EXPLOIT
SYNERGIES
AND
OPPORTUNITIES
ACROSS
TRANSPORTATION
MODES

THE EXCROSS PROJECT

Content

Introduction

The investigation of safety aspects in transportation has been one of the core investments of the European Commission in recent years. However, the approaches to safety adopted in the different transportation modes are quite different, in part because of the different operational conditions, equipment and user needs, and in part because of historical and traditional reasons.

EXCROSS is a Supporting Action of the European Commission to enhance cross-fertilisation and synergies between safety research initiatives in four different transport modes (road, aviation, maritime and railway). EXCROSS addresses the fragmentation that exists in Europe between safety initiatives in the different modes, with little cross-domain learning and sharing of experience, and investigate systematically the potential synergies and the areas where an improvement and a coordination of the research effort could benefit more than one transportation mode.

The project started from the identification of safety principles and safety issues in each domain to develop a mutual understanding and provide hints on those areas which are the main focus of safety related research activities. Next, the consortium identified, selected and analysed relevant European and national safety research projects in the four transportation modes, looking for:

- Cross-domain solutions, that can be transferred from one mode to another;
- Multi-domain solutions, in areas with common research needs or solutions to be developed which would benefit more than one transport mode;
- Trans-domain solutions, which require joint efforts as solutions can only be found by considering more than one transport mode.

The analysis of safety research was performed using two complementary approaches, to combine the information gathered from the source projects, the understanding achieved in the first project year, and the rich expertise of all the partners, experts, steering group members. The “Bottom-up” approach consisted in the identification of individual projects dealing with safety activities in one transportation mode and the related ones in other modes. The “Bottom-up” approach was integrated with a “Top-down” one, which started from the identification of cross-domain hot research topics on the basis of partners’ expertise and searched for projects addressing those topics. This second approach was particularly effective to compare the research activities and identify the potential research gaps.

Seven topics were selected for the analysis, as the ones on which more extensive cross-fertilisation opportunities were found. These topics do not represent the most important topics on the research agenda, only the ones where cross-fertilisation seemed more promising. For each topic the potential synergies and cross-fertilisation opportunities are presented, altogether with existing success cases (if any), like previous projects that already tackled the topic in a cross-modal perspective. Each section ends with a list of hints for future cross-modal activities.

Introduction

1

Certification topic: reduction of certification costs and effort via cross-domain activities. Two major areas of work concern the certification of cross-domain embedded systems components, and the development of common certification processes.

2

Dangerous Goods transportation topic: Ensure the safe transport of dangerous goods by improving the cargo securing, the safety of the vehicle which is carrying the cargo and safe routing of cargo transport. The topic deals also with the safety of surrounding people, environment and structures.

3

Human Factors – Fatigue topic: Compare the state-of-the-art of research on tools and methods to monitor detect and predict individual or professional operators' physiological state related to wakefulness and fatigue.

4

Human Factors – Training topic: Ensure staff and operators are properly trained to manage normal and emergency situations, in order to avoid issues related to human factors or to reduce consequences in case of unavoidable accidents.

Topics

5

Tools and methods for Incident/Accident Investigation topic: Identification of tools and methods to achieve and/or assure an appropriate level of safety. We collected and compared initiatives working on Incident/accident data collection, data storage, data extraction and processing, and projects aiming at the identification of safety indicators

6

Safety Assessment topic: Compare the state-of-the-art of Safety Assessment methods and techniques applied in the different domains to systematically identify, assess and control risk. Review the methods and techniques, and the emerging safety issues being tackled.

7

Safety Enhancement topic: Develop initiatives that work on the way safety is perceived, valued and prioritised in an organisation (Safety Culture) and initiatives to share information, knowledge and build a framework to collaborate on safety within the different transport domains.

CERTIFICATION

Projects analysed >

CHESS

SESAR 16.01.04 | EXTICE | SMAES

MULTI MODAL | OPENCOSS | MOGENTES | SAFECER

Introduction

Safety certification of embedded systems in the transportation domains is a multi-faced and complex issue. Furthermore, the multi and cross-domain framework, within which the stakeholders will have to move ever more in the future, introduces additional constraints such as the large variety of definitions/interpretations, technology/architectures and regulation/culture levels.

Different transport sectors (e.g. railway, automotive, aviation) have developed their own specific set of standards in the past years, originating a sort of "Babel Tower" effect. A multi-domain approach to support a simpler and quicker certification of components and systems could help improving safety while contemporaneously reducing costs and effort.

Two aspects of the certification research are addressed by the analysed projects:

1. Steps and tools used in the certification process, that can be transferred or re-used in another mode; by analysing the process for different domains and by contextualising the analysis itself with reference to the development of a particular product, it is possible to highlight building blocks of the certification workflows for different transportation modes.
2. Certification of cross-domain components: some components can be designed so that they (or part of them) are already certified in more than one transport mode. It typically means that the hardware and software components are highly modular and simplified (though more numerous), so to ease re-use in another mode without need for customisation and with a consequent reduction of costs and time.

