TRANSPORT SAFETY ORGANISATION
IN PUBLIC AND PRIVATE SECTORS

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The European Transport Safety Council

The European Transport Safety Council (ETSC) is an international non-governmental organisation which was formed in 1993 in response to the persistent and unacceptably high European road casualty toll and public concern about individual transport tragedies. Cutting across national and sectoral interests, ETSC provides an impartial source of advice on transport safety matters to the European Commission, the European Parliament and, where appropriate, to national governments and organisations concerned with safety throughout Europe.

The Council brings together experts of international reputation on its Working Parties, and representatives of a wide range of national and international organisations with transport safety interests and Parliamentarians of all parties on its Main Council to exchange experience and knowledge and to identify and promote research-based contributions to transport safety.

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FOREWORD

This ETSC review on transport safety organisation differs from many of its predecessors. Although it is dedicated to the same kind of *policy-oriented* reviewing process that has framed all former reviews, this review seeks to be more *explanatory* by opening up the “black box” of the organisation of safety as well as safety in organisations. It invites safety experts and policy-makers alike to think beyond the boundaries of their disciplines and policy areas. With a cross-modal, inter-disciplinary perspective on transport safety organisation this review should provide a sound initial reference point for future actions in this area. It is grounded in the conception that safety policies will deliver higher scores if they are able to mobilise their inherent synergies and thus lead to even better safety practice.

Due to its bird’s-eye-perspective on safety policies, this ETSC Review comprises more than the usual number of pages. Instead of simply deleting key points from its four chapters or hiding crucial information in annexes and appendices, the editors have decided to leave the arguments where they belong. Recognising that this kind of comprehensive approach reduces the breadth of potential readers from safety politics and decision-making, they have also invested extra efforts in compiling an executive summary for policy-makers. It is fair to say that these efforts have lead to a convincing translation of academic concepts and arguments into practical policy-recommendations. Consequently for those readers who desire to receive a custom-made overview of the State of the Art of transport safety organisation within the EU, we suggest to read first the Executive Summary and Introduction followed by the Chapter(s) of their choice.

EXECUTIVE SUMMARY

Transport safety, traditionally, is seen a matter of engineering roads and vehicles, trains and aircrafts and their control systems, ships and their navigation, educating users and training experts as well as enforcing laws and regulations. Hence, the three “Es”, engineering, education and enforcing, are generally seen as the three pillars of transport safety policies. Whether they result in successful measures is first and foremost a question of how well they are designed and implemented. But even the most thorough design and implementation of individual engineering, education and enforcement measures is likely to have little impact without appropriate integration. Successful safety polices are then determined by how well this integrated approach is organised. They are essentially a matter of transport safety organisation.

It is therefore that this review is dedicated to the organisational problems and solutions that determine contemporary transport safety policies. The importance of organisational aspects cannot be stressed enough. Only if policy-makers are able to integrate their objectives, strategies and measures are they able to deliver the kind of safety solutions that a highly complex transport system requires. Within this complex transport system integration then is a product of the ability to organise the interplay of key functions such as engineering, education, enforcement and others. In other words, if it is not considered how these key functions impact upon each other, their genuine impact on the level of safety will be much lower than potentially possible.

Consequently, this review seeks to map the various organisational aspects of transport safety and address a number of them more specifically in terms of their role and function within an overall transport safety network. At the core of this network we find an agglomeration of interrelated functions. The most significant of them have been identified in Figure 1, “The Policy Cycle” (see next page).

The illustration in Figure 1 captures the interdependences between specific functions in the shape of a cycle. It thereby suggests that theses functions are often relating to each other in a sequential fashion. One function is followed by another. The cycle is refuelled with the results of the evaluation – starting the process anew. The figure, however, also takes account of the various “non-cyclical” links that exist between the listed functions, as well as those between the functions inside and outside the cycle. Mapping transport safety organisation in such a way reflects a genuine “systemic approach” towards safety. This kind of systemic approach frames the research results presented in this review.

In supporting the Policy Cycle, the notion of a systems approach is pivotal to implement transport safety organisation. It should be realised that, although the various modes comply with this systems concept, these modes have quite a different background regarding their origin, life cycle, design, operations and environment. These differences require a dedicated approach to successfully implement transport safety organisation in each mode. The modes differ with respect to:

- the coupling and interaction between components, life phases and the environment;

- the nature of the hazards and risk involved;
- the speed of technological development;
- the rate of interactions, based on numbers and traffic volumes.

Despite these differences, the modes have common perspectives regarding transport safety organisation. ETSC has highlighted several of these perspectives in its annual Transport Safety Lectures, focusing on visions, targets and strategies (1999), decision-making tools (2000) and independent accident investigation (2001).

Clearly, the cycle is not exhaustive. There are functions, such as the various "post-incident" aspects of transport safety which are left aside. The cycle must be seen as a way to simplify the complex interplay between all functions of transport safety organisation. Only with this kind of simplification are policy-makers receiving the framework within which political action becomes feasible. It transfers the obvious result of a systemic approach, i.e. that everything is related to everything, into a practical approach that identifies key areas for political action.

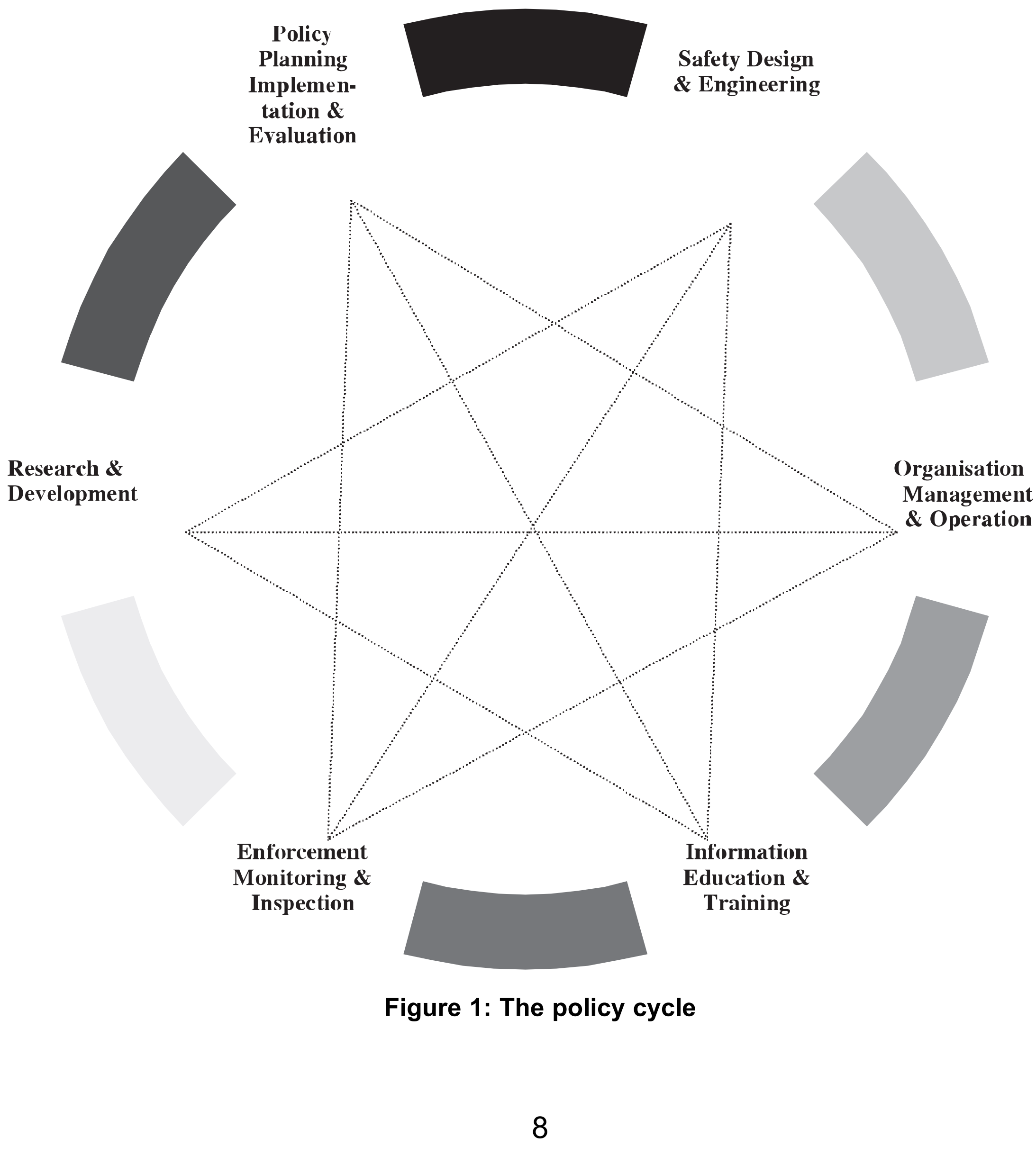


Figure 1: The policy cycle

Apart from leaving aside certain functions, the cycle also lists two very important aspects of safety organisation – safety policy planning, implementation and evaluation as well as enforcement, monitoring and inspection – which are not treated in a separate chapter. A brief overview of these two functions, however, is given in this executive summary. Presenting them at full length, and describing in detail what their features are, would duplicate part of the work published in former ETSC Reviews, such as the recent "Assessing risk and setting targets in transport safety programmes" and the one on "Police enforcement strategies to reduce traffic casualties in Europe" from 1999.

Policy planning, implementation and evaluation

Safety policy planning, implementation and evaluation are generally about the making of (inter-)governmental transport safety policies. They address the key actors of transport safety organisation, i.e. the policy-makers within the bodies of a local, regional, national and supra-national governments. Cotemporary planning, legislation and evaluation processes in transport safety assign crucial importance to the notion of "political leadership". This notion reflects a growing concern about a vanishing political will to implement measures that without doubt will improve the level of transport safety, but are not necessarily receiving widespread popular support (this is particularly true in the case of road design where certain safety measures might be conflicting with other private or public goals). The consequence of viewing the overall State of Play within safety politics in such a way is to call for stronger political leadership – a leadership that grounds itself in democratic processes and is dedicated to improving the safety of all transport users.

The kind of political leadership that governs the planning of transport safety policies, however, depends upon "shared responsibilities". Sharing responsibilities essentially means enhancing the individual responsibilities of all stakeholders. This approach, for instance, is followed by the Commission's 3rd Road Safety Action Programme. The Programme seeks to involve all stakeholders by emphasising their unique responsibilities and competences in key areas of transport safety policy.

The principles of political leadership and shared responsibility are as well central to any implementation process. Based on the setting of challenging, yet achievable targets, a successful implementation comprises a number of tools such as legislation, education, design, etc. These tools require prerequisites. For example:

- Any kind of legislation needs public support and acceptance.
- Law enforcement requires legislation that is clear and easily understandable with little room for interpretation.
- Information requires well-defined target groups.
- Education needs suitable training facilities and well-trained teachers.
- Sustainable road safety requires the qualification and involvement of experts.

Many of the most relevant legislative decisions that frame the implementation of safety policies are increasingly taken on a supranational level. They are based on global and regional agreements between the national governments and other stakeholders that are represented in, for instance, the International Civil Aviation Organisation (ICAO) or the International Maritime Organisation (IMO). In order to ensure that safety policies in all modes of transport are efficiently planned and implemented across Europe it is increasingly important that the European Union establishes itself as a key-actor in these organisations.

Finally, any transport safety policy must be subject to an ongoing monitoring and evaluation process. The success of the different planning and implementation phases of safety policies relies on the availability of appropriate evaluation techniques. Here, again, the visions, targets, sub-targets and performance indicators play a crucial role. They provide for the point of reference that monitoring and evaluation schemes have to take into consideration[1].

To summarise, the three steps of planning, implementation and evaluation undoubtedly simplify the complex process of sharing political leadership and responsibility in transport safety organisation. The virtue of this simplified structure, however, is that it allows a fairly clear identification of the roles of different actors. As a result of this pragmatic approach towards the politics of transport safety organisation the following policy recommendations can be made:

- The responsibility for transport safety should be a shared responsibility.
- The distribution of responsibilities between the actors should be clarified according to their competences and responsibilities.
- The creation and implementation of a policy should be thoroughly planned and should include a well considered target setting.
- Targets should be challenging but still realistic.
- Transport safety policies should make clear the means to reach a target.
- Policies and targets should be constantly followed up, monitored and evaluated.
- Transport safety performance indicators should be widely used in evaluating policies.
- The process and the results of the evaluation should be open and translucent.
- The evaluation should preferably be performed by external resources.
- The evaluation should result in recommendations for improvement.
- The leadership should consider the recommendations and react openly on them.
- The leadership should be responsible for the implementation of accepted recommendations.

To enable all stakeholders and actors to participate in this policy-making process, in particular transparency and independence are important conditions. Throughout the chapters of this review, these two conditions are becoming explicitly visible as leading issues in safety policy making. They are operationalised by instruments such as accident investigation during design and operation, training and education for experts and organisation of research by

[1] For more information on monitoring and evaluation see also the ETSC Review “Assessing risk and setting targets in transport safety programmes”, 2003.

networking, funding and open access to knowledge and data. ETSC has already dedicated a first overview to the instrument of independent accident investigation with the report on “Transport accident and incident investigation in the European Union” (2001).

Having briefly summarised the most important overall aspects of planning, implementing and evaluating safety policies this executive summary now follows the policy cycle clock-wise and turns to the next function, the design and engineering of safety, which constitutes the first chapter of this review.

Safety Design and engineering

Chapter one unravels the role of safety design and engineering in transport safety organisation. It shows that the engineering of technical systems represents the core business of contemporary transport safety policies. The chapter then argues for a better integration of safety design and engineering into the other functions and activities of transport safety organisation. The need for such integration evolves from the changing practices of safety policies, where responsibilities are no longer centrally distributed but equally shared. Here again, emphasis is given to a “systemic approach” towards safety organisation.

Furthermore, this chapter highlights a changing mindset amongst transport engineers. It shows how “safety comes first” and is nowadays seen as a major initial component of any transport system design process, although this approach is less well recognised in the road and maritime modes than in aviation and rail transport[2]. More and more, safety is a function inbuilt into newly emerging transport technologies. It plays an increasingly important role in transport planning and design. This process is reflected by the growing relevance of various impact assessments in transport safety organisation; it is mirrored by the general conception that a transport system has to be adapted to the needs and behaviour of its users in order to minimise safety risks, and it becomes apparent in training and education programmes, for experts and users alike, drawing attention to the importance of safety. Based on this analysis the chapter concludes with a number of recommendations all raising awareness for an integrated and systematic approach towards transport safety organisation:

- Addressing the entire transport system in engineering design. A systems approach has benefited transport safety to a high extent, most obvious in aviation. Engineering design approaches should incorporate higher systems levels and non-technical aspects in all modes of transport.
- Acknowledging different types of potential use. Based on a diversity in rationality, the engineering design process should incorporate users and other operational stakeholders in the design of transport systems. Participative design approaches facilitate user-friendly designs of complex transport systems. To facilitate sustainable and cost-effective countermeasures, the development of a multi-user design interface is encouraged.

[2] The road design process very often has to face competitive goals which may force the designers to develop less safe solutions. As a result we still find high risk sites and conspicuous dangerous road sections in newly built roads. This is why an independent audit has to be organised in the design process as part of a quality management for road safety.

