly of two parts:

1) Port Information Guide for the port as a whole, providing general nautical port information and
2) Port Sections Guide for each berth or fairway section, providing specific nautical port information per section of the port.

The Port Information Guide provides all general nautical information for the port as a whole, such as contact information and port regulations, notifications, arrival and departure checklists, port description and navigation, port safety and security, environmental information, nautical services and communication and port operations and services.

Technology applicable to transport mode:

Technology/measure possibly applicable to transport mode:

Opportunities and benefits from development and implementation:

An effective management of the high-density data transfer between all transport modes could facilitate transport of people and goods and enhance safety and security.

Barriers to development or implementation:

Different e-infrastructures at each transport mode could limit the efficient exchange of information in a timely manner.

3. Infrastructure ITS

This concept includes a wide range of services and applications grouped together under the title Intelligent Transport Systems (ITS). ITS are vital for increasing safety across all transport modes, by making it safer, more efficient and more sustainable. ITS include various types of communication technologies that is used, in all transport modes between vehicles (e.g. car to car) and between vehicles and fixed locations (e.g. road, port, airport, etc.) (ETSI, 2010). Table 7 presents the technologies and approaches identified so far for infrastructure ITS, with cross-modal applicability.

Table 7 Technologies and approaches for infrastructure ITS

Technology/measure/approach	Domains	Transport mode in which it exists	Transport mode in which it could be applied
Using V2V and road side sensors for improving road safety	Technology	Road	Rail
Implementation of a wireless sensor network to improve road safety	Technology	Road	Rail
ERTMS/ETCS	Technology	Rail	Road, Water
E-navigation/E-maritime	Technology	Water	Air, Rail, Road
Vessel traffic management system (VTMS)	Technology	Water	Road, Rail
Safety management system and interoperability for railway systems (SAMNET)	Technology & Governance	Rail	Road, Water
Single Window	Technology	Water	Rail, Road

<u>Case study – Using vehicle to vehicle and road side sensors to improve road safety</u>

The technology combines vehicle-to-vehicle communication with wireless sensor networks, which allows a link between car- and infrastructure-based technologies. This hybrid architecture makes possible the usage of data, which an OBU (on boards unit) is not able to gain. The technology allows accident prevention and also post-accident investigations which can prohibit subsequent-accidents.

The communication between the OBU's of cars is handled through a VANET (vehicle ad hoc network), standardised by IEEE 802.11p.

The road-side infrastructure handles the communication between the sensor nodes through the WSN (wireless sensor network), standardised by IEEE 802.15.4. Also the gap between VANET and WSN is done by this standard.

Technology applicable to transport mode:

Technology/measure possibly applicable to transport mode:

Opportunities and benefits from development and implementation:

Rail-side infrastructure can be used to detect nearby animals, which might cross the rail and lead to an accident.

In addition people trying to commit suicide on rails can be detected early and accidents can be prevented.

Barriers to development or implementation:

The main barrier for the integration of a hybrid system on rail is to provide a rail-side infrastructure, which is able to serve as a WSN.

In addition it has to be researched if the IEEE standards used on road also can be used when dealing with rail infrastructure.

4. In-vehicle technologies

This concept refers to all the sensors and applications that are installed in vehicles in all modes that have the ability to enhance safety. In-vehicle (by vehicle, it is to be meant: car/truck, train, vessel, airplane) technologies can be either passive (e.g. seat belts) or active (e.g. emergency brake systems, automatic train protection, etc.). Table 8 presents the technologies and approaches identified so far for in-vehicle technologies, with cross-modal applicability.

Table 8 In-vehicle technologies

Technology/measure/approach	Domains	Transport mode in which it exists	Transport mode in which it could be applied
Alcohol interlock	Technology	Road	Water
E-Call	Technology & Infrastructure	Road	All
Fatigue warning	Technology	Rail	Road
Automation in work zones for road safety	Technology	Road	Rail

Automation – truck platooning	Technology	Road	Water
Work zone safety	Technology	Road	Air, Rail

Case study – Fatigue warning

Fatigue of vehicle operator (for example locomotive pilot) may lead to his/her falling asleep and following accidents. In this regards, the state of locomotive operator vigilance is controlled with "alerter". The devices produces sound alert (within the predetermined timeframe, based on speed) and requires operator's action (pushing the button). If he/she does not react, the emergency brakes are applied – therefore the device ensures operator vigilance and prevents fatigue-related accidents.

In theory, the principle may be applied also in other transport means, for example road vehicles. It does not necessarily mean that the exact device has to be translated to road vehicles – rather the principle of application of emergency mechanism in case of detected lack of vigilance (i.e. fatigue) may be considered in order to tackle the fatigue accidents.

Technology applicable to transport mode:

Technology/measure possibly applicable to transport mode:

Opportunities and benefits from development and implementation:

Research shows that driver fatigue is a significant factor in approximately 20% of commercial road transport crashes. Vigilance control could be a potential measure to tackle effect of fatigue.

Barriers to development or implementation:

Technical questions, as well as legal prerequisites, related to implementation of vigilance control in vehicles could impede the development of a similar technology.