Findings

The two aspects highlighted are interdependent and mutually affect each other. Ideally, it could be possible to depict trans-domains benefits concerning:

- The analysis of certification steps (and possible tools for the certification workflow investigation) in order to depict common milestones for procedures in different domains;
- The analysis of the production process of embedded systems, in particular with reference to the modular decomposition of hardware and software modules which can be exploited in other transportation modes.

Two branches of the multi-domain research: common tools and steps for the certification process; cross-domain certification of the components

The harmonisation of business processes in inter-modal transport is the basis to pave the road for the standardisation of inter-modal/cross-modal certification processes. Also, the standardisation of hardware boards/embedded ICT systems (and possibly Operating Systems) is an area in which cross-mode certification could be reached with relatively small effort, and the development of common interfaces for intermodal communication will support progresses in this area.

Even if the research on certification is already moving into a multi-modal direction, the regulatory framework is still a step back. First of all, the participation into standardisation processes shall be enlarged by facilitating access to standardisation bodies and initiatives. There is also the need to start definying common approaches to technology certification process at the EU level and, at the same time, it is important to consider the certification of components for cross-border (EU vs. non-EU) safety. Finally, International or EU intermodal certification bodies are missing.
A last gap is the absence of the maritime domain within the cross-modal projects consortia, together with the difficulties in finding certification research projects in the maritime domain. The analysis of the maritime domain certification processes and components should be performed in order to compare the state-of-the-art of this domain with the status of the research in the other domains.

Need for International or EU inter-modal certification bodies and a common approach to technology certification process at EU level.

Success stories

OPENCOSS

Open Platform for EvolutioNary Certification of Safety-critical Systems

Funding scheme: EU FP7
Website: **www.opencoss-project.eu**

The OPENCOSS project aims to devise a common certification framework, spanning different transport sectors (automotive, aviation, railway, while maritime is not included), to facilitate the re-use of assurance assets across and between domains, and to establish an open-source platform or safety certification infrastructure.

SAFECER

Safety Certification of Software-Intensive Systems with Reusable Components

Funding scheme: EU ARTEMIS JU
Website: **www.safecer.eu**

SafeCer is targeting increased efficiency and reduced time-to-market by composable safety certification of safety-relevant embedded systems, such as electronics and software systems (i.e. software-intensive systems). SafeCer proposes a workflow approach to certification standards to identify common procedures to different domains, in order to find clusters of procedures in common between domains for the certification of embedded hardware and software.

Hints for future research

Development of a **multi-domain knowledge base**, useful for stimulating the research on the productive and certification processes, and creation of **political and legislative initiatives** to foster and ease multi-domain standardisation.

Certification of the management of **data ownership** and Intellectual Property Rights in all safety-related matters.

Confidence in **certification vs. liability** in case of accidents.

Certification of protection against **cyber-attacks**, in analogy with the Safety Integrity Level described in CENELEC norms (e.g. EN50129).

Certification of **multi-domain components** to allow working in different harsh environments (e.g. icing conditions).

DANGEROUS GOODS

Projects analysed >

(train)	TRAIN-MD						
(road)	GOOD ROUTE	HEAVY ROUTE	COCAE	ASSET ROAD	CVIS	SCUTUM	Risk factors relevant to road safety for truck drivers in long distance traffic
MULTI MODAL	RISK TRACKING	WIBRATE	MENTORE	MITRA			

Introduction

The term “Dangerous goods” identifies items or materials with hazardous properties which, if not properly controlled, present a potential risk to human health and safety, infrastructure and/or their means of transport. The movement of dangerous goods through transportation channels, especially through roads and railways, needs to be carefully regulated in order to prevent accidents to persons or property, and damage to the environment, to the means of transport employed or to other goods. Apart from the risk of traffic accidents, incidents such as spillage or leakage of goods have to be prevented as they can lead to fire, explosions, chemical burn or environmental damages.

The transportation of dangerous goods is controlled and governed by a variety of different regulatory regimes, operating at both the national and international levels for the regulation of the handling, packaging, labelling and transporting of the goods. However, with different regulations in every country and for different modes of transport, international trade in chemicals and dangerous products is seriously impeded, if not made impossible and unsafe.

The scope of the EXCROSS work was to review methods and technologies used in transports to ensure a safe journey of the cargo carrying dangerous goods and the surrounding environment, looking for cross-fertilization opportunities and areas for common research. The analysis included tools to:

- Ensure cargo securing and monitoring;
- Guarantee a safe and efficient routing of the vehicle, tracking and tracing the cargo and/or supporting the driver tasks;
- Manage incidents/accidents of dangerous goods transportation.