- Cross fertilisation across modes and engineering design schools could provide a most cost-effective option to substantially reduce the overall number of casualties and injuries in European transport systems. Cross-modal disseminating of best practices from engineering design experiences in aviation, shipping and railways towards the road safety system is required.
- Avoiding a lowest common denominator by introducing performance based regulations and transfer of generic scientific knowledge and engineering design principles across domains and modes of transport, such as in the areas of ergonomics, reliability, quality assurance, management, organisation and governance as well as incident handling, rescue, emergency and salvage aspects.
- Establishing an independent quality management for the design of transport infrastructure, such as road safety audits, in order to balance transport safety objectives against other competitive goals.
- Establishing professional and scientific agencies to organise the drawing up of guidelines and issuing of certificates in order to achieve a qualified level of expertise and safety performance throughout the modes of transport. In order to adequately assess the safety performance of a transport system, the assessment should be conducted on the integrated system instead of isolated components.

Organisation management and operation

The second chapter highlights how organisational processes are an intrinsic part of the safety of transport operation within any organisation. Whereas the previous chapter opened up the borders of safety engineering and technical design, this chapter explores the social aspects of safety beyond such borders. It argues that learning from accidents must involve an organisational learning that leads to necessary transformations within the organisation. This, first and foremost, entails that the logic of implementing safety measures must reflect the social dimension of safety. The lack of diagnostic techniques that take account of this social dimension convincingly illustrates how insufficient implementation processes often are.

By addressing this lack of “social thinking”, the chapter translates the systemic approach towards safety into a number of operational measures. It shows that organisational processes concerning planning, internal supply chains, personnel planning and rostering are all directly implicated in the safe functioning of organisations. Moreover, by scrutinising the situational setting in which incidents occur, the chapter highlights the need for thorough organisational changes in response to an accident. This may have far-reaching implications. Examples are contractual relationships, particularly those between prime and sub-contractor, which should be transparently compatible with safety requirements, and enforceable, at all stages of the transport chain. The Chapter leads to the following recommendations:

- Safety is implicated in everything that an organisation does. Safety is an aspect of the system as a whole – therefore a systemic approach to managing safety needs to be taken.
- Organisational processes concerning planning, internal supply chains,

personnel planning and rostering are all directly implicated in the safe functioning of organisations. Critical issues for safety include the effective co-ordination of these functions across organisational boundaries, the provision of feedback and flexibility to meet operational needs and the distribution of decision making to ensure that operational requirements can be fully addressed. The organisation of work, including rosters should respect human characteristics and limitations.

- Transport operations frequently involve the functional co-ordination of several organisations in the same transport system. Safety functions also need to be co-ordinated with specific administrative arrangements to allow a systemic approach to safety to be developed. Where large, often public, transport corporations are broken up, care needs to be taken that the active management of safety is not compromised by substituting formal legal requirements for active management processes, and by undermining a systemic safety management strategy. Contractual relationships, particularly between prime and sub-contractors, should be transparently compatible with safety requirements, and enforceable, at all stages of the transport value chain.
- Many transport operations exhibit a ‘double standard’ of performance in which the official operating or task procedures differ routinely from the way in which the operation is actually carried out. The safety implications of violations of procedures are hard to assess as such unofficial action is not normally open to official scrutiny. Such actions may represent appropriate ways of working or be symptomatic of organisational problems, as well as being implicated in incidents. It is important to find ways to adjust such procedures to actual user needs.
- Organisations are responsible for the transport activities of their staff associated with their work and should take active steps to reduce the risks of that transport activity and to promote safe and environmentally sound travel.
- The need for independent quality and safety systems is well recognised in regulations for the approval of transport organisations. Safety cases provide a more stringent requirement to demonstrate management capability. It is important to ensure that these requirements lead to active management through ‘living’ documents, despite the administrative burden of developing and maintaining them.
- Monitoring the actual operation of a transport operation or its maintenance is a difficult and elusive task, but necessary if the ‘double standard’ of task performance is to be addressed. Systems for auditing organisational processes, which assess their ability to deliver the requirements for a safe operation, need to be developed or adapted from other industries.
- It is also necessary to develop and implement ‘ecologically valid’ methods for auditing and assessing the way in which transport operations are actually carried out. Such systems require trust and the institution of measures to protect crew and operational staff from inappropriate blame and victimisation, if such staff are to be active partners in improving the safety of the operation.
- Incident management needs to be seen as an integrated process which delivers safety improvements in a transparent way. Procedures for reporting incidents need to be strengthened – in particular by making available systems for the confidential reporting of safety issues and events. Investigation and incident management processes need to be strengthened both through the creation of an organisational climate that

fosters learning from in-depth investigation and through the development of professionally competent investigation teams in transport organisations. The transition from recommendation to implementation needs to be examined and strengthened as this appears to be a weak point of the process. Transparent systems for the monitoring and evaluation of the implementation of recommendations from accident investigations should be developed both within organisations and, for public investigations, by national authorities.

Information, education and training

The organisational changes proposed in the second chapter will not happen without appropriate information, education and training programmes able to convey expert knowledge to practitioners and transport users. Consequently, chapter three addresses information, education and training as the three main categories for building a safety culture in and around organisations. The transfer of knowledge from one organisation to another ("Best Practice") is the basis for improving the safety within organisations. The various learning and education processes that are described in this chapter are seen as the prerequisite for sound practice and behaviour, both amongst political-decision-makers as well as transport users. Without the generation and dissemination of knowledge amongst all stakeholders progress will not be possible. In order to ensure such progress, the chapter highlights the role of the European Union in supporting information, education and training programmes for safety experts. Due to their key roles in moving the above cycle of functions around, these experts deserve particular attention. The EU, therefore, should assist the Member States in building the educational infrastructure and competences that are required for maintaining and improving professional safety knowledge. The Chapter leads to the following recommendations:

- In relation to information, education and training Member States should consider to what extent the existing arrangements do fulfil a systemic approach.
- The European Union should act as a catalyst for the enhancement of an appropriate "training" infrastructure.
- The European Union should encourage the establishment of international standards with a generic accreditation and support a harmonisation of standardised qualifications.
- Aspects concerning management, administration and policy are not yet fully developed in each Member State in the educational and training sector. The EU could act as a platform to exchange information and experiences in that field in view of the development of "best practice" guidelines.
- A targeted approach is essential to address the users of the transport system, mostly in the road sector where the majority of the accidents occur. Furthermore, an appropriate communication approach is needed, to improve the effectiveness of the information received by the users. The EU should continue acting as a platform to collect and exchange experiences about effective information campaigns taking into account differences in culture and mentalities.
- School education, especially road safety education, should involve explicit time tabled curricula for each grade. Particularly important topics are

walking to and from school, using school or public transport and training courses for cyclists and light motorised two-wheelers.
- The European Union should encourage the non-governmental sector to participate more actively in the educational process.

Enforcement, monitoring and inspection

While information, education and training are often considered as “soft measures”, enforcement, monitoring and inspection represent somewhat harder instruments to ensure that safety policies and measures have their impact. Therefore, the subsequent step in the policy cycle explicitly lists these three functions. Enforcement, in particular, represents the kind of function that holds the above cycle together: without proper enforcement – and also without monitoring and inspection – useful organisational measures will lose their effectiveness.

The crucial role of enforcement in transport safety organisation has been dealt with comprehensively in ETSC’s review on “Police enforcement strategies to reduce traffic casualties in Europe” of 1999, and will not be explicitly considered in this review.

Research and development

The final function in the policy cycle before it commences again and fourth chapter of this review is the one that addresses transport safety research and development. The chapter emphasises the role of sound data collection and public availability. With due consideration to the very nature of transport safety research as highly interdisciplinary, data on consistently recorded transport incidents should be freely available for independent transport research institutes across the European Union.

Moreover, the involvement of statisticians, doctors, engineers and behavioural scientists in multidisciplinary transport safety research makes it likely that the funding given to independent scientists comes from various private and public sources. The process of allocating funds, however, needs to balance the commercial interests of industries with those of independent transport researchers in terms of disseminating and publicising research results. The chapter leads to six cross-modal recommendations:

- Data should be easily and freely available for use by all independent research organisations.
- The responsibility of collecting the basic police, hospital, and exposure data at the national level should be separated from departments of transport and should be given to either an independent transport research institute, or a national statistical institute.
- In the road sector, at Community level, the EU should embark urgently and vigorously upon a timetabled and fully funded programme to achieve consistency across Member States in recording road traffic collisions involving personal injury, estimating the level and pattern of underrecording of collisions, and estimating the amount of use of the roads, together with the assembly of resulting data from all Member States in a common database accessible to all.

- To encourage independence, research should be kept separate from the operational aspects of transport safety. Research should encompass the evaluation of the operational aspects of transport safety but should remain outside those operations.
- Research findings should be publishable, and published in the open literature. From the organisational viewpoint this should lead to the active support of journals and reports with independent assessment of content from specialists outside of the organisations. At the EU level there is a clear opportunity for such activity to be supported.
- Research aims are best achieved by having independent specialists overseeing the funding arrangements, a multiplicity of research establishments, separation of those establishments from operational agencies, and open, peer reviewed publication of results.

INTRODUCTION

Substantial institutional developments in transport safety are now taking place in Europe. Over the last twenty years responsibilities for transport safety have slowly been spreading from national transport authorities to many other agencies and organisations at local, regional, national, and EU levels.

At the same time, there is new recognition of the need for a systems-approach to safety recognising that combinations of factors come together to cause accidents and injuries which need to be addressed systematically by research-based strategies and countermeasures and by a range of stakeholders.

As part of ETSC's current programme which receives matched funding from the European Commission, the European Transport Safety Council has brought together independent experts from across the EU to review the organisation of transport safety in public and private sectors at national and international level.

The importance of organisational aspects in transport safety cannot be stressed enough. Only if policy-makers are able to integrate their objectives, strategies and measures are they able to deliver the kind of safety solutions that a highly complex transport system requires.

This Review examines some key functions of transport safety organisation in all transport modes and provides some examples of best practice. Section 1 looks at the organisational issues relating to safety design and engineering. Organisation and management issues within organisations such as safety culture and in-house safety policies are considered in Section 2. The need for objective information to create consumer demand for safety and research based information, education and training to create awareness of risks and acceptance of countermeasures are covered in Section 3. Section 4 examines best practice in the organisation of research and development.

Finally, recommendations are made for appropriate national and EU actions in short to medium term.

1 SAFETY DESIGN AND ENGINEERING

1.1 ENGINEERING DESIGN IN SAFETY AND RISK

Introduction

Safety has been a focal point for about 150 years in the design of tools, equipment, vehicles, technological products and processes. Starting in the area of working conditions, labour organisation in manufacturing and transport in the beginning of the 19th century, the issue rapidly spread to other high-tech and high-risk sectors of industry.

During this period, safety in engineering design has been the responsibility of the private sector and engineering departments within governmental agencies, focusing on the design and manufacturing of technical products on a system components level, such as vehicles, aircraft, vessels, roads, railways, (air-)port infrastructure and traffic control. At present, safety also has become a non-technical issue, debated in the public domain, focusing on organisation, management, governance and institutional responsibilities

From an academic point of view, safety has been approached from technological, social, behavioural, judicial and managerial disciplines, each with their own paradigms, notions, methodologies and techniques. Each of these disciplines has fed its expertise and experiences into specific design approaches. At best, the combination of safety and engineering design is defined as an interdisciplinary activity. Present challenges in safety management, organisation, culture and governance, risk assessment methodologies, accident investigation, disaster and crisis management force the safety engineering design community to reconsider the present lack of structure, harmonisation, organisation and training in engineering design at an academic level. Safety in engineering design is now recognised as a strategic issue, integrated in the life cycle of complex systems and related to other primary functions in these systems. An integral safety engineering design notion is emerging in the transport sector, but has not yet acquired a world-wide harmonisation and acceptance.

Four schools of thought

The variety of notions and approaches may be clarified by exploring the various schools of thought, which are available in safety and risk (McIntyre 2000). Safety has evolved as an embedded issue in different domains and disciplines and has a strong practical bias.

Consequently, various 'schools of thought' have been emerging, of which the most important can be categorised as 'Tort Law School', 'Reliability Engineering School' and 'System Safety Engineering School' (McIntyre 2000). In addition a fourth school is defined as 'System Deficiency and Change' (Stoop 2002). Each of these schools represent a different pattern of thinking and can be considered as consecutive, representing the societal and scientific safety concepts of their times. These schools are supported by extensive literature covering a wide variety of domains and scientific disciplines. Each of these four schools of thought has had its influence on the way safety has been incorporated in the engineering design process and has lead to engineering design schools in transport.

1.2 ENGINEERING DESIGN SCHOOLS IN TRANSPORT

In general, for each of these four schools of thought, consecutive safety engineering design schools can be derived.

1. Deterministic engineering design

This school developed from the Tort Law school in safety thinking. It is essentially reactive in its learning potential and focuses on failure modes, identification of failure causes and accident prevention strategies by developing technical design options.

Tort Law

The 'Tort Law School' as defined by McIntyre, has a long history and roots in the U.S. railway industry since the end of the 19th century. It goes back to the introduction of safety engineering design in the railway industry to cope with the carnage among railway workers. Lorenzo Coffin is stated to be the first railroad safety advocate and champion of safety legislation in the USA. He was the first in line of a series of safety advocates, followed by people such as Ralph Nader in the automobile industry or Mary Schiavo in the aviation sector. He had a pioneering voice for the merging of two streams of safety technology and government policy control. Out of this development, an engineering design approach emerged, focusing on certification and standardisation of technical designs and products. This development found its counterpart in 'forensic engineering'. This discipline focuses on technical failure and fact-finding for the benefit of tort and litigation in liability issues concerning accident investigation, mechanical and structural failure of buildings, constructions and products (Carper 1989). Driven by a number of catastrophic events from the sixties to the eighties of the previous century, legislative efforts expanded safety litigation to almost every area from occupational and environmental to product safety, all modes of transportation and other major hazard activities. Moreover, the concept of failure is central to understand engineering, for engineering design has as its first and foremost objective the obviation of failure (Petroski 1992). Lessons learned from disaster can do more to advance engineering knowledge than successful machines or technical designs. Such learning does not only refer to enhancing the safety of design products, but refers to enhancement of the design process as well (Stoop 1990).

Failure modes are established from post-event investigations with a technical-analytical emphasis on the failure of hardware components and the acceptability of mechanical loads and margins. This school focuses on robustness and redundancy of the design product, identifying a performance 'envelope' and quantification of performance standards. On a detailing level of design, an elaborated system has been developed to facilitate compliance with standards by testing, simulation and mathematical modelling of the performance. In practice, quantitative standards for safety performance for almost any system component have become available and certification regimes have been established internationally. Undesirable deviations from operation standards are dealt with by enforcement and education strategies, focusing on the systems level of the vehicle operator. This school has seen widespread application in all modes of transport, supported by encompassing institutional arrangements, such as certification and classification regimes, single accident analysis and forensic engineering. This safety engineering design school has achieved major and sustainable achievements in vehicle design measures, highway and traffic control engineering. Especially in aviation, railways and motorcar design, these strategies have laid the basis for generic engineering design principles such as fail-safe, safe life, crash worthiness, damage tolerance, situation awareness and graceful degradation. Such principles have been focusing on crash protection, casualty reduction and accident prevention. Recently, this school of engineering is expanding its scope beyond certification and standardisation of technical designs and products. It has expanded into the area of safety management, safety auditing and impact assessment techniques after the example of stationary industrial equivalents.

2. Probabilistic engineering design

This engineering design school developed from the Reliability Engineering school of safety thinking. It primarily focuses on the mathematical probability of failure and reliability of the system components performance during the system life cycle.