3.2.2 Security of people and security of goods

Security of people – By security of a person we should understand, under the constitutional principles of freedom and liberty, the absence of physical constraint to access, use and leave from a public transport, without any kind of constraints (real or subjective), safely and in self-determined way. For passenger security, screening methods need to be taken into consideration in order to ensure high security levels with minimum hassle (Ceccato & Newton, 2015; Crime Concern, 2004, European Commission, 2012; Newton, 2014).

Security of goods (assets) refers to the_transport conditions that preserve the quality, integrity and legitimate ownership of the goods transported from any malicious acts against these principles. These conditions also include track clearance, clearance of infrastructures before and after use, freight clearance control, tracking and monitoring of rolling stock carrying goods, protection of staff and information systems, stations, buildings and infrastructure protection (European Commission, 2012; Protectrail, 2014).

1. Measures to prevent criminal activity

Measures to prevent criminal activity concept refers to all measures belonging to primary prevention stage. Primary prevention aims at preventing any kind of unlawful and dangerous acts before they ever occur, wherever, whenever and whatever they are. These kinds of measures should be particularly taking into account when planning and designing facilities, or when conceiving new technological devices oriented to crime prevention. Thus, probably these measures will be timelier expected in the infrastructure and technology domains and in the preliminary stages of the governance domain (Crowley, 2013; Welsh & Farrington, 2010). Table 9 presents the technologies and approaches identified so far for preventing criminal activity, with cross-modal applicability.

Table 9 Measures to prevent criminal activity

Technology/measure/approach	Domains	Transport mode in which it exists	Transport mode in which it could be applied
European Security Research and Innovation Agenda	Governance	Air, Rail, Road, Water	Air, Rail, Road, Water
Security in transit environments	Technology & Infrastructure	Rail, Road, Water	Air
Security in design of stations (SIDOS)	Infrastructure	Road	Air, Rail

<u>Case study – SIDOS (Security in the design of stations)</u>

There is considerable scope in the design and planning of station infrastructure to include proven and effective security measures that will prevent, mitigate or deter attacks from terrorists. The following measures can be implemented:

- Mitigating effects of blast – Implementation of appropriate physical and procedural security measures which should be 'designed in' at all stages of station development
- Operational Requirement Process – This includes containing building services and power supplies, locating public car parks as far away from station buildings as practically possible and creating a distinct separation with other 'crowded places'
- Station approaches – Increase stand-off using landscaping and road design features such as traffic calming chicane measures, but also take into account emergency vehicle access

- Station building structure – A quantifiable degree of blast resistance should be used. Any glazing should be Polyvinyl Butyral laminate
- Internal facilities – Reduction of flat-topped structures and waste management facilities located away from entrances and main concourses

Technology applicable to transport mode:

Technology/measure possibly applicable to transport mode:

Opportunities and benefits from development and implementation:
In the design process of a station, it is important to take a holistic approach considering all aspects including passenger access, health and safety and creating a place that is functionally usable.

Barriers to development or implementation:
Procedures could already be in place;
Legal barriers in terms of specific requirements (especially in air transport);

2. Measures to reduce opportunities for criminal activity

Measures to reduce opportunities for criminal activity can be understood to belong to both secondary and tertiary stages of prevention. Secondary prevention aims to reduce the impact of unlawful and dangerous acts that have already occurred. Tertiary prevention stage measures refers to those that aim to soften the impact of an ongoing structural handicap and therefore beyond a transport stakeholder's reasonable control. All these kinds of measures (secondary or tertiary prevention) are appropriate to improve the security conditions of transport facilities, usually after assessing old procedures (Crowley, 2013; Welsh & Farrington, 2010). Table 10 presents the technologies and approaches identified so far for preventing opportunities for criminal activity, with cross-modal applicability.

Table 10 Measures to prevent opportunities for criminal activity

Technology/measure/approach	Domains	Transport mode in which it exists	Transport mode in which it could be applied
Anti-terrorism aviation security policy	Governance	Air	Rail, Road, Water

Aviation security practices	Governance, Customer	Air	Rail, Road, Water
Cyber security	Infrastructure, Technology	Air, Rail, Water	Road

<u>Case study – Cyber security</u>

All the technology related with electronic data transfer can be affected by cyber hacking attacks. Technology such as electronic devices, software, hardware, and communications backbone is vulnerable and subject to cyber safety threats.

Cyber security affects surface transportation electronic devices existing in entities such as Road Traffic Management Centers (TMC), train signaling, transit systems, airports, airplanes, trains, tramways, passenger and cargo vessels. Potential cyber vulnerabilities in transport infrastructure and vehicles need to be mitigated by security protocols and plans ahead of time. The main goals of cyber security are: systems safety, system security, system reliability and system resilience.

Create a cyber security eco-system through:

- Identifying systems, connections & interdependencies;
- Assessing vulnerabilities and risks;
- Identifying and use best practices and standards;
- Including cyber security in design specs and acquisitions;
- Collaborating with IT, physical security & other groups;
- Developing policies and procedures for cyber security;
- Motivating employees with training, exercises & “hot triggers”;
- Making sure that systems and operations are resilient (i.e. layers, detection, incident response);
- Developing organization-wide strategic plan linked to funding

Technology/measure applicable to transport mode:

Technology/measure possibly applicable to transport mode:

Opportunities and benefits from development and implementation:

As vehicles become more and more automated, systems can be affected such as:

- Control domain (Vehicle Controls, Vehicle Diagnostics, Traffic Signal Priority, Video Surveillance Duress Alarms, Vehicle Immobilizers, etc.)