Findings

Analysing the status of the research, the main similarities were found between the railway and road domains, in particular on the technologies and tools adopted to support the dangerous goods transportation. The aviation domain seems to be not affected by the issue, even if a small part of dangerous goods transportation is performed by air, while the maritime domain is particularly advanced in the regulatory framework for the dangerous goods transport, as well as in the monitoring and managing of the goods.

The most promising area for joint research between the railway and road domains is on the development of technologies for tracking and tracing to monitor and control the position of objects for safety, efficiency and traceability purposes. The monitoring, tracking and tracing process should be related to the carried good, not to the type of vehicle, in order to allow a seamless monitoring independently from the transport mode and thus improve efficiency and safety.

Tracking and tracing technologies could also be integrated with Radio Frequency Identification (RFID) scanners for the automatic identification of the transported dangerous goods and related information. The information on the characteristics of dangerous goods should be provided in a standardised form, possibly related to the “risk class”, amount of the transported goods, package and other relevant aspects. This would be particularly useful to develop emergency procedures in case of incidents or accidents.

Need for an international and trans-modal regulatory framework for the transportation of dangerous goods.

Standardised and certified information on the characteristics of the dangerous goods and the countermeasures to be adopted in case of incident can support the incident management procedures. Useful information would be on how to dispose the dangerous good, the measures to be taken in case of incidents, the protection needed for the rescue services and the protection needed for the surrounding environment and population. Aviation, road and railway domain can learn from the experience of the maritime domain, which developed the International Maritime Dangerous Goods Code for the transport of dangerous goods by sea, covering matters such as wares packing, container and storage.

Further information on dangerous goods transports (e.g. axle weight, speed, behaviour of the driver etc.) could be collected in order to improve the monitoring of dangerous goods. This information could be transferred to the competent authorities before the transport is carried out, in order to inform them. Several sensors have been developed to monitor the pressure and temperatures of the tanks containing the goods. These sensors can also detect leaks and can be applied to all modes using such tanks. Another class of sensors are the ones for measuring the status of the vehicle in terms of temperature of tires, axles or vehicle vibration. Both road and railway domains have developed such kind of sensors; their transferability can be evaluated and the possibility for common research can be explored, taking into account the cross-domain certification issues. Finally, specific sensors for the detection of nuclear radiation also exist, but their application to the transportation domain has still to be evaluated.

Need for standardised and certified information on the characteristics, disposal and management of dangerous goods, looking at the maritime example.

An interesting research branch regards the development of planning tools for dangerous goods vehicles routing, re-routing and driver support, which is particularly advanced in the road domain and can be explored for the railway and maritime too.

Success story

MENTORE

iMplemENtation of GNSS tracking & tracing Technologies fOR Eu regulated domains

Funding scheme: EU FP6
Website: **www.gnsstracking.eu**

MENTORE aims at demonstrating and validating the added value of EGNOS and GALILEO at the service of tracking and tracing applications to monitor and control the position/displacement of objects for safety, efficiency and traceability purposes. The project also analysed and developed services supporting the implementation of the corresponding National and European regulations for goods tracking and tracing.

Hints for future research

Joint research between rail and road on **Tracking and Tracing technologies and sensors** to monitor the vehicle/good status, able to take into account the issue of multi-domain certification of the components.

Standardisation of dangerous goods information and **data sharing** across domain, possibly through on-line databases.

Development of **trans-domain decision support systems** to handle environmental accidents caused by, or involving dangerous goods.

Transfer of knowledge on **vibration monitoring systems** from aviation, rail and road to the maritime domain.

FATIGUE

Projects analysed >

Fatigue Risk Management System

M'AIDER

MULTI MODAL

SENSATION

Introduction

Fatigue is currently one of the hottest topic in transport safety research, since it has been recognised as one of the key factors in several industrial incidents/accidents. Sleep deprivation, fatigue and drowsiness decrease individual awareness, attention, and increase reaction time. Much research has been conducted on human fatigue prevention, looking for systems, methods and tools for detecting and predicting it, with the goal of reducing its impact and consequences.

Despite its major influence on individual performance, the fatigue concept is still poorly understood, even within the scientific community. There is no developed theory concerning its origins or functions, and different types of fatigue (mental, physical, sleepiness) are usually mixed. Also, a standard definition of fatigue is missing. The concept is usually associated to a physical and/or mental state deriving from sleep loss, or extended wakefulness, circadian phase, or workload.

The fatigue issue is common to all the domains, with research activities and approach differing from one transport mode to the other.
The characteristics of each transport mode play a major role. Structured and centrally controlled domains, such as railway and aviation, address operators' fatigue by managing their schedule and shift patterns. In both domains, specific policies are in place to set limits on working hours, overtime and shift-swapping, trying to prevent fatigue. The same policies exist in the maritime domain, but the different operational context makes it almost impossible to check the operators' compliance with the IMO work rest mandates. The conditions in which seafarers work are becoming increasingly demanding and there are still occasions where individuals simply have to work for more than 12 hours with a 6 hours' break, for example during discharging operations. Ship type also has a role in determining fatigue. Seafarers based on ferries reported higher levels of fatigue than other vessel types. The situation differs in the road domain, where most of the users are non-professional drivers and there is no way to set limits, or regulate the driving/not driving hours.