Reliability Engineering

Reliability Engineering became a new engineering school based on the problems of maintenance, repairs and field failures during the Second World War. In communication and transport, the rapid growth in complexity and automation fuelled the development of sophisticated techniques in probabilistic risk assessment (PRA). The drive to understand the likelihood of hardware malfunctions and errors led to the adoption of PRA in many high-risk industries, among which the process industry and the energy supply sector (McIntyre 2000). After laying a basis for the design of man-machine interfacing in the second World war in the military sector, the ergonomics area rapidly expanded to these industrial domains. It was only a natural development that the focus of mechanical reliability engineering expanded to the area of the human factor, predicting human reliability. Cognitive aspects of human error came to maturity by the work of James Reason, defining and operationalising the concept of human failure. Most recently, the reliability concept is expanded from the technical aspects into organisational aspects of systems. The concept of High Reliability Organisations by Laporte and Normal Accidents by Perrow examined the complex relation between organisational culture and safety.

Originally, this probabilistic concept was developed in non-transport sectors of industry such as hydraulic engineering, process industry and nuclear power supply, but has gained a wide acceptance in the transport industry over the past two decades. In particular the issue of transport of hazardous materials has spread the probabilistic engineering concept from process industry onward. To prevent accidents and damage, potential deficiencies are identified during the design and manufacturing life phases of a product, related to maintenance, availability, reliability and safety of the system and its components. This approach relies on the availability of large amounts of reliable data and data registration systems. This design strategy has primarily been developed from a technical point of view, but has gradually evolved and at present incorporates ergonomics, human factor and organisational aspects, applying cognitive models of behaviour. This school applies a wide diversity of techniques such as RAMS (reliability, availability, maintenance and safety), PRA (probabilistic risk assessment), FMEA (failure mode and effect analysis), human engineering and HRO (high reliability organisations). From a safety perspective, quantification of acceptable risk levels have been defined, such as individual risk levels, risk contours and group risk exposure thresholds. From an engineering design perspective, this school focuses on prevention and deals with risk quantification and generic failure mode modelling.

3. Systems engineering design

This engineering design school developed from the systems engineering in safety thinking. It emerged from aerospace and defence applications and expanded into a wider area.

Systems Engineering

The modern Systems Engineering school developed with the dawn of space transport. This approach focused on accident prevention and was heavily supported by the development of safety standards, specifications and operating instructions. The Systems Safety Concept calls for a systems life cycle safety analysis and hazard control actions from the conceptual phase of a system on into the design, development, manufacturing, construction, operation until modification and finally demolition.

However, this quantification of risk standards raised questions about the acceptability of such risk levels and the application of scientific methods in assessing design consequences. The terrifying accidents in aviation with the crashes of the El-Al 747 freighter in Amsterdam, of the Valuejet, and of the TWA-800 underscored the need to draw a distinction between regulatory compliance for 'certification' and 'safety' when communicating risk to the public (McIntyre 2000).

Based on the analysis of a series of disasters, the sociologist Turner defined disaster not by its physical impact, but by its social impact: a significant disruption of existing cultural beliefs and norms about hazards and their impacts. He introduced the systems concept to sociological analysis of accidents and expanded the technical systems approach into socio-technical systems. An even further expansion of the systems scope of a disaster redefined disaster as 'crisis': unique events, embedded in the social context in which they occur, irrespective of their origin and causation, deprived from their specific (technological) characteristics. The focus shifts from sectoral and technical-analytical towards social-managerial, in which 'crisis' is a 'battlefield of subjective constructions, definitions and feelings, where objective risk analysis and expert based norms do not work any longer' (Rosenthal 1999). As a consequence, causes of accidents may remain obscured or even become irrelevant. The complexity and dynamics is assumed to be so overwhelming, that a shift in focus to administrative responsibilities of national and local authorities is legitimate. This concept implicitly restores the notion of liability and blame.

Demarcation lines between investigating accidents and Parliamentary Inquiries become thin. After a major accident or disaster a Parliamentary or Public Inquiry may be installed to find out what happened, focusing on administrative and policy management responsibilities at a national administrative level, conflicting with objectives of independent investigation agencies.

Especially in the area of high-risk probabilistic attempts to evaluate operational mishaps by predictive analysis failed due to the lack of specific data needed to analyse such mishaps. Unpredictable interactions among an elaborated structure and intricate environmental influences characterise complex systems and modern technology. This school therefore combines deterministic and probabilistic approaches to compensate for methodological shortcomings in both approaches. In particular the domain of low-probability/high-consequence events is not covered by conventional probabilistic approaches. Based on the experiences with a series of major events, this engineering design school evolved from a strict technical intervention in objects and artefacts into incorporating the environmental, organisational, social and societal circumstances within which they operate. Consequently, organisational design, institutional frameworks and a wider operational environment has become the focus of attention for designers of such socio-technical systems. In addition, the interest in the safety performance of the systems components is supplemented by the overall systems safety performance by investigating mishaps and evaluating the quality of the programmed system safety performance (Rimson and Benner 1996).

As a consequence of expanding scopes, attention is also paid to higher order systems levels and post-event consequences dealing with rescue, emergency and crisis management or administrative responsibilities, institutional constraints and policy decision making and policy management issues. Methods and tools of this systems engineering design approach deal with modelling systems and the dynamic interactions with their environment. It focuses on the overall system during all phases of its life cycle and an overall sequence of events such as before, during and after an accident or disaster. Consequently, technical-analytical approaches from the previous schools are supplemented by behavioural, sociological, managerial, decision making and governance policy making methodologies. Risk assessment procedural models are applied, such as Formal Safety Assessment and Safety Impact Statements.

4. Safety deficiency and system change

This school in safety thinking focuses on system deficiency and system change. This engineering design school is in its early phases of development.

System deficiency and change

In addition to the previous three 'schools of thought' a fourth school has emerged during the last decade. Based on the operational experience of Transport Safety Boards throughout the world, a school of 'safety deficiency and system change' is developing. Essentially, this school elaborates on the systems engineering approach and transforms notions from accident investigation experiences into a theoretical framework. In this school the concept of independence is crucial, separating the investigative mission and efforts from allocation of blame and vested interests of major stakeholders. This school also separates the investigations from scientific preferences or biases of a technical, behavioural, organisational or cultural nature. A fundamental issue is how to achieve a neutral and objective analytic result as a basis for safety enhancements. Consequently, this school does no longer focus on 'deviation' from a normative performance, but refers to 'system deficiencies'. It emphasises the need to implement sustainable safety changes in the system rather than issuing recommendations without monitoring their lasting effects (Rasmussen and Svedung 2000). A 'layered' model of the complexity and dynamics of socio-technical systems is being developed (Evers et al. 1994). The focus is on safety critical characteristics in its structure, culture, contents and context with respect to safety critical performance throughout the life cycle of the systems (Stoop 1990). These characteristics can be identified and analysed along the lines of:

- an analysis of the primary processes and relevant actors during design and operation including their safety critical strategic decision making issues. However, such a pro-active encompassing analysis is not always feasible in practice due to the complexity and dynamic nature of transport systems.

Therefore, a second reactive approach is indispensable:

- an in-depth and independent investigation into systemic incidents, accidents and disasters. Such independent investigations may provide a temporary transparency as a starting point for removing inherent deficiencies in such systems.

There is a growing consensus that such – reactive – investigations may require separate institutions with formal and functional independence such as Transport Safety Boards with their own, specific methodology (Van Vollenhoven 2002, Stoop 2002). The concept of independent accident investigation has a generic potential, expanding its application to other sectors outside transport, such as defence, other high-risk industry, natural disasters, threats to health and environment, and major events such as explosions, major fires or the collapse of buildings and structures (IDAIP 2001). The concept deals with an integral safety notion, addressing events throughout their sequence through a multidisciplinary investigation into all causes, before, during and after the event. Consequently, safety enhancement recommendations may cover issues of pro-action, prevention, preparation, repression and after care.

Due to a series of major events in the design, construction and operation of large transport infrastructures in Europe, a new design paradigm is beginning to develop. Based on the experiences with the Channel Tunnel design and certification process in the UK and the international co-operation with French authorities in a partnership relation, safety has been integrated into the design process. Consequently, safety is not only assessed in relation to the safety performance of the product as such, but also to the quality and consistency of the engineering design process itself. This approach is consistent with a more general trend in engineering design methodology to develop dedicated design methodologies focusing on integrating specific aspects in the design, the 'DFX' approach. (Design For X, in which 'X' refers to the specific aspect). The Channel Tunnel is one of the first projects in which a design process management approach was applied, commonly known as a 'Safety Case' approach. Such an approach provides a safety assessment design document as a 'living' document for all system life phases, relating design decisions to operational safety management requirements. This engineering design school is dealing with the participative nature of such major projects, taking into account safety requirements and interests from various groups of stakeholders during normal and deviant operation of the infrastructure. In particular after the major fire incidents in the Alps region, fire fighters and rescue and emergency services have been acknowledged as a new group of stakeholders (Stoop 2003). Certification and performance standard setting for the required operational safety levels is under discussion, bearing similarities with earlier developments in the sixties of the previous century, such as environmental impact statements and ISO 9000 Quality Assurance procedures during design and construct of such infrastructure. In this configuration, transport safety boards may serve as problem providers for the actors responsible for safety throughout the system by disseminating the results of their investigations. As a part of the feedback mechanisms after a major event, guidelines for safe design and operation of major infrastructures are under consideration within the framework of European Directives. This school transforms the closed nature of the engineering design process into a participative, collaborative and open process in which stakeholders are able to express their requirements and new public-private partnership configurations are elaborated (De Bruijn et al. 1998, Leeuwendaal 2001). Such Public-Private-Partnership configurations are established under conditions of an open European competition regarding tendering and contracting of major projects. In such a competitive environment, the pressure to innovate technologically, organisationally as well as methodologically is clearly present. To integrate safety conceptually in such innovative configurations, methods and procedures, however, are not yet developed practically as well as theoretically. At present, best practice and ad-hoc approaches are applied, based on consensus among actors, leading to lowest common denominator types of solutions.

1.3 DEALING WITH CHANGE

The previously described schools of engineering design demand a reflection on new forms of co-operation among public and private partners. Such new forms may require change in organising and allocating safety responsibilities and the development of new safety assessment methods during the engineering design process of transport systems.

Four aspects of change prove to be relevant for such a reflection: the diversity of rationality among partners, changes in allocation of safety responsibilities, changes in the engineering design process itself and the role of technological innovation and conceptual change.

Diversity in rationality

It should be realised that actors involved in new, open and participative methods of safety engineering design may have fundamentally different notions of risk and may apply completely different rationalities (Stoop 1996).

To understand risks and safety issues two different lines of reasoning are available:

- An ‘inside-out’ vision of commissioners, designers, engineers and other actors which have an oversight of structure and contents of complex systems during their design, development and manufacturing. They are capable of defining complex interactions, couplings and causal relations within the system, risk management, mitigation and control included. They are less capable of dealing with the actual behaviour of the system in its dynamic social environment in terms of risk perception and risk acceptance issues.

- An ‘outside-in’ vision of operators, users, risk bearers, regulators, administrators and other stakeholders who have to cope with the system characteristics in their operational environment. They are capable of dealing with global risk notions and causal relations at an aggregated level, but lack a profound insight into the functioning of complex systems. They may concentrate on perception and acceptance rather than controlling risks.

An ‘inside-out’ vision is likely to define risk in terms of a programme of requirements and standards, as a consensus document for the actual design and manufacturing. An ‘outside-in’ vision is likely to define risk in terms of a defined reality among actors, negotiating risk as a ‘social construct’ to achieve consensus on perception and acceptance between stakeholders. If such a consensus is lacking during events with a high social impact such as disasters, a ‘battleground’ situation may occur. In such a situation, safety is defined as a ‘social construct’, leaving only room for a lowest common denominator of safety perceptions.

Changes in responsibilities

Each of the engineering design schools has contributed significantly to the way safety performance has been defined and assessed by public and private partners.

In particular, the roles of the actors and stakeholders in the engineering design, construction and certification of the designs differ across these schools. In the first three schools, public and private partners have clearly distinct roles, separating their responsibilities. These schools see a role for government to supervise and enforce private enterprises in controlling their performance with respect to their engineering design efforts. These schools apply a notion of ‘non-interference’ with private responsibilities in safety and design activities of private enterprises. They only define performance standards without interference within the design process itself.

The deterministic school has assessed safety along two lines: product and type certification, based on quantified performance standards and guidelines for safety design principles. Safety performance standards and design guidelines are supplied by international organisations such as PIANC, PIARC, JAR or CENELEC.

The second school expressed safety performance assessment of design products based on external risk experiences with hazardous materials in the process industry by quantifying risk standards in terms of individual, group risks and threshold values for tolerable risk and failure probability levels. Legal limits are introduced to cover the performance of designs and products.

The third school adds a procedural assurance to the design assessment by defining procedures, drafting documents and in gaining transparency over the process, which has to lead to a safe design or product. Safety Cases and Formal Safety Assessments should guarantee a permanent balance between safety and other design parameters.

The fourth school sees a co-operation and even merging of public with private partners, requiring redefinition of their relations and re-allocation of their mutual responsibilities. A design process integration takes place, in which ‘collaborative’ and ‘knowledge based’ design notions are applied and new areas of expertise are integrated in the design process such as rescue and emergency engineering. This fourth school abandons a prescriptive and quantified system of safety performance standards and focuses on safety assurance by process control and functional requirements, closing the gap between research and practice by integrated project development. A shared responsibility to assure the safety of the integral system in a life cycle approach is favoured, dealing with concepts of ‘value for money’ and ‘risk transfer’ between partners, as demonstrated by the High Speed Line-South railway project in the Netherlands. New approaches regarding ‘design and construct’ for the infrastructure component, ‘service level agreements’ for the infra provider and ‘concession agreements’ for the operators have been developed. DBFM concepts (Build, Design, Finance and Maintain) on development, availability and functional requirements have been explored, supported by system integration, life cycle standardisation and Safety Cases. Finally, insurance companies play a new role in covering a shared public-private liability for major events.

Changes in the engineering design process

Four consequences exist regarding the role of safety in complex systems which may stimulate changes in the engineering design process:

- Safety has evolved from a technology and sector specific activity to a broad umbrella concept. Design of safe systems incorporates also non-technical aspects, higher system levels and participation of lay people and stakeholders in safety critical decision making.
- A shift in focus occurs from the content of safety decision making to the management of the decision making process itself. Engineering detailing, best practices and consensus on acceptability of risk levels and cost-effectiveness of solutions dominate deliberations. In particular during the aftermath of major events a safe design of a socio-technical system may

be subjected to the 'battlefield of disaster' where objectivity and expert judgement fade.

- Dealing with disasters and major events, an integral safety notion is required to comply with demands of rescue and emergency aspects. A gradual upgrading of technical solutions beyond the level of crash-worthiness of vehicles should take place, combined with the development of new principles such as self-reliance of victims and accessibility of disaster sites for rescue and emergency services. In this process, a gradual shift is taking place from vehicle and traffic control system components to infrastructural issues and multifunctional use of the system.
- In discussions on safety and risk, two different rationalities can be acknowledged among stakeholders. In such a debate, a separation exists between decisions on the risk of safety critical decisions on the design of safe systems versus control of safety during operation. In the road transport system this separation is characterised by an error-preventing and forgiving road design versus the traditional exclusive responsibility of the road user. Since development of technology is relatively autonomous, this distinction in rationalities is relevant for safety consequences of technological innovation and implementation of complex systems in their societal environment.