- Operations domain (Automated Dispatching Vehicle Location, Route/Schedule Status Passenger Counters, Stop Annunciation Electronic Payments, etc.)
- Infotainment Domain (Customer use of Wi-Fi and WiMAX Real-time Travel Info & Trip Planning, etc.)

The implementation of cyber security could not only protect development in infrastructure and in-vehicle technologies, but also help increase acceptance of new technologies, e.g. autonomous vehicles.

Barriers to development or implementation:
Difficult to standardize;

3. Transportation safekeeping

Transportation safekeeping integrates all measures, namely codes, norms, technical recommendations and others, that aim to keeping safe and protect users, staff and transportation infrastructures (including buildings, vehicles, equipment) from unacceptable risks and vulnerabilities. This concept regards to technical procedures which are mostly generated within the own transport system and as a result of its technical expertise. In this sense, it has a less interdisciplinary reach and resembles a formal rule system and its procedures (European Comission, 2012).

Table 11 Technologies and measures to transportation safekeeping

Technology/measure/approach	Domains	Transport mode in which it exists	Transport mode in which it could be applied
Monitoring and intervention for the transportation of dangerous goods (MITRA)	Technology	Rail	Air, Road, Water
Reduction of Suicides and Trespasses on Railway property (RESTRAIL)	Infrastructure & Governance	Rail	Air, Road, Water
Technology and measures for security of railways against electromagnetic attacks (SECRET)	Technology	Rail	Air, Road, Water
Specific technologies and measures for Secured Urban Transportation (SECUR-ED)	Technology	Rail	Road
Technology and measures for blast resistant and fire safe metro vehicles (SECUREMETRO)	Technology & Governance	Rail	Air, Road, Water
Station and terminal design for safety, security and resilience to terrorist attack (SECURESTATION)	Technology & Infrastructure	Rail	Air, Road, Water

<u>Case study – Station and terminal design for safety, security and resilience to terrorist attacks (SECURESTATION)</u>

A compendium of technologies, means, materials and engineering techniques for safety, security and operational uses in passenger terminals, which can be implemented as a basis for the development of the Constructive Design Handbook, have been proposed:

- CCTV and Video analytics tools to improve security in public transport (Intrusion, tracking, Crowd assessment and face recognition).They can help investigate incidents;
- Access Control System (ACS) for help points, announcement facilities, signage, vehicle management, intrusion and materials detection, alarm systems;
- Smoke, flame and fire detection and protection systems (devices and control panels);
- The use of matured tools: blast attack simulations, Fire Dynamic Simulator, Fire & smoke and evacuation modeling;

Technology/measure applicable to transport mode:

Technology/measure possibly applicable to transport mode:

Opportunities and benefits from development and implementation:
Some relevant techniques/technologies could be implemented for the others transport stations/terminals as help points, alarms and announcement facilities, signage, access management controls, vehicle management, threat detection systems (screening, materials detection), intrusion detection systems, tracking applications, access controls and barriers, indoor and outdoor systems, perimeter protection, fencing, walls, gates and vehicles design.

Barriers to development or implementation:
Suitability and adaptability for implementing project results need more investigation, especially regarding road/water transports passenger stations/terminals security against terrorist bomb blast and CBRN attacks. Technologies need to be investigated for the road/water transport from the ethic, legal and social points of view.

4. Surveillance

Surveillance regards all measures aiming at monitoring water, air and land transportation facilities, including people, goods and infrastructure and increasing transportation security. Surveillance could be included in the overall scope of the concept regarding the measures to reduce opportunities, however, because of the technological specificity it is considered as an independent concept should not be reduced to closed-circuit television (CCTV). According to literature, a surveillance task can be divided into three phases: event detection, event representation, and event recognition. The detection phase handles multi-source spatio-temporal data fusion for efficiently and reliably extracting motion trajectories from video. The representation phase summarizes raw trajectory data to construct hierarchical, invariant, and content-rich representations of the motion events. Finally, the recognition phase deals with event recognition and classification (Welsh, Farrington & O'Dell, 2010; Wu et al., 2003).

Table 12 Technologies and measures for surveillance

Technology/measure/approach	Domains	Transport mode in which it exists	Transport mode in which it could be applied
Technology and measures for Integrated Security of Rail Transport (PROTECTRAIL)	Technology	Rail	Air, Road, Water
Total Airport Security System (TASS)	Technology	Air	Rail, Road, Water

<u>Case study - Total Airport Security System (TASS)</u>

TASS is a multi-segment, multi-level intelligence and surveillance system, aimed at creating an entire airport security monitoring solution providing real-time accurate situational awareness to airport authorities. The TASS concept is based on integrating different types of selected real time sensors & sub-systems for data collection in a variety of modes, including fixed and mobile, all suitable for operation under any environmental conditions.

TASS divides the airport security into six security control segments (environmental, cargo, people, airplanes, vehicle-fleet & facilities) each of them being monitored by various technologies that are fused together, creating a multisource labyrinth fusion logic enabling situational and security awareness of the airport anytime and anywhere.