Findings

The analysis of the Fatigue topic within EXCROSS is centred on the project SENSATION. This project carried out research on fatigue monitoring, detection, and prediction across three transport modes (road, maritime, and aviation), making most of the results transversal to the transport modes. Other projects were initially selected for the analysis, but none of them specifically targeted fatigue monitoring and detection, dealing instead with shift management models as means to manage fatigue and targeting professional drivers and pilots. Also, they addressed fatigue only in one transport mode, thus adding little insights to the SENSATION findings. The focus of SENSATION was on brain activity sensors for hypovigilance detection, prediction and management as well as diagnosis, treatment and remote monitoring of sleep disorders. In its industrial applications, the project targeted sleep and stress detection and prediction through multi-sensorial systems in order to prevent accidents occurring due to these factors. The project delivered clusters of sensors that can be used in different industrial systems, taking into account the different operational environment and driver/pilot's skills.

In the road and maritime modes, a higher impact on fatigue monitoring and detection for professional drivers could be achieved by designing HMI with warnings and status indicators for the operator, rather than by shift management and regulation. Type of systems that can be used in the road and maritime domains include warning systems that prevent the operators from dozing off, helping them to make the right decision when alarms are coming in.

Fatigue measures selection based on the context (experimental vs. operational), objective (off-line vs. real-time monitoring) and target users (professional vs. non professional)

Research gaps on fatigue have been identified in all the domains. In the maritime area, fatigue on large vessels is monitored in simulated environments but not in real operations. Even if simulation studies are a good starting point, the experience suggests that simulator findings should be generalised with caution. In rail transport, fatigue is under-researched. Although train automation is at a high level, there are still scenarios where the train drivers make key decisions/actions.

Road domain is probably the one which is investing more energy and resources on fatigue research. Automation is seen as one of the most promising solutions to deal with fatigue. The research focus is on semi-automation with the horizon towards the fully automated driving. Specific focus of research are the driver-automation interaction, driver workload and distraction management. A specific research area of interest concerns those scenarios when the system gives back control to the driver. The research question is to define which information the driver should receive to be kept in the loop. In respect to semi-automated systems, further research activity is needed to define the principles that regulate the man-machine interaction, i.e. how/when the system has to warn the driver and how to regulate the handover process. Another key aspect is the regulation of the automated vehicles behaviour in mixed environment, i.e. when they are surrounded by non-collaborative and non-automated road participants.

No research project specifically dealing with fatigue management was identified in the aviation domain. However, Fatigue Risk Management Systems (FRMS) are adopted in this transport mode, for the continuos monitoring of fatigue-related safety risks. Based upon scientific principles and knowledge, as well as operational experience, it aims to ensure relevant personnel are performing at adequate levels of alertness. Despite of this, research activity in the aviation domain on the fatigue topic would be beneficial.

Standardise the Fatigue concept definition, criteria and attributes, independently from the domain of applied research.

Success story

SENSATION

Advanced sensor development for attention, stress, vigilance & sleep/wakefulness monitoring

Funding scheme: EU FP6
Website: **www.sensation-eu.org**

SENSATION explored a wide range of micro and nano sensor technologies for unobtrusive, cost-effective, real-time monitoring of sleep and sleepiness within medical and industrial applications. SENSATION has provided integrated solutions for real-life measurements that will have a major impact on both the applications of present insights and the production of new scientific models and knowledge.

Hints for future research

Application of the **Hypo-vigilance Management Systems** developed in the road domain to the maritime one.

Implementation of **warning systems** in the maritime domain, to prevent operator from dozing off and support alertness state.

Joint research on fatigue, hypo-vigilance, distraction and stress, starting from a common **theoretical framework of the concept**.

Identification of systems that allow **real-time monitoring** in different operational environments.

Development of field operational tests to produce **wide public databases** with fatigue and hypo-vigilance data.

TRAINING

Projects analysed >

- 2TRAIN
- BEMOSA
- M’AIDER

Introduction

Human and organisational factors have contributed to the causes of several recent incidents in a variety of safety critical industries. Thus, investing in people training is one of the most effective ways of improving safety, reliability and efficiency of critical industries such as the transportation ones. Training is the process by which the operators and staff learn to practice and assess their ability to respond to different contingencies. Its goal is to ensure that all levels of staff are competent to meet the operational requirements set by the organisation.