The role of innovation and conceptual change

Common safety issues and engineering design deficiencies are commonly encountered during implementation and social acceptance of major projects in traffic and transport innovation. Rather than applying proven technology and pragmatic improvements on a detailing level, a 'system shift' may be necessary to overcome constraints in system development (Connekt 2001). In the past, such technological innovation and conceptual change has had tremendous impact on the overall system performance and increase in achievable safety levels. Examples are to be found in the transformation from sailing to steam and diesel engines propulsion in shipping, from steam engines to electrical powered locomotives in railways, from propeller driven commercial aeroplanes to jet engines with pressurised cabins in aviation or, in the road sector, from slow to fast vehicles mostly on roads with an unchanged old fashioned geometry but with pavements allowing high speeds. More recent developments are the implementation of ICT applications and telematics in all modes of transport or the introduction of new hybrid construction materials in aviation.

Major issues in various transport systems have led to such high a system pressure that fundamental changes are required. They may be achieved through conceptual change in areas such as inland shipping logistics, dedicated terminals and reversed container logistics in ports, 'free flight' logistic concepts in aviation, spatial planning and urban development with respect to underground structures and multiple land use. To incorporate safety in such conceptual change, it may become necessary to transform safety from an operational cost into a strategic policy making issue (Stoop 2001).

Application of new design approaches such as 'collaborative' and 'knowledge based' engineering is applied in order to overcome deficiencies in existing engineering design processes.

In practice, however, technological innovation may introduce new unforeseen safety issues and side effects. An example of such a situation is given by the introduction of electronics in motor vehicles, causing shortcuts in escape systems during ditching due to which occupants may drown in their cars by blocking electronically operated windows and doors (RvTV 2002).

1.4 CONCLUSIONS

A number of general conclusions may be drawn form this survey on safety engineering design developments:

- The role and impact of engineering design in transport safety has been huge and will remain so because it constitutes the beginning of any transport system at the level of conceptual change and technological innovation. It has led to reduction of casualties, crash protection and accident prevention. Engineering design methods are in a process of upgrading from a technical focus on components towards a systems level, incorporating organisation, management, policy making, risk assessment, institutional aspects and learning in the systems design process.
- Various engineering design schools exist simultaneously and migration of notions and methodologies occurs across domains and disciplines. Dissemination of experiences across transport modes, industrial sectors and system components is taking place. Application of an engineering design school depends on its history in a sector and inherent risks involved in its components, but schools exchange experience across modes or even merge. They are submitted to a dialectic process of improvement.
- Each school has contributed significantly to a sustainable and cost-effective enhancement of safety in transport, by setting standards for performance and quantifying safety levels. At the same time however, the need for avoidance of lowest common denominators and the importance of performance based regulation have been demonstrated, questioning the validity and acceptance of risk levels and biases towards technical aspects.
- Over time and over safety schools, the allocation of responsibilities, functions and roles of private and public partners regarding safety assessment has been shifting from a distributed responsibility to a shared responsibility. This change, from a focus on component responsibility towards an integrated systems approach, poses new demands on the engineering design process and partnership configurations. To comply with these demands, a change of mindset is required in the positioning of safety in the engineering design process: safety comes at the beginning of any transport system design process.
- Harmonisation of notions and a common level of minimum safety performance is emerging. In particular road safety seems to benefit from this dissemination of notions: ergonomics and human engineering/tolerance find their application in the designing of road infrastructure by the notion of which self explaining roads and safety impact assessment techniques are developed. The importance of the role of the EU in vehicle standards and best practice guidelines to aid professionals has been demonstrated.
- Although safety has been successfully privatised in engineering design responsibilities, a harmony should be established between public and private interest in the engineering design process in order to comply with integral safety demands. Examples of how public interests meet private

ones are independent road safety audits of new designed roads and independent safety checks of the existing road network.
- Reconfirmation of the importance of accident investigation and safety board methodology towards system engineering design is emerging. Upgrading from technical-analytical approaches to deficiency identification and system change at a socio-technical level is taking place. Safety boards may serve as problem providers to all those actors which are responsible for safety enhancement.
- At present, there are no engineering design methods available to accommodate safety assessment of technological innovation and conceptual change. In order to accommodate such innovation and change, methods should be developed dealing with impact assessment, adaptation of systems to the nature and needs of users and participative design methods.
- Academic training and education in designing safety into integrated systems should be provided in all design disciplines.

1.5 RECOMMENDATIONS

There seem to be opportunities for enhancing safety by:

- Addressing the entire transport system in engineering design. A systems approach has benefited transport safety to a high extent, most obvious in aviation. Engineering design approaches should incorporate higher system levels and non-technical aspects in all modes of transport.
- Acknowledging different types of potential use. Based on a diversity in rationality, the engineering design process should incorporate users and other operational stakeholders in the design of transport systems. Participative design approaches facilitate user-friendly designs of complex transport systems. To facilitate sustainable and cost-effective countermeasures, the development of a multi-user design interface is encouraged.
- Cross fertilisation across modes and engineering design schools could provide a most cost-effective option to substantially reduce the overall number of casualties and injuries in European transport systems. Cross-modal disseminating of best practices from engineering design experiences in aviation, shipping and railways towards the road safety system is required.
- Avoiding a lowest common denominator by introducing performance based regulations and transfer of generic scientific knowledge and engineering design principles across domains and modes of transport, such as in the areas of ergonomics, reliability, quality assurance, management, organisation and governance as well as incident handling, rescue, emergency and salvage aspects.
- Establishing an independent quality management for the design of transport infrastructure, such as road safety audits, in order to balance transport safety objectives against other competitive goals.
- Establishing professional and scientific agencies to organise the drawing up of guidelines and issuing of certificates in order to achieve a qualified level of expertise and safety performance throughout the modes of transport. In order to adequately assess the safety performance of a transport system, the assessment should be conducted on the integrated system instead of isolated components.

2 ORGANISATION, MANAGEMENT AND OPERATION

2.1 ORGANISATION AND MANAGEMENT OF THE TRANSPORT OPERATION

2.1.1 The role of the organisation in safety

Apart from private car transport, general aviation, and boating for pleasure, the great bulk of transport activity is conducted through the agency of public and private organisations, both large and small. Transport safety is thus not a private matter of the driver or crew of the vehicle but a matter of accountability of the transport organisation concerned and its management system, whether it be a bus or road haulage company, a railway, airline or shipping line. While the driver or crew may be held responsible for their actions in controlling the vehicle, these actions are, to a greater or lesser extent, directed, controlled or managed by the organisations for which they work. The transport infrastructure is also constructed and maintained by organisations – sometimes different organisations to the transport operator. Some transport operations, for example airports, comprise a complex of separate organisations. The principle of organisational accountability is embedded in a wide range of European regulation on safety, including the regulations on occupational safety (which naturally apply to transport operations), the Joint Aviation Regulations of the Joint Aviation Authorities, and the maritime and railways regulations of the different member states. All of these are founded on the premise that in order to protect the traveling public, those who operate the transport systems as well as those who may be affected by transport accidents, it is necessary to regulate and monitor the organisations which conduct the various transport operations. What therefore are the requirements for the safe operation of a transport organisation? When accidents happen, what is the role of the organisation in failing to ensure a safe system?

Major accident enquiries in all transport modes have made it increasingly plain over the last three decades or more that factors deep in the organisation make a decisive contribution to such accidents. It is not possible to understand such accidents without systematically uncovering the chain of causation leading back into the organisation. It is also not possible to know how to prevent such accidents happening again unless we have a clear understanding of how organisations should exercise their roles and responsibilities for safety.

A very wide range of organisational deficiencies have been identified in accident enquiries, many of which occur again and again in different accidents and in different modes. These contributory factors include:

- Lack of sufficient appropriately skilled or qualified personnel to undertake the operation satisfactorily.
- Inadequate systems for personnel planning and rostering, leading, for example, to excessive hours of work or overtime.
- Poor management of parts or equipment leading to the unavailability or poor availability of suitable parts and equipment.
- Inadequate or inflexible planning and scheduling of operations and maintenance.
- Inadequate monitoring of operational performance.

- Inadequate procedures and procedural documentation.
- Routine non-compliance with operational and safety procedures.
- Incompatibility between procedural requirements and normal operational practice.
- Inadequate oversight and monitoring of sub-contractors.
- Lack of feedback of operational problems and safety concerns.
- Lack of response to feedback on operational problems and safety concerns.
- Inappropriate management and investigation of incidents and accidents.
- Failure to implement recommendations from incident and accident investigations and enquiries.
- Management pressures to achieve operational goals.
- Poor risk assessment and management decision making.

Different combinations of these factors have been found in accidents as far apart as the Clapham Junction rail accident (Hidden, 1993), the Hatfield rail accident (HSE, 2000, 2001, 2002), the explosion of the Space Shuttle Challenger (Vaughan, 1990), the sinking of the Herald of Free Enterprise (Sheen, 1987), the Kegworth air accident (AAIB, 1990), the air incident near Daventry (AAIB, 1996), the air accident at Gottrora (SHK, 1993), the King's Cross Underground fire (Fennel, 1988).

Our understanding of the contribution of organisational systems and processes to incident, accident and disaster has been greatly helped by the development of powerful theories, which have drawn from this evidence, from Turner (1978), Perrow (1984), Reason (1990) and Weick (2000). The Reason model has been particularly influential in identifying the latent failures in the organisation which predispose the organisation to unsafe acts, which in turn can lead to human error and system failure. This model also emphasises the defences in the organisation which can interrupt and prevent this probable chain of causation.

2.1.2 Organisational culture and safety

Safety culture concerns the deep and enduring values of an organisation – not only those who conduct the operation itself but also the management and leadership of the organisation. The critical role of leadership in setting the values of an organisation is well recognised. For example, the values of the leadership of NASA were strongly implicated in the decision to launch the Challenger shuttle (Vaughan, 1990); for the UK railways, the core of the whole programme of change is seen to be safety culture (HSE 2002). A comparative study of aircraft maintenance organisations has shown a clear relationship between the leadership values of senior management and the way in which the quality and safety systems of their organisations function (McDonald et al., 2000).

However, safety culture is not just a matter of the leadership of the organisation. In coping with the day to day realities of transport operations, those who drive, pilot, maintain, control, or otherwise conduct the operation of transport develop routine ways of overcoming unexpected problems or delays, learn what to expect or not to expect from their organisations in providing what is needed to ensure that the operation goes smoothly, and get to know what will happen to them if they commit an error which may have serious consequences. Thus, the professional culture of those who work in transport reflects the normal ways in which people manage the constraints in which they operate. For example, for truck drivers, this involves a balance between keeping within the speed limits, violating the drivers' hours regulations in order to get the job done and, if possible, getting back home when the job is finished (Germain and Nierat, 1989). The management culture is equally important. For many transport operations in all modes of transport, those in management grades have either achieved their position through rising from the ranks of operational staff or have been recruited for their technical qualifications. Either way, the fundamental values of management tend to be those of the engineer or skilled technician rather than the manager of people. This means that the quality of management action often leaves a lot to be desired in ensuring that the human side of the enterprise goes smoothly, that the opportunity for error is minimised and that when errors occur the system recovers effectively before serious consequences arise.

Conclusions and recommendations

From all of this, two conclusions stand out.

Virtually all aspects of the organisation and its systems and processes have been implicated in one way or another in the failure to ensure safety. For this reason we cannot regard safety as the province of a separate organisational function that sets standards, monitors and controls – safety is implicated in everything that the organisation does. The critical issue is how the safety requirement influences, or fails to influence sufficiently, the whole range of activities for which the organisation is responsible. Safety is an aspect of the system as a whole – therefore we have to take a systemic approach to managing safety.

The organisational characteristics which are implicated in an accident or disaster are, most often, enduring and persistent characteristics of the organisation, rather than being temporary lapses in otherwise efficient systems. It is the unhappy co-incidence of relatively normally occurring patterns of organisational activity that appears to give rise to the typical system failure. The implication of this is that unless we are able to change these deep-seated and enduring characteristics of organisations, we are in danger of repeating the same general types of accident – the particular circumstances may change but the underlying organisational reality remains the same. For example, the series of accidents in the UK rail system in the late 1990s related to a common set of organisational weaknesses (Health and Safety Executive, 2002) and many of these were also characteristic of the Clapham Junction rail crash two decades earlier. This poses one of the most difficult questions – how is it possible to change organisations so as to improve safety?

For these two reasons this section first considers some of the normal organisational processes which support transport operations and then considers the activities of monitoring, reporting, investigating and improving these processes in the light of evidence which has implications for safety.

2.2 NORMAL PROCESS OF THE ORGANISATION

2.2.1 Planning and co-ordination

Many transport organisations have a traditional organisational structure in which planning is a top down process, with little flexibility to deal with the requirements of the transport operation itself. This is compounded by inefficient supply chains for the resources needed for the maintenance of equipment and infrastructure. Poor systems for manpower planning and for the scheduling of work shifts and rosters can also create bottlenecks of pressure which make the system vulnerable. The result of these problems is that it is the operational staff themselves (crew members, technicans, etc) who have to cope with the particular demands that such deficiencies of planning inevitably bring. These problems can be particularly acute in the maintenance of transport systems where the deficiencies in the system may not be immediately apparent in the transport operation itself. A good example of this type of problem comes from studies of the aircraft maintenance industry (McDonald et al., 2000).

Planning in Aircraft Maintenance

The traditional functional organisation system is horizontally divided between areas of specialisation - engineering, planning, quality, production, finance, personnel and other departments. This tends to dictate a top-down process of planning and organisation. For example, the Engineering Department oversees the higher order and long term planning and produces the maintenance schedule (MS) for each aircraft. The Planning Department receives the MS from the Engineering Department and produces, certifies and dispatches work-packs required to accomplish scheduled maintenance. The scheduling section in the Production Area then receives the work-packs from the Planning Department and further breaks the packs down into the daily work. On completion of the checks on the aircraft the Planning Department then audit and maintain the work-packs and any other records for the aircraft. One consequence of this top-down process is that delays, which are often endemic in such a system, are inexorably fed forward to the next level down, creating great surges of urgent work with little time to prepare. In this kind of system there is no effective feedback loop from the operational areas to the higher functions of planning and scheduling which would enable some of these consequences to be anticipated and ameliorated before they become acute. Similar kinds of problems occur in the supply of spare parts and equipment, where there is a conflict between the convenience and time saving of maintaining a large inventory of spares and the cost of doing this. These systemic deficiencies create the conditions in which it is impossible to fulfil the operational requirement by following standard procedures and in which the operational workforce becomes highly adept in finding ‘work-arounds’ and unofficial practices in order to get the job done.

Some organisations are trying to move to a more process-based organisation that in effect calls for the breakdown of traditional departmental barriers in order to create an overall planning process which is cross-functional. Thus, while engineering, planning and materials departments still exist, the planning process involves the integration of these to oversee the planning of long term and day to day maintenance activities. The planning and co-ordination of daily work take place within production control centres located in the hangars. The make up of the production control centres brings together functions previously carried out in Planning, Materials and Engineering.

Several characteristics are central to improvements in these planning processes. The first concerns the integration of functions in order to support the planning process. This involves some restructuring of organisational departments and their relationships as well as developing better information and administrative systems for the provision of materials, documentation and personnel to fulfil the companies ‘operational requirements’. Critically, this integration of functions, particularly at the operational level, allows for validation of plans, as the people who have first hand knowledge of the operation are involved in monitoring and reviewing the day to day plans. Finally, this results in much more flexibility in the organisation both for higher order planning and for what actually happens in practice.