These fused control segments will be accessed through the TASS WEB-based portal by running a suite of applications making the airport security control centralized to all airport authorities.

Technology/measure applicable to transport mode:

Technology/measure possibly applicable to transport mode:

Opportunities and benefits from development and implementation:

TASS is a very promising technology that combines different audio and video scenario recognition. The possibility of having a pre-modelling social interaction scenario within transport vehicles, as well as pre-defined disruptive events (individual or group misconduct events), including pre-recognition of criminals, combined with recording just in time real situations could be useful to better protect vehicles and passengers from anti-social behaviour.

Barriers to development or implementation:

The main barriers are:

- Technological: mainly due to modelling as pre-classification framework, which must be adapt to different transport scenarios and operating conditions.
- Environmental: due to lightning conditions, both natural as artificial inside transport vehicles.
- Economic: considering the high-technology used and time-spent.
- Social: due to unknown conditions regarding public acceptance of the technology (the existence of the system inside the vehicles can bring some constraints)

5 Conclusions and next steps

5.1 Conclusions

Transport and mobility represent one of the most important elements 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 and secure transport across all modes is paramount.

In WP3 a significant number of technologies and approaches with capabilities to ensure and enhance transport safety and security were identified and selected as having potential to be transferred from one transport mode to another. They are categorized in areas and concepts, as shown below:

Table 13 Areas and concepts in WP3

Area	Concept
Safety of people & Safety of goods	Accident reduction measures
	Human factors and education
	Infrastructure ITS
	In-vehicle technologies
Security of people & Security of goods	Measures to prevent criminal activity
	Measures to reduce opportunities for criminal activity
	Transportation safekeeping
	Surveillance

The literature review identified approximately 40 technologies and approaches that ensure and enhance transport safety and security. These were mainly in the technology and infrastructure domains and arose from road, rail and water modes. It must be noted that, although the first literature review yielded over 70 potential technologies, only the ones with potential for crossover were selected for a detailed reporting. Using available data, as well as the expert assessment of the project team, barriers and opportunities of applying a technology or approach from one transport mode to another were detailed.

5.2 Next steps

The next step is to build on the information obtained from the literature review through a number of stakeholder engagement activities:

- Stakeholder workshop – On 21st January 2016, the preliminary findings will be presented to key stakeholders to obtain their feedback and stimulate discussion on common challenges and opportunities across modes.
- Questionnaire – A wider range of stakeholder input will be sought via a joint USE-iT/FOX questionnaire. This was distributed in December 2015 and responses are expected in December 2015/January 2016. The questions related to WP3 can be found in Appendix B.

- Interviews – Additional detail will be obtained from key stakeholders through teleconference or face-to-face meetings December 2015 to February 2016.

This information will be used to map out common research topics and will be developed further in the cross-modal research roadmap.

6 References

Airports Council International (ACI) (2012) *"Realizing Europe's vision for aviation Strategic Research & Innovation Agenda Volume 1 and 2, ACARE"*, September 2012, at http://www.aci.aero/media/aci/file/aci_priorities/safety/aci_policies_and_recommended_practices_seventh_edition_5.pdf, Last accessed 2nd December 2015

Belmonte, F.,Boulanger, J.-L. & Schön, W. (2007): "*Human Reliability Analysis for Automatic Train Supervision*. Proceedings of the 10th IFAC/IFIP/IFORS/IEA Symposium on Analysis, Design, and Evaluation of Human-Machine systems". Seoul. Korea.

Berquist, S., Grante, C., Fredriksson, J., Sjöberg, J. (2013) "*Automation for improved safety in roadside construction*", Proceedings of the 30th International Symposium on Automation and Robotics in Construction and Mining, vol. 2013, http://publications.lib.chalmers.se/records/fulltext/182255/local_182255.pdf, Last accessed 4th December 2015

Car2Car Communication Consortium, (2015): [image]. Available at: https://www.car-2-car.org/fileadmin/_migrated/pics/BMW_3D_Car2Car_CityScenario.jpg, last accessed 3rd December, 2015

Colorado Department of Transportation (CDOT) (2014) "*Zone Safety and Mobility Rule – Procedures Document*", https://www.codot.gov/library/traffic/lane-close-work-zone-safety/work-zone-safety-mobility-program/WZSM_Procedures.pdf, Last accessed 2nd December, 2015

Ceccato, V. & Newton, A. (2015) (Eds.) "*Safety and Security in Transit Environments*", London, Palgrave Macmillan, ISBN 9781137457653

Crime Concern (2004) "*People's Perceptions of Personal Security and Their Concerns about Crime on Public Transport*". Department for Transport, London, UK.