Safety training of staff in the transportation domains was found to be related, mainly, to two main categories: the first one is the training for emergency situations and the second one is training to enhance safety culture. These are two aspects of the same subject, both directed at improving safety in transportation modes in a proactive way rather than in a reactive one. In particular, emergency training is targeted towards teaching operators procedures to avoid issues related to human factors or to reduce consequences in case of unavoidable accidents. A proper preparation helps saving lives, limiting damages and reducing disruptions (or interruptions) to service, with positive consequences from the human, social and economic points of view.


CARNIVAL

Findings

All the training projects analysed within the EXCROSS project could be transposed to other domains to spread the safety culture (whether it represents an answer to emergency situations or to the need of proactivity) and to increase the education and the training level of employees. The transposition is possible in respect to two aspects: cross-fertilisation of the training approach and method, and development of a shared platform (e.g. simulation platform) to host training activities.

The training process is well defined and structured in three of the four domains considered in EXCROSS. Aviation, maritime and railway have identified specific solutions and programmes to train their operators. These solutions and programmes are not applicable for the majority of non-professional road users. In most of the cases, the national training programmes for road users correspond to the courses to get drivers licence. There is no chance for recurrent training and no way to prepare the drivers to answer to emergency situations, due to the incredible variety of unpredictable situations the drivers can face.

Comparing the more standardised and centralised domains (aviation, railway and maritime), different solutions and procedures exist. However, it seems possible to identify a framework for managing issues which are in common among them. This will ease the exchange and comparison of training approaches and methods, even if training for safety needs has to be constantly improved and adapted to the contingent situations. Cross cultural issues, common training platforms, mandatory vs. voluntary training issues (e.g. simulators training) etc. are just a few of the topics that need to be looked at close level.

Gaps in training of seafarers need further investigation. The problem may be strictly related to the absence of sufficient number of personnel on-board the ships due to recruitment problems. Likewise recommendation exists to analyse the actual trainers capacities, such as 'Train the Trainer', training for regulators and qualified inspectors, etc. The maritime domain suffers also of lack of technical interpersonal communication on board. The problem has been faced in the aviation too, and the solutions adopted in the training courses as well as the recommendations on this topic can be compared between the two domains. The comparison could be carried out by analysing the training needs in the two modes, identifying similarities and differences, to then map existing syllabus contents on the maritime needs. Existing aviation training plans and courses could also be included in the analysis, in order to populate the proposed syllabi and to optimise costs by re-using aviation training resources. Minor customisations may be needed to provide maritime-related examples.

Probably, the most appealing joint-research activity is the development of cross-modal platforms for training, to host e-learning courses. Once a clear insight is obtained as to how people behave during emergencies situations and what behaviour contributes to increase safety, shared platforms for simulation could be developed. Simulations could be used to develop practical training exercises, considering relevant combination of events and possible courses of action. This approach is currently widely adopted for the recurrent training of aviation pilots, who are routinely exposed to unusual situations and emergencies, drilling their competences and reactions. This approach is considered to be very successful when real emergencies do occur.

Use information provided by voluntary reports on safety events to update training programmes or plan new courses

Success stories

M'AIDER

Maritime Aids' Development for Emergency Response

Funding scheme: Leonardo
Website: **www.maider.pro**

The project addressed the aspects of human error related to emergency situations that could be corrected through the removal of existing deficiencies in the training of cadet officers as well as those working on board vessels as officers of various ranks. The project delivered a range of scenarios simulating actual accidents, incidents and near-misses focusing on emergency situations and incorporated these in the existing MET programmes.

TRAIN-ALL

Integrated System for driver TRaining and Assessment using Interactive education tools and New training curricula for ALL modes of road transport

Funding scheme: EU FP6
Website: **www.trainall-eu.org**

TRAIN-ALL aimed to develop a computer-based integrated training system for different land-based drivers of passenger vehicles, trucks, motorcycles and emergency vehicles, that integrates multimedia, driving simulator, virtual driving simulator and on-board vehicle sensors into a single modular platform. The project developed a modular simulator design process for multi-user groups.

Hints for future research

Development of a **common platform for training** (e.g. simulation systems), with peculiarities for different domains created in a "plug-in" approach on common topsoil.

Analyse **past accidents** in source based orientation, identifying the key human factors that led to failures.

Improve shipping safety by transferring and adapting successfully implemented **methods and strategies** for training from the air transport sector to the maritime sector.

Transfer integration of **resilience engineering principles** from aeronautical industry into maritime.

INCIDENT ACCIDENT INVESTIGATION

Projects analysed >

- UIC Safety Database
- ACEM-RAIL

- SESAR 16.01.01
- RAT
- ASMT
- EVAIR
- TOKAI

- SUPREME
- DaKoTa
- SAFETYNET

- METKU
- SAFESEANET

Introduction

The retrospective analysis of incidents and accidents is one of the key elements of any systemic approach to safety. Understanding the causes of past adverse events can help preventing their recurrence. ICAO Annex 13 clearly states that “The sole objective of the investigation of an accident or incident shall be the prevention of accidents and incidents. It is not the purpose of this activity to apportion blame or liability.”
The current research efforts address different aspects, each one of them needed for an effective analysis of past adverse events:
- Incident/accident data collection;
- Data storage;
- Data extraction and processing;
- Identification of safety indicators.