Here it is evident that the inflexibility of the planning process is partly a consequence of the hierarchical organisational structure with strong functional boundaries between departments. Planning is primarily top-down. There is little opportunity for feedback of operational difficulties, some of which are caused by planning delays. This makes it difficult for the system as a whole to respond flexibly in order to make the operation go smoother. These are typical of the organisational problems which were identified in a number of aircraft incidents investigated by the UK Air Accident Investigation Branch (1992, 1995, 1996).

A general principle is that the organisational structure and the planning and supply processes have to address the realities of the operational level in a flexible way, providing the resources needed and facilitating effective control and decision making. The importance for safety and efficiency of real time co-ordination between planning and maintenance operations functions has been described by Bourrier (1997) in the nuclear power industry. Likewise, the ability of high reliability organisations to adjust their operational decision making according to the operational environment by reconciling a clear chain of authority and accountability with considerable flexibility in distributed decision making illustrates similar principles of organisation design for safe but effective organisations (Grabowski & Roberts, 1996).

Rostering of transport personnel to meet particular operational schedules is another critical planning function for a transport operation which has an important influence on safety. The requirements for a 24-hour operation across great geographical distances mean that the issue of working time is a core problem for the management of safety. In commercial road transport very long hours of work are the norm and there is an extreme demand for flexibility to meet new forms of commercial organisation, like ‘just-in-time’ production systems (Hamelin, 2000). The cumulatively increased risk of accident associated with irregular working patterns, long hours of work and working at night have been demonstrated by Hamelin (1999). Transport enterprises need to counter this risk through the development of more effective management systems to manage fatigue and working time (see ETSC, 2001a; Rosekind et al., 1995; Commonwealth of Australia, 2000).

Recommendation

Organisational processes concerning planning, internal supply chains, personnel planning and rostering are all directly implicated in the safe functioning of organisations. Critical issues for safety include the effective co-ordination of these functions across organisational boundaries, the provision of feedback and flexibility to meet operational needs and the distribution of decision making to ensure that operational requirements can be fully addressed. The organisation of work, including rosters should respect human characteristics and limitations.

2.2.2 Co-ordination between organisations

Many, if not most, transport systems involve the co-ordination of a number of different organisations. Airports are a classic example of this with their combination of airlines, airport authority, air traffic control, maintenance organisations, ground handling organisations, freight handling organisations and others. The lack of common standards of safety or of an integrated framework for the assessment and management of risk has been highlighted in a previous ETSC report (ETSC 1999b). Schiphol Airport provides a good example of an airport authority which has taken a proactive initiative in establishing an integrated safety management system across these organisational boundaries (Hale, 2000). The various organisations located in the airport voluntarily participate in this co-ordinated safety management initiative under the leadership of the airport authority.

A very different set of problems are typical of the relationships between companies in road haulage. Here there is a complex chain of relationships between shippers, prime and sub-contractors in which those at the bottom of the chain are left with the haulage work which requires the most flexibility and which routinely cannot be done without violating the regulations on driving hours. As has been said, the consequences of this are that those with the greatest demands for flexible and irregular work, long working hours and working at night have an increased risk of accident (Hamelin, 2000).

In the shipping industry, complex sub-contracting arrangements are also the norm with similar consequences. The least profitable work is often done under the lowest safety margins. For example, the carriage of heavy fuel oil, which has relatively low commercial value is regularly carried out in tankers nearing the end of their economic lives, i.e. ships which pose the greatest safety risks. Recent examples include the Erika accident in 1999 and the sinking of the Prestige off Galicia in November 2002. Liability for accidents is often dissipated and entirely lost between shipowners, charterers, operators and managers of the vessel in question.

Problems of co-ordination between different public authorities and organisations are also critical to the development and implementation of policy in road transport safety. Different government ministries, state agencies, regional and local authorities all have a role in the planning and implementation of road safety measures, ensuring efficient road maintenance, and auditing the road system, providing safety training and information, monitoring safety levels, etc. The development and implementation of a policy such as Vision Zero demonstrates a 'joined-up' approach to government and administration, integrating requirements of health, justice, environment and industry, for example. This contrasts with a country like Greece which has the lowest level of road safety in the EU, and where the lack of co-ordination and integration of road safety measures undermines their efficiency.

The privatisation of the railways in the UK has been accompanied by the break-up of the former British Rail into a number of separate rail operators and a separate company responsible for the track and infrastructure. The recent enquiry by Lord Cullen following the Ladbroke Grove rail accident examined the role of privatisation in safety and found that while privatisation per se could not be shown to have resulted in a lower level of safety in the industry overall (as the annual accident rate for the industry was improving), the manner in which it had been done had had a number of consequences which had undermined the safety of the system. He cited 'disaggregation' and problems of coordination between the new separate organisations and the loss of an important cadre of skilled and experienced personnel. Furthermore, this enquiry highlighted the endemic problems to do with the quality of subcontractors and their oversight by the main contractor (Cullen 2001). The manner in which the former British Rail was broken up cut across important functional safety relationships, for example between track and operation, which had the consequence of making the co-ordination of these functions difficult and meant that there was an absence of authority to take decisions and make investments which were critical to safety from a systemic point of view (Maidment, 1998). Furthermore, the break-up of the railway into separate commercial organisations was accompanied by the development of formal contractual relations including performance targets with penalties for non-attainment of these targets. While safety was built into these targets, the key performance indicators for safety were less clear and are probably inherently more difficult to specify than operational service targets. Safety thus became relegated to a subsidiary goal as the culture of ensuring performance goals were met became quite dominant (Maidment, 1998; Cullen, 2001).

Dysfunctional relationships between organisations as a source of safety problems have been identified by Wilpert and Falbruch (1998) as a major challenge for contemporary safety management. All of the transport modes exhibit these problems in one form or another.

Recommendation

Transport operations frequently involve the functional co-ordination of several organisations in the same transport system. Safety functions also need to be co-ordinated with specific administrative arrangements to allow a systemic approach to safety to be developed. Where large, often public, transport corporations are broken up, care needs to be taken that the active management of safety is not compromised by substituting formal legal requirements for active management processes, and by undermining a systemic safety management strategy. Contractual relationships, particularly between prime and sub-contractors, should be transparently compatible with safety requirements, and enforceable, at all stages of the transport value chain.

2.2.3 Procedures and practice

In transport operations, standard operating procedures are a core mechanism for ensuring safety. The rule book has governed work in the railway system since the foundation of the railway system in the mid-nineteenth century. Flight operations and aircraft maintenance are equally governed by comprehensively documented standard operating procedures and manuals. Failure to follow standard operating procedures is frequently cited as contributing to major accidents. For example, in the Herald of Free Enterprise accident in Zeebrugge, it was evident that the standard procedures for closing the bow doors were not followed on the occasion in question and indeed were routinely not followed. The Ladbrook Grove Rail accident in the UK involved passing signals at danger. Incidences of signals passed at danger (SPADs) are a frequent occurrence on the railway and are now routinely monitored by the HSE.

Summary statistics suggest that violation of procedures can be cited as a significant contributory factor in accidents and incidents in a broad range of industries. Vienott and Kanki (1998) report that of 83 maintenance related incidents recorded on NASA's Aviation Safety Reporting System between 1986 and 1992, 60% were attributable to deviations from, non-completion and/or misinterpretation of procedures. Because of the voluntary reporting system of the ASRS, it is difficult to relate the reported frequency of procedure violation to what may be the natural frequency of procedure violation in incidents outside the system. Lautman and Gallimore (1988), dealing with pilot error, cite "deviation from basic operational procedures" as the leading cause of the accidents (33%) that they studied. Similarly, McDonald (1996) reports that failure to follow standard operating procedures was a contributory factor in 42% of airport ramp accidents studied.

There is a growing body of evidence to show that these 'violations of procedures' are rarely examples of willful irresponsibility and carelessness by operational staff but are part of a pattern of behaviour which is deeply embedded in the operational system. Unofficial behaviour, which often involves formally violating procedures, is an integral part of any operational system. Some examples of this are given in the following box which demonstrates that minor deviations from procedures are often routine parts of operational practice and sometimes necessary or inevitable responses to unclear or difficult situations.

Violations of procedures

Compared to the expectation that procedural compliance is a cornerstone of safe operations, the evidence suggests that in many industries routine compliance with operational procedures is surprisingly low.

On the basis of systematic observation of a large number of normal flight operations Helmreich (2000) demonstrated a consistent pattern of professional behaviour by civil aviation flight crews. During the normal operation when there is no threat or particular difficulty there is considerable latitude in the range of acceptable behaviour of experienced and professional crews. Procedural deviation and minor errors are quite common and unexceptional. However, when the situation changes to become more difficult or when the level of threat on the environment (from other traffic, the weather, etc.) is elevated then the envelope of acceptable behaviour spontaneously narrows. This has given rise to the interpretation that the critical performance requirement in proceduralised systems is not necessarily following each procedure to the letter, but having good awareness of the situation and being able to recover in a timely and effective fashion from any non-standard situation.

In the aircraft maintenance industry, a rate of non-compliance with procedures in approximately one third of aircraft maintenance tasks was found by Daly et al. (1997). Aircraft maintenance technicians report that they do not follow procedures more often when there are better or quicker ways to do the job and there is a high level of belief that it is important to use one's own judgement and experience rather than just following procedures to the letter. Indeed it is commonly stated that if one follows procedures to the letter the job will not get done on time (Daly et al., 1997). Many examples of procedural deviation can be seen as ways of coping with situations where it is necessary to find some way around a difficult or unclear situation, particularly when the resources of personnel, time or material are severely constrained, due to the planning difficulties mentioned earlier.

In rail operations, passing signals which are signalling danger and requiring the train to stop, is a frequent occurrence. While this was once seen as being simply an instance of driver error and violation of a basic safety procedure, systematic analysis of these SPADs (signals passed at danger) shows that factors such as visibility, conspicuity and situational influences on the driver's attention are important determinants of SPADs (HSE website).

We might conclude from this that for many transport operations there is a kind of 'double standard' – there is an official way in which the task should be done, and then there is the way in which it is actually done. These are routinely different. It is important to see these deviations from official procedures in a systemic context because they are often a response (whether deliberate or unintentional) to deficiencies in the operational system. Because these are violations of rules they are often illegal and thus they cannot be officially admitted even if everyone knows about them. Because such violations are so common but hidden from public scrutiny, when they are implicated in an accident it is very easy to over-interpret the causal contribution of the violation to the accident. These routine unofficial patterns of behaviour are a major issue for quality and safety systems in transport.

In improving safety, it is important to be aware that blaming the individual or exhorting people to follow procedures more closely are likely to be ineffective. On the contrary, it is important to fully understand the context of such behaviour and to change the situation which invites unofficial action which appears to be violating rules and procedures which are supposed to guarantee safety. A large part of this is to develop and adapt rules and procedures so that they do reflect the reality of the operational environment and provide an adequate guide to practice. Too often procedures are written without the benefit of operational experience, reflect an idealised version of what should happen, and are there primarily to provide legal protection to the organisation, rather than as a guide to good practice.

One of the barriers to achieving a solution to the problems of procedural compliance concerns the 'ownership' of procedures. In aircraft maintenance, for example, the basic task procedures are written by the manufacturer and are part of the legal basis by which the national authorities certify aircraft and subsequently audit and assure that approved maintenance organisations are operating according to an appropriate quality standard. The scope, therefore, for any maintenance organisation to improve these procedures in the light of experience is very limited. Manufacturers have procedures for correcting reported technical defects, but tend not to have effective mechanisms for making the procedures more user-friendly. This is a common problem across transport modes. Hale (personal communication) cites the efforts of the Dutch railway organisation to gain responsibility for, and control of, the railway procedures, precisely because this would then enable them to improve their usability. In aviation, with manufacturers serving large numbers of customers worldwide, this may not be an easy problem to solve. But even so this requires a specific process to develop and adjust such procedures in the light of a realistic understanding of user needs (Ward, Corrigan and McDonald, 2002).

Recommendation

Many transport operations exhibit a 'double standard' of performance in which the official operating or task procedures differ routinely from the way in which the operation is actually carried out. The safety implications of violations of procedures are hard to assess as such unofficial action is not normally open to official scrutiny. Such actions may represent appropriate ways of working or be symptomatic of organisational problems, as well as being implicated in incidents. It is important to find ways to adjust such procedures to actual user needs.

2.2.4 Organisational policy on transport safety

Organisations, whether within the transport industry or not, can have an important influence on the activities of their staff which involve both public and private transport. In Sweden, twenty-five percent of the total number of work related accidents leading to fatalities in 2001 took place on the roads. Thus the risks of driving a car or heavier vehicle such as a lorry are not only a road safety problem but also a work environment problem, coming under the responsibility of the Work Environment Authority. Under the work environment legislation, the employer is responsible for systematically surveying, assessing and taking action on risks at work, ensuring that the prerequisites exist to work safely. This includes the requirement to abide by safety regulations in road traffic as regards to speed limits and the right to take breaks, and ensuring that the vehicle is suitably equipped and that alcohol and drugs are not used while driving.

A good example of an organisational policy implementing this principle is the Swedish National Road Administration, which has developed a wide-ranging policy designed to influence staff travel. The policy applies to all trips undertaken on official business. These are required to be economical, safe, environmentally sound and to suit the individual's needs. Emphasis is placed on knowledge about safe and environmentally sound transport. A high personal value is placed on translating this into action so that a good example is set which actually contributes to increasingly safer and more environmentally sound travel. Appendix 1 includes further information about this policy.

Recommendation

Organisations are responsible for the transport activities of their staff associated with their work and should take active steps to reduce the risks of that transport activity and to promote safe and environmentally sound travel.

2.3 MONITORING AND IMPROVING SAFETY

There are three aspects to the monitoring and improving safety of organisations:

- Approving a transport organisation to operate a transport service, or to provide maintenance or other safety critical services (e.g. structural safety checks on ships). The approval is based on the organisation's ability to demonstrate that it has a safety or quality system according to certain requirements.
- Monitoring and auditing the way the system and the operation perform.
- Monitoring how the system responds to accidents and incidents.

The focus of this review will be on the monitoring of the way in which organisations function (or malfunction), and the way in which the operation is actually carried out, rather than on the monitoring of the physical facilities of plant, vehicles and equipment.

2.3.1 Safety and quality management systems and safety cases

Quality and safety management systems have the responsibility for monitoring the safety of the transport organisation and its operation. How well do such systems work and how do they cope with the organisational problems which have been outlined in this section?

One of the core principles of European safety regulation is the independence of the safety management function from commercial and operational constraints. Thus having an independent safety management system with a safety manager accountable to the chief executive is a common requirement of safety regulations. In civil aviation these operational safety functions are included in the requirements for an independent quality system. The following box provides a short overview of this requirement.

Independent quality system

The regulations for European aviation require that commercial airlines and maintenance organisations have a quality system for monitoring the operation. It is a fundamental requirement that this quality system is independent of the operational management of the enterprise and headed by a manager responsible for quality who reports directly to the 'accountable manager' – the person who is nominated as being accountable to the national authority for the safe operation of the enterprise. This quality requirement demands an exposition of all the relevant operational roles and the persons responsible for key functions, together with the set of organisational and operational procedures which govern and ensure that the operation is conducted safely. Internal processes of feedback about quality and safety concerns are also required under these regulations, and all incidents in which safety has potentially been compromised have to be investigated and reported to the authorities. Approved organisations are then subject to a periodic audit by the national authority, acting on behalf of the Joint Aviation Authorities (JAA). The JAA comprises the pooled authority of the National Authorities of the European states. Thus, on paper, there is a strong requirement for all commercial aviation organisations to have, and be accountable for, an internal management system which is responsible for assuring the quality and safety of the operation.