Cuculic, D., Bosnar, A., Stemberga, V., Coklo, M., Nikolic, N., Grgurevic, E. (2009) *"Interpretation of blood alcohol concentration in maritime accidents — A case report*". Forensic Science International, Vol. 1 (December 2009), pp. 35-37, www.fsisupjournal.org/article/S1875-1741(09)00012-3/abstract, Last accessed 18th November, 2015

ECORYS (2014) "Study on the prevention of drink-driving by the use of alcohol interlock devices", Final Report, ECORYS, Rotterdam, 2014, http://ec.europa.eu/transport/road_safety/pdf/behavior/study_alcohol_interlock.pdf, Last accessed 18th November, 2015

ECTA, EPCA and CEFIC, (2003). "*Guidelines for Transportation Security*", http://www.ecta.com/media/1042/8_transportation_security.pdf, Last accessed 2nd December, 2015

Elvik, R., Voll, N. G. (2014) "*Challenges of improving safety in very safe transport systems*". In Safety Science, Vol. 63 (March 2014), pp. 115-123, http://www.sciencedirect.com/science/article/pii/S0925753513002579, Last accessed 2nd December 2015

European Union (2011) "*White Paper on Transport – Roadmap to a Single European Transport Area – Towards a Competitive and Resource Efficient Transport System*", ISBN 978-92-79-18270-9, available at http://ec.europa.eu/transport/themes/strategies/doc/2011_white_paper/white-paper-illustrated-brochure_en.pdf, last accessed 7th December, 2015

European Comission, 2002. "*Amtsblatt Nr. L 245 vom 12/09/2002 S. 0037 – 0142. Bruessles*", http://eur-lex.europa.eu/legal-content/DE/TXT/HTML/?uri=CELEX:32002D0731&from=EN, Last accessed 2nd December 2015

European Commission (2009). "*A European Security Research and Innovation Agenda - Commission's initial position on ESRIF's key findings and recommendations*". Brussels, December 2009

European Commission (2012)." *Commission Staff working document on Transport Security*". Brussels: SWD(2012) 143 final, at http://ec.europa.eu/transport/themes/security/doc/2012-05-31-swd-transport-security.pdf, last accessed 18th December, 2015

European Commission (2015) "*What is the EU doing to improve security and safety of transport in the EU?*", available at http://ec.europa.eu/transport/themes/security/index_en.htm, last accessed 7th December 2015

European Commission (2015) "*Aviation Security*", at http://ec.europa.eu/transport/modes/air/security/index_en.htm, last accessed 18th December, 2015

European Commission (2015) "*eCall: Time saved = lives saved*" (image), available at https://ec.europa.eu/digital-agenda/en/ecall-time-saved-lives-saved, last accessed 18th December 2015

European Aviation Safety Agency (EASA) (2015) "*Annual Safety Review 2014*", ISBN 978-92-9210-195-4, available at http://easa.europa.eu/system/files/dfu/203807_EASA_SAFETY_REVIEW_2014.pdf, last accessed 7th December, 2015

European Railway Agency (ERA) (2014) "*Railway safety performance in the European Union*", available at http://www.era.europa.eu/Document-Register/Documents/SPR2014.pdf, Last accessed 7th December, 2015

European Road Safety Observatory (ERSO) (2015) "*Traffic Safety Basic Facts 2015 – Main Figures*", available at http://ec.europa.eu/transport/road_safety/pdf/statistics/dacota/bfs2015_main_figures.pdf, last accessed 7th December, 2015

European Telecommunications Standards Institute (2010) "*Human Factors (HF); Intelligent Transport Systems (ITS); ICT in cars*", Technical Report ETSI TR 102 762 v1.1.1, available at http://www.etsi.org/deliver/etsi_tr/102700_102799/102762/01.01.01_60/tr_102762v010101p.pdf, last accessed 15th December 2015

European Transport Safety Council (2001) *"The role of driver fatigue in commercial road transport crashes",*. ETSC, ISBN 90-76024-09-X, Brussels, 2001, http://etsc.eu/wp-content/uploads/The-role-of-driver-fatigue-in-commercial-road-transport-crashes.pdf, Last accessed 18th November 2015

European Transport Safety Council (2001) "*A Strategy for EU Transport Safety Research*", available at http://etsc.eu/wp-content/uploads/ETSC-Transport-Research-Strategy.pdf, last accessed 10th December 2015

European Transport Safety Council (2003) "*Assessing risk and setting targets in transport safety programmes*", ISBN: 90-76024-14-6, http://etsc.eu/wp-content/uploads/Assessing-risk-and-setting-targets-in-transport-safety-programmes.pdf, Accessed 30th November 2015

Eurostat (2015) "*Transport accident statistics*", available at http://ec.europa.eu/eurostat/statistics-explained/index.php/Transport_accident_statistics, Last accessed 7th December 2015

Favo, F., Semerano, A. (2013) "*Improving safety & security roadmap*", European Rail Reseach Advisory Council (ERRAC), at http://www.errac.org/wp-content/uploads/2013/07/ERRAC-WP04-Roadmap-Y3_Final-1008.pdf, last accessed 18th December, 2015

FEHRL (2013) "*FORx4 Forever Open Road, Runway and river: A co-modal transport initiative for research*", FEHRL, Brussels, Belgium

Festag, A., Hessler, A., Baldessari, R., Le, L., Zhang, W., Westhoff, D. (2008) „*Vehicle to vehicle and road side sensor communication for enhanced road safety*", in Proceedings of IST World Congress and Exhibition, New York, USA, November 2008, available at http://www.festag-net.de/doc/ITS2008_VANET-WSN_w.pdf, last accessed 17th December, 2015

Fjortoft, K. E., Hagaseth, M., Lambrou, M. A., Baltzersen, P. (2011) "*Maritime Transport Single Windows: Issues and Prospects".* In International Journal on Marine Navigation and Safety of Sea Transportation, Volume 5, Number 3 September 2011.