There are tools and methods to monitor the system and collect safety events, others directly seek to gather information on specific potential safety issues, others carry out an automatic data collection to complement voluntary incident reporting. Other initiatives collect in a centralised way heterogeneous data coming from different sources throughout the network.

Each transportation mode shows a different understanding of what an adverse event is, either by a different definition, or by a different classification. For instance in some transport modes, it takes damage to properties or humans, while other modes classify also consequence-free near-misses. Such differences are reflected in the way data is collected and processed and in the tools and methods adopted for the incident/accident reporting and analysis.

Findings

The differences among domains have a serious impact on the possibility to compare safety initiatives or to cross-fertilise the results and research.

The four domains differ for:

- Degree of centralisation: reflects the way the domains are regulated and managed (international level vs. national or industrial level).
- Degree of standardisation: reflects the regulatory framework and the standards existing in the domain.
- Quality and availability of Safety Indicators: differentiates the domains on the availability of a shared set of safety indicators (consistent definition vs. highly-differentiated), quality of indicators (trustworthy vs. untrustworthy), and quality of the measurement tools (harmonised vs. heterogeneous).
- Safety Culture maturity: reflects the individual and organisational approach to safety, from a proactive approach to a pathological one.

These four characteristics clearly separate the three more structured modes (aviation, maritime, railway) from the road transport mode, where many stakeholders exist, there is less centralisation and standardisation, safety indicators are more sparse and collected by many organisations.

The level of standardisation and centralisation of the domains plays a role on the way the information is collected and stored. Also, the presence or not of a non-blame culture significantly affects the implementation of voluntary reporting systems. Incident Reporting Systems are successfully implemented in the aviation domain and in railway domain, and have started to be adopted in the maritime domain too, even if the absence of the "no-blame culture" impairs the effectiveness and reliability of the reports, so that underreport remains a big problem. Examples of application in the road domain exist, but there is not enough data and it is not entirely clear who should analyse the available information and at what level.

Maritime and road domains need to improve the level of standardisation, to centralise and reduce the fragmentation of data collection, to increase safety culture.

The lack of a precise and stable classification of safety events impacts on the implementation of automatic tools for safety events monitoring and data collection. Tools like ASMT (aviation) could be very interesting for the maritime and road modes, as they would support safety monitoring by collection and analysis of large quantity of safety data, in order to identify potential difficulties, problems and trends. However, the relevant data are hard to collect in these domains, as they would require surveillance tools (like radar in aviation), monitoring facilities (e.g. air traffic control centres). Also, these tools need a clear factual definition of what should be collected. For instance, in aviation there is a clear, easy to implement in an algorithm, definition of what a separation infringement is. In maritime and road transport the precursors to actual collisions are not so clearly defined. A third barrier to the tool implementation is the organisational one. Implementing automatic collection of safety data gives a clear benefit to air traffic service providers, by an indirect "check" on the airline performance. This is not true for the maritime domain, while the road mode domain fragmentation reduces the scope of such a monitoring to limited areas.

Maritime and road can implement ASMT-like tools, by reviewing what can be collected, who has the interest in collecting safety data and the authority to act on them, which technologies can be used to monitor.

A comparison between information collected in the safety events databases of the different domain would be beneficial to perform a quality check on what is being gathered. The information stored for rail, road and maritime is highly heterogeneous and it can hardly be compared, so the standardisation of data collection will open the doors to the connection between databases from different domains.

Cross-modal comparison to perform a quality check on what is being gathered.

Success story

ECCAIRS

European Co-ordination centre for Accident and Incident Reporting Systems

Funding scheme: EU
Website: **www.eccairsportal.jrc.ec.europa.eu**

ECCAIRS is a co-operative network of European Transport Authorities and Accident Investigation Bodies. Its mission is to assist National and European transport entities in collecting, sharing and analysing their safety information in order to improve public transport safety.

Hints for future research

Look at aviation experience to develop **standard definitions** and classification of safety events, and consequently to improve safety **data analysis**.

Implementation of **near-miss reporting systems** in order to improve the current underreporting in the maritime domain, working to move from a blame culture to a just-culture. Explore also the transferability to the rail domain.

Deployment of **automatic detection of safety relevant events**, drawing from the aviation experience. Develop multi-domain databases and multi-domain investigation teams, especially to deal with safety of intermodal areas.

Work on **multi-domain policies** to increase intermodal collaboration by setting common standards, definitions, and indicators.

Promote joint research initiatives to increase the passengers' perception of safety and **enhance door-to-door travel experience**.