The main focus of this quality requirement is to document the organisational system and its procedures for managing quality and safety. This forms the basis for the national authority to grant the organisation approval to operate. A more stringent requirement is to require the organisation to demonstrate not only that it has a safety management infrastructure but also to show how it will identify the risks and manage the safety critical aspects of its operations. This approach is built around requiring organisations to present safety cases.

In the railway industry, there is a requirement under some countries' regulations (e.g. the U.K. and shortly Ireland) for rail operators to be approved by the national authority through the submission of a 'safety case' which documents all the internal organisational functions which ensure the safe operation of the railway. It identifies and assesses the risks which the operation faces and how they are to be managed. This places a heavy administrative burden on the management of the railway. However, it is essential, if the safety case is to be an effective instrument of management, that it be developed by operational management themselves rather than be delegated to an internal or external consultancy (Maidment, 1998). Amongst the strengths of the safety case system are the requirements to assess risks, which then allows targets and performance criteria to drive management effort. Hale (2000) provides an example of a risk assessment exercise for quantifying the risks to passengers and staff at railway stations in the Netherlands.

For it to work the safety case has to become a ‘living document’ which provides a practical guide to management action and decision making and which will be revised and developed in the light of experience. This is a difficult requirement to fulfil in practice and one of the comments of the Cullen (2001) enquiry was that there was a tendency for the safety case to become more of a bureaucratic exercise than a living document. This comment applies not just to safety case regimes but even more so to any quality or safety management system which places a strong emphasis on documentation, without having to demonstrate that the documentation is a real guide to action and everyday practice.

Recommendation

The need for independent quality and safety systems is well recognised in many regulations for the approval of transport organisations. Safety cases provide a more stringent requirement to demonstrate management capability. It is important to ensure that these requirements lead to active management through ‘living’ documents, despite the administrative burden of developing and maintaining them.

2.3.2 Monitoring the operation

If a transport operation is to demonstrate that its operations are conducted to a safe standard then it should be subject to periodic monitoring or auditing. Such monitoring may require an independent inspection or the certification by approved staff that the operation has been performed correctly and safely. Quality and safety departments employ auditors and inspectors whose job is to monitor that the operation and its facilities comply with the quality and safety standards required. This monitoring activity may also be subject to auditing ultimately by a national authority.

Auditing and inspections concern how the system is monitored. In principle, auditing systems should be able to reconcile how the work is done with how the work officially should be done, and if there is a discrepancy to adjust either the official procedure or the pattern of work, or both. Audits should also be able to assess the systems and processes of the organisation which govern and influence the way in which the operation is carried out.

Audits and inspections tend to focus on those aspects of the operations which can be physically inspected, clearly recorded and documented. Thus, for example, there are European requirements for the inspection of road vehicles, for the inspection of ships in EU ports, and for the certification of airworthiness of aircrafts. Some of this monitoring and inspection activity addresses the conduct of the operation itself, as well as the condition of the vehicle, vessel or aircraft. For example, the tachograph regulations for road transport require the automatic monitoring of a range of vehicle operating parameters including speed and duration of travel. Unfortunately, it is commonly believed that the tachograph records are not a reliable record of the drivers’ hours of driving because they are too easy to falsify (see ETSC report on “The role of driver fatigue in commercial road transport crashes”, 2001). This illustrates the dilemma: the actual operational performance of the system is often the most elusive and difficult to monitor.

To take another example, in aircraft maintenance, the monitoring and inspection processes leading to the certification of airworthiness of an aircraft may either employ systems of independent inspection or 'self-certificaton' (approved individuals signing-off for the quality of the work for which they are responsible). The system relies upon documenting that maintenance work has been done according to the required procedures and standards. These normal quality assurance processes find it difficult to deal with a 'double standard' of task performance. This 'double standard' is when there is a systematic divergence between the way in which things should be done from an official point of view and the way in which they are actually done in order to get the job done and for the operation to proceed as smoothly as possible (see Box on "Violations of procedures"). Quality audits are designed to audit the <u>documented</u> compliance with the regulation rather than directly monitor what actually happens in practice. Hence one can achieve a perfect paper trail of compliance with official procedures but which imperfectly intersects with the real way in which the work is done. Thus normal auditing practice is not very effective in addressing the operation as it actually works, with all the normal deviations, errors, violations and problems of organisation and planning. It rarely captures those unofficial practices and routine organisational failures which are endemic in normal organisational systems. It is these aspects of the system which need to be captured if the system is to be improved and made more impervious to operational failure.

An example of good practice which does address this issue involves a particular model for a naturalistic audit of operational performance which has been developed for flight operations. It is called a 'Line Oriented Safety Audit (LOSA)' (Helmreich, 2000). This audit is based on an independent observer, with a checklist, observing on a selection of normal flight operations and noting errors or deviations from procedures and evaluating how well the crew dealt with the range of situations presenting during the operation – both normal as well as difficult and threatening situations. What is being audited is the operation, not the individual crew, therefore this method of auditing requires special undertakings to preserve the anonymity of the crew and to protect them from disciplinary action (in most circumstances). This is necessary in order to create an environment in which behaviour is as normal as possible, so that the organisation can learn how to improve the functioning of the system from a baseline of what normally happens, rather than from an artificial standard based on what the crew would otherwise be prepared to let an official auditor or inspector see. The LOSA system has demonstrated considerable power in being able to create an entirely new understanding of the role of human error in safety, in which informal practices are opened up to scrutiny for the first time, allowing a productive approach to be taken to improving normal operational procedures. It also recognises that a critical characteristic of professional behaviour is not so much never making an error but being aware and in control of the situation so that one is able to recover from error and manage non-standard situations in a smooth and effective manner. This method of auditing has been recommended by ICAO.

Monitoring and inspection are not only in use for aircraft maintenance but also for railway tracks and the road network. The road safety check for roads in operation is done by authorities, the police and the road administrations. They analyse the accident situation and suggest suitable measures to enhance safety.

Auditing the organisational system

It is also necessary to develop better ways to audit not just the operational part of the transport system but also the management system and organisational processes which direct, control, provide the inputs for and monitor the outputs of the transport operation. Management audit models have been developed for the process industry by Hale and his associates in the University of Delft (Hale et al., 1999). These focus on a number of generic parts of the management system which deliver resources and controls to safety critical tasks in operations, inspection and testing, maintenance and emergency situations. These generic parts include manpower planning, selection and training, motivation, incentives and training, documentation and planning, design and layout, purchase and issue, information and meetings, and policy planning and leadership. This provides a good practice model for the kind of system audit which would also be appropriate in transport operations, but which is not yet common practice.

Recommendation

Monitoring the actual operation of a transport system or its maintenance is a difficult and elusive task, but is necessary if the 'double standard' of task performance is to be addressed. Methods for doing this are being developed in aviation, but these require organisational conditions of trust and protection of operational staff which may be difficult to achieve in other transport modes. Systems for auditing organisational processes, which assess their ability to deliver the requirements for a safe operation, need to be developed or adapted from other industries and applied in transport organisations.

2.3.3 Incidents and their prevention

What happens following an incident in order to prevent similar incidents happening again? The fundamental premise of safety systems is that faults or problems which were implicated in the causation of accidents can be rectified. How well does this actually work? Most attention has been given to the investigation and analysis phase of incident management, to the neglect of a systematic evaluation of the preventive impact of the implementation of recommendations. How well are the human and organisational factors that have been discussed in this review dealt with when they are implicated in incidents? Can the incident management process address the problem of unofficial action? It is important to review the evidence about the effectiveness of each stage of the incident management process leading to the implementation of recommendations.

Confidential reporting

In nearly any organisation or system people often feel reluctant to report their own errors or incidents they have been involved in, even when these could have compromised safety. For this reason confidential incident reporting systems have proved an invaluable avenue for getting into the public domain critical information to improve safety. This approach has been pioneered in aviation through the ASRS (Aviation Safety Reporting System) in the United States and the CHIRP system in the UK. Many other national aviation systems worldwide now have such a system, though as yet there is not a European wide system. It was one of the recommendations of the Cullen (2001) report that such a system be established in the UK railways. The systems in aviation were initiated with a primary focus on reporting by flight crew, but have progressively extended their cover to cabin crew, air traffic control and maintenance. This demonstrates the potential for system-wide coverage which could be generalised to other transport modes.

Achieving adequate recommendations

When an incident occurs the transport organisation which is involved comes under many pressures. Not least, it has to reassure the major stakeholders in the operation (shareholders, national authority, customers, the public) that the situation is being managed effectively and appropriately, demonstrate that it is in control of the situation and demonstrate that measures are in place to prevent a similar incident from happening again. It needs to maintain the continuity of its operation as far as possible, so as to minimise its economic losses. It is also concerned about its potential liability for consequential damages arising from the incident. If the incident involves the active role of people belonging to the company, then the organisation has to decide how to implement its policies in relation to ensuring safety and prevention on the one hand and discipline on the other. The employees involved will be concerned about the consequences of their involvement and how this issue will be managed by the company.

Many organisations find it difficult to separate their incident investigation process from their disciplinary systems. Thus the investigation of human error leading to an incident will inevitably be distorted by attempts to attribute liability to individuals for their actions and by individuals seeking to avoid blame for what may have been a completely unintentional error. Such systems cannot provide an adequate basis for learning how to make the system safer. For this reason many organisations are trying to develop ‘no-blame’ policies or ‘just cultures’ in which innocent mistakes or errors are not punished, reporting is encouraged, so that safety of the system can be improved. The following box provides an example of normal but not very effective practice in relation to how a series of incidents were managed in one company which had developed its own version of a ‘no-blame’ policy for managing incidents. It illustrates the difficulty of finding ways of managing incidents which have a real preventive value. If the organisation is not really learning to be safer, then a lot of organisational effort is going into preserving the status quo.

Incident management

Company X had a series of serious incidents over a relatively short period of time. While the immediate circumstances of these incidents are quite diverse, underlying them all is a common pattern of lack of strict adherence to procedures (either organisational or maintenance manual procedures) and a habitual propensity to adopt unofficial ways of doing things where this allows highly pressured staff to accomplish the task with a minimum of inconvenience and disruption. The company’s response is to temporarily suspend the licences of those directly involved in the incidents. Investigations lead to recommendations for an obligatory half-day retraining session, which emphasises the importance of following procedures. The aviation authorities, notified of these incidents, are concerned with what appear to be systematic failures at the level of the organisation and its management and their ability to ensure a safe system of work. Concern is expressed about the organisation’s culture and it is firmly suggested that something be done to ‘tweak the culture’ in the direction of more active management of this type of problem. Mass meetings of the whole workforce are held in which the chief executive emphasises the fundamental importance of following procedures and stresses the risks to the company and its commercial future if the type of incidents recently experienced is repeated. Deviations from procedures will no longer be tolerated. A management team begin a crash programme of rewriting organisational procedures, which have never been reviewed since the maintenance exposition document was first drafted. This sequence of organisational action has the approval of the National Aviation Authority. It is thus entirely sufficient to get the organisation back on track in terms of the confidence of the major external stakeholders - the authorities and customers - as well as senior management and the directors of the company.

However, it is unlikely that this response will prevent such incidents happening in the future. Nothing has been done to uncover the underlying cause of systematic deviations from procedures or to correct the organisational problems which make such unofficial action a necessary part of getting the job done effectively and on-time. What has been ignored is the systemic basis of such unofficial action - the pragmatic requirement to get the job done safely and well, but on time, when the conditions for accomplishing this are normatively inadequate and where there is little reliance on following documentation. Exhortation or threat will not change these situational demands, nor will rewriting documentation radically change the role of such documentation to make it central to task performance. The organisation has protected itself, while shifting the responsibility to those at the front line of the operation. The cycle of managing these incidents is thus brought to completion without bringing about the prospect of serious change in the underlying dynamic which gives rise to these incidents.

Some transport organisations have a well trained internal safety investigation team who have considerable professional expertise in in-depth investigation, and who will go to considerable lengths to undercover the underlying issues which need to be put right. Even that is often not enough to ensure that effective preventive measures are taken first time. It can take the bitter experience of several incidents before the core safety issues are properly addressed. McDonald et al. (2000) provide a case study which examined a sequence of incidents in the same company over a number of years, in order to understand why the recommendations from earlier incidents were not sufficient to prevent later incidents occurring. This is a critical safety issue which has received very little attention, though the difficulty of implementing safety recommendations is becoming more generally recognised (Carroll, Rudolf and Hatakenaka, 2002).

Response to a series of incidents

A case-study of how one organisation responded to a series of incidents involving what turned out to be a particularly difficult and intractable problem provides some insight on the organisational issues involved in achieving effective recommendations. This case study describes the Air Traffic Accident on 27th December 1991 at Gottrora (SHK, 1993), what had happened previously to that incident, and a similar incident 6 years later. It discusses how the organisation introduced a number of changes as a result of the investigations (McDonald and Corrigan, 1999). The organisation involved had a fully professional team of investigators, who conducted thorough investigations with cogent recommendations. However succeeding incidents demonstrated the inability of previous recommendations to prevent the occurrence of succeeding incidents. Tracking each succeeding incident and the associated recommendations can be seen as a gradual progression from developing solutions which are technically adequate (but where the implementation has not been really thought through) to solutions which take into account the realities of the operation as they occur on a day to day basis, and actively involve operational staff in actually formulating such recommendations. Thus even when accident and incident investigations are good at diagnosing what went wrong in the sequence which led to the incident, they do not necessarily lead to actions which are effective in preventing similar incidents happening again. It can thus take a series of incidents to achieve an adequate solution.

Many transport organisations do not have such a sophisticated safety analysis system as the airline involved in the above case. Here such organisations have to go through a much more difficult process of learning the lessons from their incidents – a problem that is as well evident for road administrations.

Implementing recommendations

There is very little information in the public domain about the implementation of recommendations from major accident enquiries – were the recommendations implemented, were they effective in addressing the causes of the accident, are we sure that similar incidents have not occurred which call into question the preventive value of the measures taken? The latter was precisely the question posed by the Ladbrook Grove rail crash in the UK in 1999. How far had underlying factors, which had been shown to contribute to the Clapham Junction rail crash nearly twenty years previously, persisted in the railway system and contributed to the Hatfield crash? One of the outcomes of the recent series of accidents in the UK railways has been the establishment of a consolidated record of all the recommendations from the relevant enquiries, grouped according to their functional area. This has enabled a public and systematic process of monitoring of the implementation of the recommendations by the Health and Safety Executive. Each recommendation is labeled as closed if the action has been taken and concluded to the satisfaction of both the company and the authority, left open if the company believes sufficient action has been accomplished but the authority is not yet satisfied, or if neither party is satisfied that the action has implemented the recommendation. Such a system does not appear to exist in other transport modes.

Recommendation

Incident management needs to be seen as an integrated process which delivers safety improvements in a transparent way. Procedures for reporting incidents need to be strengthened – in particular by making available systems for the confidential reporting of safety issues and events. Investigation and incident management processes need to be strengthened both through the creation of an organisational climate that fosters learning from in-depth investigation and through the development of professionally competent investigation teams in transport organisations. The transition from recommendation to implementation needs to be examined and strengthened as this appears to be a weak point of the process. Transparent systems for the monitoring and evaluation of the implementation of recommendations from accident investigations should be developed both within organisations and, for public investigations, by national authorities.