Florida Department of Transportation (2015) "*Royal Trucking & Equipment and Micro Systems demonstrate Autonomous Technology*", http://www.automatedfl.com/royal-trucking-equipment-and-micro-systems-demonstrate-autonomous-technology/, Last accessed 2nd December, 2015

Heddebaut, M., Souheir, M., Sodoyer, D., Jacob, E., Aguado, M., Zamalloa, C., Lopez, I., Deniau, V. (2014): "*Towards a resilient railway communication network against electromagnetic attacks*". In Transport Research Arena Conference Proceedings. Paris.

Hill. C. (2015) "*Florida DOT to test autonomous truck mounted attenuators in work zones later this year*", in Equipment World, http://www.equipmentworld.com/florida-dot-to-test-autonomous-truck-mounted-attenuators-in-work-zones-later-this-year/, Last accessed 2nd December, 2015

Hermitte, T. (2012) eSafety, "*Deliverable 5.8; Final Report on Safety and eSafety*", DaCoTA project, available at http://www.dacota-project.eu/Deliverables/DaCoTA_D5.8_Final%20Report.pdf, last accessed 18th December 2015

Huang, J. (2009) "*Aviation Safety and ICAO*" at https://openaccess.leidenuniv.nl/bitstream/handle/1887/13688/000-huang-diss-28-01-09.pdf?sequence=1, last accessed 18th December 2015

International Transport Forum (2008) "*Towards Zero Ambitious Road Safety Targets and the Safe System Approach*", Summary Document, ISBN 978-92-821-0195-7 http://www.internationaltransportforum.org/jtrc/safety/targets/08TargetsSummary.pdf, Accessed 29th June 2015

Japan Radio Co. (2015) "*VTS/VTMS Integrated Information Management System*" (Images), http://www.jrc.co.jp/eng/product/jmarine_gis/app02_vtsvtms.html, Last accessed 2nd December 2015

Jootel, P.S. (2013) "*Safe Road Trains for the Environment (SARTRE) – Project Final Report*", http://www.sartre-project.eu/en/publications/Documents/SARTRE_Final-Report.pdf, Last accessed 4th December, 2015

Kochsiek, J. (2015) "*CARONTE – Creating an Agenda for Research on Transportation Security*", available at www.caronte-project.eu/wp-content/uploads/2015/06/Mid_Term_Conference_V0.6-FINAL.ppt
, last accessed 18th December, 2015

Koursi, E. M. E., Duquenne, N., (n.d.): "*Assessment of the Safety management system in railway sectors*". INRETS. Villeneuve-d'Ascq. URL: www.uic.org/cdrom/2006/wcrr2006/pdf/150.pdf, Last accessed 19th November 2015.

Kwiatkowski, M. Popik, J. & Buszka, W., Wawruch, R. (2012). **"***Integrated Vessel Traffic Control System"***.** International Journal on Marine Navigation and Safety of Sea Transportation, Volume 6 Number 3 September 2012

Lahausse, J.A., Fildes, B.N. (2009) *"Cost-Benefit Analysis of an Alcohol Ignition Interlock for Installation in all Newly Registered Vehicles*", Traffic Injury Prevention, Vol. 10 (December 2009), pp. 528-537, www.ncbi.nlm.nih.gov/pubmed/19916122, Last accessed 18th November, 2015

Methodical recommendations M 034500778-700:2012 *Technique for carrying out safety audits and inspections at the stage of operation of public roads*. http://dorndi.org.ua/sites/default/files/m_03450778-7002012_3x.pdf

MODSafe (2010): "*WP1 – D1.2 Final Report - State of the art on Safety Responsibilities and Certification*". URL: http://www.modsafe.eu/fileadmin/documents/deliverables/DEL_D1.2_INRETS_WP1_V3_01.pdf?PHPSESSID=4c84e615484233838f6a9816b5d2e633. Last accessed 16 December 2015.

Möckel, S., Brenker, M. & Strohschneider, S. (2014) "*Enhancing Safety through Generic Competencies"*. International Journal on Marine Navigation and Safety of Sea Transportation, Volume 8 Number 1, March 2014.

National Cooperative Highway Research Program (2003) "*Safety Management Systems – A Synthesis of Highway Practice*", NCHRP Synthesis 322, ISSN 0547-5570, Transport Research Board (TRB), Washington D.C., http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_syn_322.pdf, Last accessed 2nd December, 2015

Newton, A. (2014) "*Crime on Public Transport", Encyclopedia of Criminology and Criminal Justice*", London: Springer, 709–720, ISBN 978-1-4614-5689-6

Organization for Economic Co-operation and Development (OECD) (2008) "*Towards Zero: Achieving Ambitious Road Safety Targets through a Safe System Approach",* Paris, http://www.internationaltransportforum.org/Pub/pdf/09CDsr/PDF_EN/TowardsZero.pdf, Last accessed 2nd December 2015

Palumbo, M. (2014) "*The ERMTS/ETCS signalling system. An overview on the Standard European Interoperable signalling and train control system"*. railsignaling.eu, London, http://www.railwaysignalling.eu/wp-content/uploads/2014/08/ERTMS_ETCS_signalling_system_MaurizioPalumbo1.pdf, Last accessed 2nd December 2015

Pascale, A., Nicoli, M., Chiara, B. D., Spagnolini, U. (2012) "*Wireless sensor networks for traffic management and road safety*", in IET Intelligent Transport Systems, Vol. 6, Issue 1, pp. 67-77, doi: 10.1049/iet-its-2010.0129

Patraiko, D. (2007). *"The Development of e-Navigation".* International Journal on Marine Navigation and Safety of Sea Transportation, Volume 1 Number 3 September 2007.