SAFETY ASSESSMENT

Projects analysed >

SESAR 16.01.03 | SAM | MISSA | ISAAC

UPTUN | RANKERS

SAFEDOR

MULTI MODAL: OPENCOSS

Introduction

The proactive assessment of existing, new, and emerging risks is the hallmark of systematic approaches to safety management. Safety assessment is usually done by identifying hazards, assessing the relative risks, to then consider mitigation actions and improvement initiatives.

The research projects screened by EXCROSS address Safety Assessment from two perspectives:

1. Development of a general methodology, or guidelines, for hazard identification and risk assessment. In this case, projects can also propose a list of mitigation actions to control and minimize the identified risks.
2. Developing dedicated guidelines, methods and techniques to address some specific aspects, safety issues, or system components.

These two aspects are present and transversal across the four transport modes. All the four modes have reference safety assessment methodologies, at least to some extent, and all the methodologies share the same basic principles and structure of the EUROCONTROL SAM, which is reported to be already widely known beyond the aviation community. All the four modes have identified some specific safety issues, for which dedicated methods are being developed.

Findings

The aviation and maritime modes possess general methodologies for Safety Assessment (SAM and SAFEGUARD), supporting hazard identification and risk assessment. These two can be defined as the key reference projects for the two transport modes, since these methodologies are used in most of the other projects. The two modes are also regulated at the European level by central organisations, which maintain a level of consistency and coherence inside the specific domain.

The road and rail modes also possess reference safety assessment methodologies, similarly structured as the EUROCONTROL SAM, which is recognised as a common standard and is currently being used especially in the road domain. Fragmentation remains a big issue, with the analysis of the same problem being tackled in different ways by different organisations. The maritime domain is affected by the same problem, but its negative effects are partially counterbalanced by a higher level of standardisation. For the railway domain the main issue is about the different standards and infrastructures across the borders of the Member States. This hampers the harmonisation of the different assessment methodologies. Recently, the European Railway Agency approved the application of Common Safety Methods for all the Member States, but these documents are still not consolidated, waiting for feedback and approvals by stakeholders involved in the domain.

The steps of hazards identification, risk assessment and mitigation are usually covered by all the safety assessment methodologies, in all the domains. There are some minor differences for the methods to assess risks, but the overall approach can be considered as quite standardised among the domains. On the other hand, all the four domains present projects focussed on particular methodologies/techniques, fine-tuned to address a specific issue, like for instance tools to support safety assessment, to collect and manage safety arguments in aviation, or technologies for fire safety in road and rail tunnels. These projects could be transferable, provided that the target issue is in common with the other transport mode(s). To summarise the research landscape for this type of projects, the aviation projects tend to tackle new emerging risks and issues, the maritime ones aim to consolidate the current risk assessment practices and make them more effective, whilst road projects address present risks and issues.

The current issues being tackled by research in this area include:

- Independent scrutiny of safety assessments of highly automated systems. Automation is constantly increasing and with it the software components of a system. There are currently no established means to assess the quality of safety assessment activities concerning software.
- Integration of safety assessment and historical data, so as to inform safety assessment processes with past performances. The collection of data has not been standardised yet and the quality could be improved in terms of classification, time window covered, and frequency of collection.
- Harmonisation of reference taxonomies across the different transport modes. One of the long-term goals is to enhance safety in a door-to-door travel, which could include the use of all the four means of transportation. The harmonisation of safety assessment activities (i.e. underlying principles, criteria, taxonomies) could for instance be necessary to set a unique acceptable risk level.
- Development of a safety assessment framework as broad as possible, to include the maximum number of considered hazards and collateral exposures, such as surrounding inhabitants and environment exposure. This increase in complexity can now be managed with modern technologies and software: higher number of hazards does not lead to a more complex evaluation of risks.

Trans-domain policies to support risk assessment for safe door-to-door travels.

Methodologies to address specific issues could be shared across the modes, provided that the issue is relevant for more than one mode.

Success story

SAM

EUROCONTROL Safety Assessment Methodology

Website: **www.eurocontrol.int/articles/safety-assessment-methodology-sam**

SAM was developed by EUROCONTROL to provide guidelines for and standardise safety analysis. The objective of the methodology is to define the means for providing assurance that an Air Navigation System is safe for operational use. It reflects best practices for safety assessment and provides guidance for the production of Safety Cases. SAM presents tools and techniques to perform: Functional Hazard Assessment; Preliminary System Safety Assessment; and System Safety Assessment.

Hints for future research

Need for a **high level methodology** in the road and railway domains, possibly consistent with the aviation experience.

Create **integrated community** of safety practitioners across transport modes, given that all the reference methodologies share a similar approach, in order to increase the level of sharing and comprehension of the obtained results.

Define safety assessment methodologies for **safe door-to-door travels**, to take into account risks in intermodal and connection areas. This will require policies that involve all the transport modes.