2.4 OVERVIEW OF RECOMMENDATIONS

- Virtually all aspects of the organisation and its systems and processes have been implicated in one way or another in the failure to ensure safety. Thus, safety is implicated in everything that the organisation does. The critical issue is how the safety requirement influences, or fails to influence sufficiently, the whole range of activities for which the organisation is responsible. Safety is an aspect of the system as a whole – therefore we have to take a systemic approach to managing safety. The organisational characteristics which are implicated in an accident or disaster are, most often, enduring and persistent characteristics of the organisation, rather than being temporary lapses in otherwise efficient systems. This poses one of the most difficult questions – how is it possible to change organisations so as to improve safety?

- Organisational processes concerning planning, internal supply chains, personnel planning and rostering are all directly implicated in the safe functioning of organisations. Critical issues for safety include the effective co-ordination of these functions across organisational boundaries, the provision of feedback and flexibility to meet operational needs and the distribution of decision making to ensure that operational requirements can be fully addressed. The organisation of work, including rosters should respect human characteristics and limitations.

- Transport operations frequently involve the functional co-ordination of several organisations in the same transport system. Safety functions also need to be co-ordinated with specific administrative arrangements to allow a systemic approach to safety to be developed. Where large, often public, transport corporations are broken up, care needs to be taken that the active management of safety is not compromised by substituting formal legal requirements for active management processes, and by undermining a systemic safety management strategy. Contractual relationships, particularly between prime and sub-contractors, should be transparently compatible with safety requirements, and enforceable, at all stages of the transport value chain.

- Many transport operations exhibit a ‘double standard’ of performance in which the official operating or task procedures differ routinely from the way in which the operation is actually carried out. The safety implications of violations of procedures are hard to assess as such unofficial action is not normally open to official scrutiny. Such actions may represent appropriate ways of working or be symptomatic of organisational problems, as well as being implicated in incidents. It is important to find ways to adjust such procedures to actual user needs.

- Organisations are responsible for the transport activities of their staff associated with their work and should take active steps to reduce the risks of that transport activity and to promote safe and environmentally sound travel.

- The need for independent quality and safety systems is well recognised in regulations for the approval of transport organisations. Safety cases provide a more stringent requirement to demonstrate management capability. It is important to ensure that these requirements lead to active management through ‘living’ documents, despite the administrative burden of developing and maintaining them.

- Monitoring the actual operation of a transport operation or its maintenance is a difficult and elusive task, but necessary if the ‘double standard’ of task performance is to be addressed. Methods for doing this are being developed in aviation, but these require organisational conditions of trust and protection of operational staff, which may be difficult to achieve in other transport modes.

Systems for auditing organisational processes, which assess their ability to deliver the requirements for a safe operation, need to be developed or adapted from other industries.

- It is also necessary to develop and implement ‘ecologically valid’ methods for auditing and assessing the way in which transport operations are actually carried out. Such systems require trust and the institution of measures to protect crew and operational staff from inappropriate blame and victimisation, if such staff are to be active partners in improving the safety of the operation.

- Incident management needs to be seen as an integrated process which delivers safety improvements in a transparent way. Procedures for reporting incidents need to be strengthened – in particular by making available systems for the confidential reporting of safety issues and events. Investigation and incident management processes need to be strengthened both through the creation of an organisational climate that fosters learning from in-depth investigation and through the development of professionally competent investigation teams in transport organisations. The transition from recommendation to implementation needs to be examined and strengthened as this appears to be a weak point of the process. Transparent systems for the monitoring and evaluation of the implementation of recommendations from accident investigations should be developed both within organisations and, for public investigations, by national authorities.

3 INFORMATION, EDUCATION AND TRAINING

3.1 INTRODUCTION

Information, education and training aim at raising awareness of safety, at changing behaviour and at preparing professionals and safety-related persons to cope with safety problems. To this effect, different groups of stakeholders must be considered:

- Opinion formers and politicians;
- Experts, i.e. engineers and designers, and
- Users of the systems (e.g. pilots, drivers, general public).

Besides these levels, the role of the non-governmental sector in promoting safety and in supporting the measures in the field of implementation of education and training is crucial.

Before a safety problem can be effectively addressed, it needs to be described and understood. Transport safety organisations, institutions, experts and interested users have to get across:

- The sheer scale of the problem in statistical and epidemiological terms.
- The source and nature of injuries and how they can lead to permanent disability.
- The tragic waste, particularly of young lives, and the amount of working life lost.
- The huge socio-economic cost.
- The fact that there is a huge gap between what is known and what is implemented.

3.2 ADDRESSING DECISION MAKERS

Awareness of the problem needs to be raised not only amongst individual users but also amongst policymakers who are responsible for the safety of the transport system as a whole and who aim at achieving a balance between safety, mobility and environmental objectives in transport policy.

In this respect, the non-governmental sector plays an important role in providing impartial advice on transport safety policies:

- Helping to raise awareness and understanding of the crash injury problem.
- Identifying and actively promoting effective measures for the benefit of all transport system users, unbiased by commercial or any other sectoral interest.
- Implementing, where appropriate, effective safety activity as part of a strategic plan.

With the help of the scientific community, the medical profession, victims' groups, consumer and user groups and the media, the non-governmental sector has to bring forward the need for action to the wider community and to policymakers. Furthermore it has to find ways to ensure that the consequences of transport crashes are studied until understood.

One measure of the usefulness of non-governmental organisations, especially in the road safety field, is how well they achieve this. Soft options are easy to promote and resources to support them are not difficult to find. It is tempting to be drawn into issues that will excite the press or other mass media but which are not necessarily important from a casualty reduction point of view. Safety organisations really have a responsibility, in dealing with the media and in the identification of priorities, to differentiate between the issues that really matter and those which make good copy or require least effort.

It is also important for this sector to take a broad view of all the strategies which can achieve casualty reduction. In addition to crash prevention, managing exposure to risk, reducing injury in the event of a crash, and post impact care are all key strategies and need to be used more.

In presenting the safety case, it is necessary not to think only about what works, but also to demonstrate its value for money and its general public acceptability. It is important to get across the message that, for example, the road using public does care about crashes and support more intervention as indicated in the Sartre Survey in 1998 which, for example, found that:

- 81% of those questioned supported an EU zero alcohol level for new drivers;
- 70% were in favour of more traffic law enforcement;
- 57% supported in-car devices to prevent exceeding speed limits.

The right of road users to make demands for safety in the transport system should be promoted and should apply to services and products. In various fields of transport, stringent demands are made in procurement for certain environmental criteria to be complied with. Similar demands should also be made with regard to transport safety, in particular for transport purchased with tax revenues.

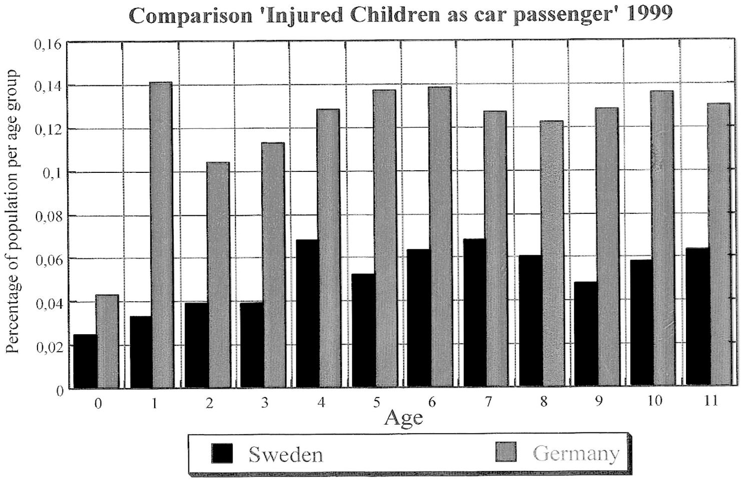
Research and experience worldwide show that measures such as seat belt use and helmet use, vehicle crash protection measures, reducing drinking and driving through publicity and enforcement activity, reducing vehicle speeds through area-wide 30 km/h speed zone engineering and camera technology and measures to reduce crashes at high risk sites have probably the largest influence on reducing casualties. These should be at the top of the wish list of every organisation concerned with road safety.

In the longer perspective, all purchasing of transport should include demands for the supplier to guarantee that transport takes place in a safe vehicle, airplane or ship, and that the user of the system is well-trained, sober, and respects traffic and transport rules. Information and training should also be developed in such a way that they lead the users of the transport system to make demands for safety. The following box shows a “good practice” example from Sweden.

Creating Demands in Sweden

Very few children under three years of age die in road accidents in Sweden. This is because they sit rearward facing in a childseat. If the equipment is correctly mounted, practically all children survive. The few fatalities that occur are due to objects penetrating the car.
It is, however, still incredibly difficult to get other countries to fully apply the “Swedish model”. This is probably due to cultural resistance, effectively supported by a car industry that considers that children should sit in the back seat.

This graph compares the situation between Sweden and Germany. At the age of one year the Germans switch from a rearward- to a forward-facing child seat for their children. This situation is similar in most of the EU-countries



NTF, Folksam, and VTI are examples of three actors who demand that children sit in a rearward-facing position in cars up to the age of four-five years. This would require children to be seated on the front seat, which in turn would necessitate the car industry to solve the problem of the front airbag on the passenger side in relation to the use of child restraints.
Full use of a rearward facing system for children up to four-five years of age would mean implementing the Zero Vision in this area. It is unrealistic to expect help from legislation and evidently, it is also extremely difficult to obtain full acceptance of an additional moment in EuroNCAP which would speed up this development. If the car industry were forced to take responsibility for children being able to sit rearward facing up to four-five years of age, the technical solution would be achieved very quickly.
If one cannot obtain assistance either from legislation or from the car industry, implementation must take place with the aid of consumer demands and this can be done with the aid of effective influencing of public opinion.

A “bad practice” example, to illustrate the importance of the responsibility towards safety by political and/or administrative decision-makers on one side and the need for user demands on the other, is given by the campaigns encouraging speeding instead of road safety in Athens, Greece.

Public authorities promoting wrong driving behaviour in Athens, Greece

With the opening on 2003 of 13 more kilometres of the Athens ring road motorway, the Road Authority (Concessionaire) launched a large scale campaign for the promotion of the new motorway, with the main message being “covering 30 kilometres in 14 minutes” (=128.5 km/h), i.e. with an average speed much higher than the motorway speed limits (120 km/h outside built up areas and 100 km/h inside built up areas). With the opening of the first 17 kilometres, Public Work Authorities were also promoting a similar message “covering 13 kilometres in 6 minutes” (= 130 km/h). In both cases, the new motorway, which is a much safer road environment, is not exploited for the promotion of a safer driving behaviour and one of the rare opportunities for substantial change in driver behaviour is lost.

3.3 TRAINING OF ACADEMICS AND RESEARCHERS IN TRANSPORT SAFETY

To practice a profession as a safety and risk expert is an activity that has to be learnt. An inventory among various application domains in safety and risk shows a number of issues dealing with training safety and risk experts.

These issues can be subsequently categorised as:

Practical

- There are only few formal courses available for safety and risk training and safety management responsibilities. Such courses are currently only offered in specific sectors of industry and public governance.

- Only few institutes can offer a broad range of courses and can rely on experienced and motivated teachers with experience in these activities. In addition, only few individuals possess a combination of practical, broad-based experience, pedagogical instinct and skills to conduct the training.

- Academic courses focus on substantive aspects within their own specific professional domain and have generally little practical applicability.

- Specific industrial training institutes do not have the resources or the time to develop and train safety and risk experts.

- On a national level, there are too few students to justify the production of general training courses. Consequently, training focuses on specific expertise and applications on demand basis.

Differences in context

- There are substantive differences per country, discipline and sector. There are no international standards with a generic accreditation and no or hardly any arrangements are available to harmonise or standardise qualifications.

- There are differences in national training institutions and training and education infrastructure. Each country in the EU has a specific national or industrial background.

Substantive diversity

- Regarding a technical-analytical approach, a fair harmonisation of methods and techniques has been achieved. There is little development in the technical-analytical area, a dissemination of techniques is taking place from specific high-technology niche markets into more general applications. Risk and safety notions from various high-tech sectors are more and more applied in other sectors.

- In the area of human factors and organisations, theoretical development is almost completed. The ‘James Reason‘ school has become dominant. A translation and implementation from theory into practice is taking place. Many safety and risk experts, however, do still lack practical skills and a uniform interpretation of the human factor during their professional activities.

- Factors concerning management, administration and policy are not yet fully developed. Scientific theoretical developments are ongoing, and a variety of preferences for multiple theories exists (such as learning organisations, safety culture, change management or participative decision-making in network configurations). Practical applicable methods and techniques are not generally available or are only founded on a single theory or experiences within a single domain. Theoretical models and normative notions seem to be dominant.

The current supply in training courses is mostly sector-specific and provides in-depth expertise on specific subjects. Although training institutes may provide courses on an academic level, they very frequently have a commercial basis and are not formally connected with academia. Consequently, best practice approaches and ad-hoc post-event training seem to dominate the commercial training market. Only recently has training by academia been initiated at a post-doc training level. Specific courses are on the market, dealing with occupational safety and health issues, crisis management, risk decision making or other specific academic aspects of the risk and safety spectrum.

An example of experts' training is given by the Swedish maritime pilots.

Good practice in training safety experts — Swedish maritime pilots

A pilot is used for guiding an arriving vessel in a safe way from sea to port through a marked fairway. The pilot should be seen as an advisor to the ship's master.

Training of new pilots

Pilots are employed and trained by the Swedish Maritime Administration (SMA). A new pilot is educated in the fairways belonging to the maritime traffic area where he is employed. This takes between 0.5 to 5 years depending on the status and the amount of fairways. During this time, the pilot works together with an experienced pilot. Besides this practical training there is a four week introduction programme starting with two weeks of information and training in the head office and practicing at a simulator installation owned by the SMA. This is followed by a 3.5 day BRM-course (Bridge Resource Management) where the pilot is trained within the following areas:

- Attitude and management skills
- Cultural awareness
- Communication and briefings
- Short term strategy
- Authority and assertiveness
- Management style
- Workload
- State of the bridge
- Human involvement in errors
- Judgement and decision making
- Emergencies and leadership
- Crisis and crowd management
- Automation awareness

Finally there is a five day course in Ilawa, Poland, where pilots are trained in manoeuvring different types of vessels during different weather situations.

Recurrent training programme

In order to keep up the competence there is an extensive programme supplied by the SMA which consists of the following courses and practices:

Every second year (compulsory)

- Fire-protection and fire-fighting
- CPR
- Handling of personal and system security equipment

Special courses (as required)

- Supplementary course in Ilawa, Poland, for five days where the use of tug boats is practiced and exercises in current water, handling of stress and other exercises are carried out.
- A BRM-refreshment course for 1.5 days covering a follow-up of the pilot‘s own experiences since the first course, refreshment of the knowledge of the earlier course, studies of accidents and near-accidents and course evaluation.

Special courses (for different categories of pilots)

- General operator‘s certificate (marine radio communication). This certificate must be possessed by pilots that are piloting in open-sea and by pilots functioning as “On Scene Co-ordinators” in case of a search and rescue mission.
- SAR-G (10 days) and SAR-OSC are courses within the field of search and rescue: the former is a basic course and the latter is for the above mentioned co-ordinators.
- VTS (Vessel Traffic Services)-Course for pilots serving in a VTS-centre.
- Course in open-sea pilotage.
- Handling of electronic nautical charts in pilotage.