Peltola H. (2009) "*Evaluating road safety and safety effects using Empirical Bayesian method*", Proceedings of the 4th IRTAD Conference, Seoul 2009, Session 8, http://www.internationaltransportforum.org/irtadpublic/pdf/seoul/8-Peltola.pdf, Accessed 15th August 2015

PIANC - The World Association for Waterborne Transport Infrastructure (2012) "*Safety Aspects Affecting the Berthing Operations of Tankers to Oil and Gas Terminals",* Marcom WG 116 - December 2012 issue, MarCom Working Group 116. Pages 50-52.

Pillich, B. . "*Developing e-Navigation, the early stages"*. BMT Ports and Logistics.

Planas E., Pastor E., Presutto F., Tixier, J. (2008) "*Results of the MITRA project: Monitoring and intervention for the transportation of dangerous goods*", In Journal of Hazardous Goods, Vol. 152, Issue 2, 1st April 2008, Pages 516-526, in http://www.sciencedirect.com/science/article/pii/S0304389407010084, Last accessed 4th December 2015

Poole, R.W. (2008) "*Towards risk based aviation security policy*", Organization for Economic Co-operation and Development (OECD), Discussion Paper No. 2008-23, http://www.internationaltransportforum.org/jtrc/discussionpapers/DP200823.pdf, Last accessed 2nd December 2015

PROTECTRAIL (2014): "*High speed track and tunnel experimentation with SNCF/RFF accessed*". URL: http://www.protectrail.eu/IMG/pdf/01-prail_20140527_thales_villecresnes_demo.pdf, Last accessed 19th November 2015.

Restrail (2014): "*Reduction if Suicides and Trepasses on RAILway property. Practical guide. How to prevent suicide and trespass on the railways and mitigate the consequences*?". at http://www.restrail.eu/IMG/pdf/restrail_book.pdf , Last accessed 19th November 2015.

Safety Audit Certificate of the black spot on the road with high accident degree OF 04 September 2014, the city of Kirovohrad
http://www.dorndi.org.ua/news/novini-saytu/2015/11/23/audit

Secret Project (2015): "*Security of Railways againt electromagnetic attacks*". URL: http://www.secret-project.eu/, Last accessed 19th November 2015.

SECUR-ED Youtube Channel: [Several Videos containing information about SECUR-ED]. Retrieved from: https://www.youtube.com/channel/UCkgup8VreaTBtW8v_7hHe1A/videos, Last accessed 19th November 2015.

SECUREMETRO (2012): "*WP 3 – Design Solutions for Fire and Firebombs– DELIVERABLE: D3.02 Practical and Operational Implementation of Firebomb Mitigation Technologies*". URL: http://securemetro.inrets.fr/fileadmin/depository/PublicDocuments/WP3/D3.02%20Final%20Version.pdf , Last accessed 19th November 2015.

SECUREMETRO (2012): "*WP 3 – Design Solutions for Fire and Firebombs– DELIVERABLE: D3.01 Critical inventory of technologies for firebomb mitigation*". URL: http://securemetro.inrets.fr/fileadmin/depository/PublicDocuments/WP3/D3.01%20-%20Final%20Version.pdf, Last accessed 19th November 2015.

Seventh Framework Programm (2012): "*D2.3 - Compendium of technologies for designing safety and security*". URL: http://securestation.eu/documents/securestation_d2_3.pdf, Last accessed 19th November 2015.

Shelter International (2015) "*Vessel Traffic Management Information System (VTMIS)*", http://www.sheltermar.com.br/en/vts/vtmis/, Last accessed 2nd December, 2015

Schooley, B., Horan, T., Botts, N. and Noamani, A. (2009) "*ITS and Transportation Safety: EMS System Data Integration to Improve Traffic Crash Emergency Response and Treatment*", CTS Project #2008012, Final report, Intelligent Transportation Systems Institute, Centre for Transportation Studies, University of Minnesota, US, available at http://cgu.edu/pdffiles/KayCenter/emssystemdataintegration.pdf, last accessed 16th December 2015

Standard of organization of Ukraine SOU 45.2-0018112-007:2008 Traffic safety. Public roads. "*Procedure for defining black spots on public roads*". http://dorndi.org.ua/sites/default/files/sou_45.2-00018112-0072008_2w.pdf, Last accessed 2nd December 2015

Stephan Schade (2015) "*The fast-paced development of urban mobility platforms*", at http://blog.bosch-si.com/categories/mobility/2015/11/fast-paced-development-urban-mobility-platforms/, last accessed 18th December, 2015

Swedish Transport Administration (2012) "*Road Safety – Vision Zero on the move*", ISBN 978-91-7467-234-3. 3nd edition. http://online4.ineko.se/trafikverket/Product/Detail/44646

Thales (2014): "*SECUR-ED Final Report"*. Secured Urban Transportation – European Demonstration (SECUR-ED). Deliverable D01.11". URL: http://www.secur-ed.eu/wp-content/uploads/2014/12/D01.11_SECUR-ED_Final_Report.pdf , Last accessed 19th November.