Joint initiatives to align all the domains to the same **reference framework**, considering the future need of strong cooperation in case of door-to-door travels.

SAFETY ENHANCEMENT

Projects analysed >

UIC Safety Platform	2TRAIN		
SESAR 16.01.01	SAFETY CULTURE	EVAIR	SKYBRARY
RANKERS	SUPREME	DaKoTa	SAFETYNET
METKU	CAFE	M'AIDER	

Introduction

The importance of safety culture is extensively recognised and acknowledged and a large number of strategies and initiatives have been developed within each transportation domain regarding how to prevent incidents and accidents by enhancing the commitment to safety. All transport modes are working on safety perception, value and promotion, although not all of them reached the same safety culture level in daily operations. Besides, even within the same mode, there are noticeable differences in the safety culture level among the different member states, or among the different industries and market segments. Aviation is unanimously considered the leading domain for safety in complex systems.

A formal and standard Safety Management System (SMS) approach has been adopted by industries in order to achieve an acceptable level of safety. The maritime domain has followed a similar path, with the establishment of the International Management Code for the Safe Operation of Ships and for Pollution Prevention (ISM Code), even if the approach to safety is less harmonised and standardised compared to the aviation domain. On the other hand, railway and road domains are still trying to constitute a common framework at European level to harmonise the different safety initiatives and to uniform data collection in order to identify areas for safety improvement. However, a set of shared and consistent definitions of safety events is still missing (e.g. distinction between incidents and accidents, between incidents and non-relevant events) and this compromises the possibility to develop or adopt tools and methods able to capture this information.

Findings

The approaches adopted in each transport mode to increase their commitment to safety were compared along the following categories: (I) the way each domain is regulated and managed; (II) the regulatory framework and the existing standards; (III) the quality and availability of safety indicators; (IV) the safety culture maturity level. All these aspects impact on the possibility to compare, or cross-fertilise the results and research.

The aviation industry is still considered a forerunner in respect to commitment to safety and safety culture maturity, while maritime is a step backward, moving from a bureaucratic approach to safety culture to a proactive one. Although the implementation of the ISM Code has effectively supported a safety culture improvement, there are still deficiencies in the reporting and handling of near-miss incidents, and in the identification of reliable safety performance indicators. Also, there is a remarkable fragmentation in safety culture maturity between the different sectors of the domain (oil tanker, offshore, shipping). In line with the lack of harmonisation, the lack of international organisations able to push forward the implementation of the current regulatory instruments can play a role in the spotted differences. Audits and management systems are based on certificates and bureaucratic paperwork not necessarily related to the actual purpose of identifying systemic issues and gaps for safety improvement. The general impression is that the implementations of existing regulations fail at some point.

Overall acceptable level of risk or minimum level of requirements for each transport domain could be beneficial.

As anticipated, railway and road domains are intensively working to build a common European framework to harmonise the different safety initiatives, despite a noticeable fragmentation in the definition of safety events. The two domains show different levels of safety culture maturity, with the railway domain maturity assessed at a bureaucratic phase, while the road one is moving towards a bureaucratic approach.

Differently from the others, in the road domain safety is assessed independently for each single system component, with little attention to their interactions. Areas of Safety Culture improvement (especially for rail and road) are:

- Homogenisation of Safety Culture maturity amongst the Member States, industries, or market segments;
- Shift from a “blame-culture” to a “just-culture”, an atmosphere of trust in which people are encouraged for providing safety-related information;
- Identification of indicators able to reflect and evaluate the organisational efforts to raise and maintain the Safety Culture, pro-actively lowering the risks.
- Information systems that facilitate analysis and synthesis of data taking into account accident investigation reports, accident statistics and incident reports.

Finally, effort has to be put into reducing the distance between safety regulators, certification organisations and operators in maritime, rail and road domain. The aviation domain could serve as an example, showing how to coordinate these organisations and enhance their commitment to safety.

Need for shared and consistent definitions of safety events to support and uniform data collection in road and rail domains.

Hints for future research

Enhancement of **Safety Culture** across Europe in the different domains, achieving the same or similar maturity level amongst the Member States, industries and market segments.

Adoption of **common methods and tools** across domains to assess and measure organisational Safety Culture.

Reduce legal and cultural barriers that discourage the **collection and sharing of safety information**, and encourage government organisations to support the development and implementation of sharing information.

Increase **intermodal collaboration** through multi-domain policies that promote the continuous exchange of solutions and lessons learnt at industrial level.

Enhancement of **regulatory systems** to accommodate the new challenges related to **globalisation** and **liberalisation** of markets.

Stimulate common **standards, definitions, and criteria** to allow benchmarking and coordinate efforts across all modes at Supranational level in the area of Safety Culture promotion.

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EXPLOIT SYNERGIES AND OPPORTUNITIES ACROSS TRANSPORTATION MODES THE EXCROSS PROJECT