The Engineer (2012): "*Improved carriage design could reduce bomb-related injuries*". URL: http://www.theengineer.co.uk/sectors/rail-and-marine/news/improved-carriage-design-could-reduce-bomb-related-injuries/1015305.article, Last accessed 19th November 2015.

Tingvall, C. Haworth, N. (1999). "*Vision Zero – An ethical approach to safety and mobility*" 6th ITE International Conference Road Safety & Traffic Enforcement, Melbourne 6-7 September 1999. http://www.monash.edu.au/miri/research/reports/papers/visionzero.html

Transport Research and Innovation Portal, (2006): "*SAMNET. Safety management and interoperability Thematic Network*." URL: http://www.transport-research.info/project/safety-management-and-interoperability-thematic-network, Last accessed 19th November 2015.

Transportation Control Systems (2015) –" *Emergency Vehicle Preemption (EVP) for Law Enforcement*", (Image) at http://tcstraffic.com/emergency-response/, last accessed 18th December 2015

Urbanski, J., Morgas, W., Miesikowski, M. (2009) "*The Present and Expected Changes in Marine Safety, Security and Defense Functions*" in International Journal on Marine Navigation and Safety of Sea Transportation, Vol. 3, No. 1, at http://www.transnav.eu/Article_The_Present_and_Expected_Urba%C5%84ski,9,129.html, last accessed 18th December ,2015

Vanderhaegen, F., (2009): "*Rail simulations to study Human reliability*. Proceedings of the 3rd Conference on Rail Human Factors". Lille. France.

Vilnius Gediminas Technical University (2012) *Ranking of High Accident Concentration Sections and Network Safety Ranking*", BALTRIS project http://www.baltris.eu/Procedure-manuals-from-BALTRIS/BALTRIS_WP3.4_Ranking-of-HACS-and-NSR-2-kopia.pdf, Accessed 15th August 2015

Vu, V.-T., Bremond, F., Davini, G., Thonnat, M., Quoc-Cuong Pham, Allezard, N., Sayd, P., Rouas, J.-L., Ambellouis, S. and Flancquart, A (2006) "*Audio-video event recognition system for public transport security*", In The Institution of Engineering and Technology Conference on Crime and Security, IET, ISBN 0-86341-647-0, London, June 2006

Welsh, B. C., Farrington, D. P. & O'Dell, S. J. (2010) "*Effectiveness of Public Area: Surveillance for Crime Prevention: Security Guards, Place Managers and Defensible Space*". Swedish National Council for Crime Prevention, Stockholm, Sweden: Edita Norstedts Västerås

Wu, G. Y., Jiao, L., Wang, Y-F, Chang, E. Y. (2003) "*Multi-camera Spatio-temporal Fusion and Biased Sequence-data Learning for Security Surveillance*", In 11th ACM Int. Conf. on Multimedia, pp. 528-538

Wu, J., An, M., Jin, Y. & Geng, H. (2014) "*Training safely, Training safety"*. International Journal on Marine Navigation and Safety of Sea Transportation, Volume 8, Number 3, September 2014.

7 Appendix A: Templates

Please see separate file, in .pdf format.

8 Appendix B: WP3 questionnaire

Where do you see the greatest potential to increase **SAFETY** in ROAD / RAIL / WATER / AIR (please apply the question to transport mode in which you perform your activity)?
Please tick all that apply:

- Technology
- Infrastructure
- Governance
- Customer

Additional information box

Where do you see the greatest potential to increase **SECURITY** in ROAD / RAIL / WATER / AIR (please apply the question to transport mode in which you perform your activity)?
Please tick all that apply:

- Technology
- Infrastructure
- Governance
- Customer

Additional information box

Are there any Technologies/Methodologies/Guidelines that you already employ within your organization to ensure or increase **SAFETY** (in the transport mode in which you perform your activity) that could be applied to the other transport modes?

- Yes
- No
- Don’t know
- If yes, please specify

Additional information box

Are there any Technologies/Methodologies/Guidelines that you already employ within your organization to ensure or increase **SECURITY** (in the transport mode in which you perform your activity) that could be applied to the other transport modes?

- Yes
- No

- Don’t know
- If yes, please specify

Additional information box

Do you employ any cross-modal activities to ensure or increase **SAFETY** and/or **SECURITY** within your organization?

- Yes
- No
- Don’t know
- If yes, please specify

Additional information box

FOREVER OPEN INFRASTRUCTURE ACROSS ALL TRANSPORT MODES
USERS, SAFETY, SECURITY AND ENERGY IN TRANSPORT INFRASTRUCTURE

Project Coordinator	Dr. Thierry Goger, FEHRL, Blvd de la Woluwe, 42/b3, 1200 Brussels, Belgium. Tel: +32 2 775 82 34, Fax: +32 2 775 8245. E-mail: thierry.goger@fehrl.org Website: www.useitandfoxprojects.eu