Other courses (for the above mentioned co-ordinators)

There are some other courses that are optional but can be attended by most pilots. These are, for example, basic computer courses and language courses.

In the road sector, an example of good practice in the training of safety experts is provided by the German road safety auditors[3].

Good practice on training road safety experts – German Road Safety Auditors

Road Safety Audit (RSA) is a formal systematic road safety assessment of road or road scheme carried out by an independent, qualified auditor or team of auditors who report on the project’s accident potential for all kinds of road users. The purpose of RSA is to focus on the road infrastructure to ensure that all road schemes function as safely as possible and that the road users are exposed to a minimal risk of accident.

Road standards are a very important tool and a reference for the designer and the auditor. But Road Standards are more or less on a balance between considerations of road safety,

[3] It needs to be noted that also some other EU Member States carry out safety audits on their roads.

accessibility, environment and economy. Standards may not always be up-to-date. That is why the auditor must go beyond the standards to make a qualified assessment of the road safety aspects.

This quality management for a safer road design is spreading out all over the world. There is a RSA-Manual of Austroads (Australia/New Zealand). Malaysia is working with an own Manual. In Europe, the UK, the Netherlands and Denmark have developed their own RSA manual. Moreover, in October 2003 the British Highways Agency will present the new Road Safety Audit standards. However, in most of the other European Countries RSA has not yet been introduced.

The German Ministry of Transport (BMVBW) recommended in 1999 to study and evaluate the suitability and feasibility of road safety audits by an ad-hoc working group of the German Road and Transportation Research Association (FGSV). The working group finally presented a road safety auditing procedure.

The main structure of German audits is as follows:

-Checklists for Motorways, Rural Roads, Urban Main Roads and Urban access Roads;
-Audit Reports in four phases of planning (initial planning, initial design, detailed design, before opening);
-Decisions of the Road Administration about suggestions of the Audit report;
-Training and Exchange of experience;
-Evaluation of the reports for better training, qualification of the standards and possibly legal activities.

Characteristics of the checklists:

-Function of the road	-Characteristics of design and operation
-Design of cross sections	-Lining
-Intersections	-Road furnishings
-Roadside plants	-Bridges
-Railway crossings	-Bus stops
-Help for pedestrians' and bicycles' crossing	-Parking, delivering of goods

A curriculum has been developed by the Institute for Road Traffic in Cologne (ISK) of the German Insurance Association (GDV), in cooperation with BAST, the FGSV and the Universities of Weimar and Karlsruhe, covering all necessary topics to be mastered by qualified road safety auditors (with university qualification in civil engineering). The curriculum itself is made up of 6 phases and will range over a period of 6 months. The phases are:

-Phase 1	Qualification seminar/basics	(1 week)
-Phase 2	Project task for rural roads	(4-6 weeks)
-Phase 3	Qualification seminar/presentation of project tasks/site visits, etc.	(1 week)
-Phase 4	Project task for cross town links	(2-3 weeks)
-Phase 5	Training programme/accompanied auditing	(8-12 weeks)
-Phase 6	Final discussion/certification	

Regarding the needs in the field of training of experts, the following aspects can be seen as questionable and should be tackled:

- There is a frequent need for training novice safety and risk experts in view of the oncoming European Directives on safety and risk and the growing interest in risk and safety throughout industrial sectors and public governance.

- A growing interest exists to participate in training courses by industrial parties, governmental agencies and by academia.

- Substantive as well as managerial expertise and skills are required, distinguishing between generalist and specialist qualifications.

- At present, there are only a few training opportunities available which meet the demands of system complexity, using interdisciplinary approaches or quality demands on professional performance standards.

- Commercial institutes may have the flexibility, focus and quality which enable them to meet training needs much more rapidly and efficiently than academia, but they are likely to lack methodological basics and general applicability of their notions and approaches.

3.4 ADDRESSING THE USERS

Information, education and practical training are essential to acquiring the attitudes, skills and knowledge needed for safe road use, from childhood through to old age. They have an important role to play in achieving:

- Increased awareness about crash risks;
- Increased understanding and acceptance of the need for road safety measures;
- Transference of safety skills.

In the field of road transport, traffic safety education is a task that belongs to public responsibilities. However, even if the responsibility for road safety education lies in the public sector, the private sector should be involved to strengthen the outcome of the educational process by supporting the implementation of educational programmes.

Education and training are not only for the young: they also have a role to play for experienced road users, for example for those who have committed particular traffic offences or whose changing capabilities require new skills and strategies to cope with daily traffic. Users of the roads today have to cope with increasingly complex demands of the system, and there are limits as to what road safety benefits should be expected from education and training without appropriate urban safety planning and management and without a target-group oriented approach which takes greater account of the capabilities of the users, particularly those who are most vulnerable: children and the elderly.

Generally speaking, a target-group-oriented approach is known and practised in most of the European countries. The implementation of road safety programmes dedicated to pre-scholar and school children and their parents is mostly carried out by voluntary organisations which are often supported by private companies and institutions. The following box gives an example of a programme dedicated to pre-scholar children.

Organisation of education and training measures for children

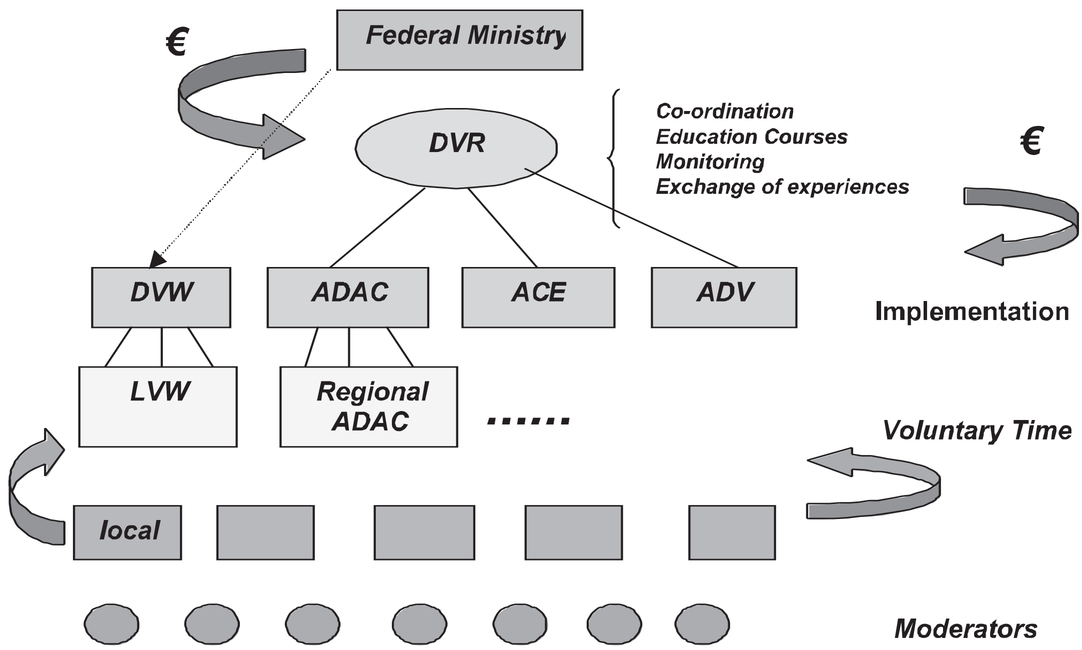
Children typically begin to use roads as pedestrians at kindergarten age. The same holds true for the use of cycles (mostly for play, but also near roads). The age distribution of pedestrians and cyclists involved in crashes shows the relative importance of these types of risks for children (for pedestrians, risk is greatest at age 6 to 8, for cyclists at age 11 to 14).

For the organisation of the pre-school children education, different actors, which have a strong influence in the development of the children and their safety, have to be considered:

- the parents and carers
- the kindergardens and nurseries

In Germany, the implementation of the pre-scholar road safety education programme "Child & Traffic" is a good example of the joint effort undertaken by the public and the private sector. During its 20 years of existence the programme has contributed to the reduction of child fatalities from 883 in 1981 to 232 in 2001 in the age group of under 15 year-olds.

"Child &Traffic"
Pre-scholar Education Programme



The German Road Safety Council (DVR) has the task to co-ordinate the implementation which is carried out by its member associations. "Moderators", who have been given special training, carry out events for parents of pre-school children all over Germany, focusing traditionally on "Children as pedestrians" and "Children as bikers". The moderators receive a public funded compensation for their own engagement per event. Moreover, they obtain flyers and brochures free of charge to disseminate to the parents.

With support obtained from the Federal Highway Research Institute, the contents of the programmes and their structures have been submitted to scientific evaluation. This evaluation process has led to a complete restructuring of the programme. Not only the monitoring of the programme was reconsidered, bus also the media and the training of the voluntary moderators.

The following box, on the other hand, gives an example of road safety education within the school system.

Organisation of road safety education within the school system

Best practice in road safety education in school for ages of up to 10-12 involves explicitly timetabled curricula for each grade. Education should impart both knowledge and age-related practical training in road use in active co-operation with children's families. Particularly important topics are:

- Walking to and from school (safer routes, dangerous crossing situations, safe play);
- Using school or public transport (behaviour and risks at stops and during travel);
- Programmes for cyclist training.

Well established programmes for cyclist training are offered in different countries, with target ages ranging from 8 to 12 years, in some cases influenced by national rules about on-road cycling. Best practice training schemes comprise:

- Combinations of theoretical and practical training ending with a cycling test of theory and practice, with a clear understanding that attendance at the training and success in the test do not in themselves make children competent to cycle on the roads; and
- Learning conditions including training areas at first, and later on real traffic situations.

In many countries cyclist training is performed by school teachers in close co-operation with the local police. The latter can be necessary for training in real traffic situations. In addition, the participation of the private sector in the educational work is a catalyst for its implementation. An example of this catalyst function and the integration of the private sector in the educational process at primary school level are the road traffic schools in Germany, which have existed since 1949. Initiated by the Shell Company, which provides bicycles, helmets and other educational materials, the children road safety schools were developed in co-operation with the school authorities and the police, and provide both theoretical and practical training for children aged between 8 and 11 years. Although the participation in road safety education was initially optional, the system of road safety schools now forms part of the official road safety education programme of the Federal States and is jointly run by Jugendwerk Deutsche Shell, school authorities, police and voluntary road safety organisations at local level. The training and examination of bicycle skills thus has a recognised place in the curriculum for the 3rd and 4th primary school level. Road Traffic Schools supported by Shell are now established in many countries around the world.

The condition or prerequisite for an objective-oriented traffic education of children and youngsters is the relevant preparation and instruction of the teachers in this particular subject. The necessary instruction measures would have to form an integral part of the basic and advanced training of the teachers.

Training of teachers

In Spain for example, a long-distance course "road safety education" was developed for teachers by the University of Salamanca in co-operation with the Dirección General de Tráfico which allows a broader dissemination of knowledge about the matter among teachers. This way of organising advanced studies can be very successful by using new communication media such as the Internet.

Finally, it is worth noting that in several European countries the traffic safety education does not experience continuity at the secondary school level. Particularly during the period before obtaining the driving license, young persons should obtain all relevant information needed to promote a safe behaviour as future vehicle drivers. The educational system, therefore, plays an important role and, even if the obligatory school assistance has finished, means of targeting this road user group (e.g. via vocational schools) are needed. Furthermore, new communication forms, such as computer-based technology, should be used much more widely in order to support the dissemination of knowledge.

3.5 CONCLUSIONS AND RECOMMENDATIONS

- In relation to information, education and training Member States should consider to what extent the existing arrangements do fulfil a systemic approach.
- The European Union should act as a catalyst for the enhancement of an appropriate “training” infrastructure.
- The European Union should encourage the establishment of international standards with a generic accreditation and support a harmonisation of standardised qualifications.
- Aspects concerning management, administration and policy are not yet fully developed in each Member State in the educational and training sector. The EU could act as a platform to exchange information and experiences in that field in view of the development of “best practice” guidelines.
- A targeted approach is essential to address the users of the transport system, mostly the road sector where the majority of the accidents occur. Furthermore, an appropriate communication approach is needed in order to improve the effectiveness of the information received by the users. The EU should continue acting as a platform to collect and exchange experiences about effective information campaigns taking into account differences in culture and mentalities.
- School education, especially road safety education, should involve explicit time tabled curricula for each grade. Particularly important topics are walking to and from school, using school or public transport and training courses for cyclists and light motorised two-wheelers.
- The European Union should encourage the non-governmental sector to participate more actively in the educational process.

4 RESEARCH AND DEVELOPMENT

4.1 INTRODUCTION

This section deals with the conditions and organisational structures which are likely to encourage good research and development in transport safety. The main focus is on the road safety aspects because this is numerically the most important, the most complex and the most fragmented of the travel modes. Some lessons can be drawn, however, from the organisation of the other modes.

4.2 RESEARCH AND DEVELOPMENT IN THE ROAD MODE

4.2.1 General principles governing good research

There are some underlying principles which apply to all research regardless of the subject:

1) Good research flourishes when data is freely and easily accessible.

2) Plurality of research organisations encourages cooperative programmes and stimulates the dissemination of knowledge.

3) An open peer review process is essential for high quality work. The wide and open dissemination of results is important.

4) Separation of the research and evaluation functions from the operational aspects of (transport) management gives independence and legitimacy to the R&D process.

5) Multiplicity of funding of R&D from several government agencies and commercial interests aids independence.

6) Effective policies at EU, national and regional levels (in transport safety) can only be based on sound, science-based solutions, which in turn must be founded on legitimate research. Research is fundamental to identify emerging problems, quantify them and suggest countermeasures.

Given these general principles this section addresses some of the current R&D issues in transport safety.

4.2.2 Database development

Among the countries of the EU, data collection systems on transport deaths and injuries vary in quality and have limited compatibility. Deaths in all transport modes are counted reasonably well, but underreporting of casualties and varied definitions of levels of severity make cross-country comparisons difficult (ETSC 2001). There is no adequate EU database to give an overall picture of the extent and nature of road transport casualties.

The CARE programme is an attempt to address this issue but although currently functioning, its usefulness is severely hampered by the restrictive policies for access by the national authorities, whereby most leading road research institutes in the EU are not allowed to use the data.

In virtually all countries of the EU transport casualty data are collected by the police and compiled and controlled within Ministries of Transport. Such data is often not easily (or freely) available to researchers outside of government. There is very little routine linkage of hospital and police data although some pilot projects are currently underway.

Given that such overall epidemiological data on the nature and quantity of traffic injuries within the EU should be the bedrock of much research and consequent policy development, it is extraordinary that such data and its access should be so restricted.

Elsewhere in the motorised world such data is freely available. In the United States for example the FARS and NASS CDS systems can be researched freely by anyone with an interest. The development of those databases has had a profound beneficial effect on the quantity and quality of traffic safety research in that country.

A second general limitation of national and EU mass databases is a major absence of control data. Without such information exposure measures of risk are impossible. This is not just a matter of estimations of vehicle kilometres travelled per year, but exposures in various traffic environments for all classes of road users.

Beyond mass data there are many other data sources useful for traffic safety research. Insurance data, fleet data, specific clinical hospital data are such examples. In addition, in-depth multidisciplinary research linking vehicle/medical/highway/behavioural areas is underway in a small number of European institutes. Such work has been extremely useful in evaluating countermeasures in the past but is absent from the research programmes in many EU states.

There are therefore many opportunities for useful research if better databases were developed. This would best be progressed with the following organisational changes:

- At the national level, separate the responsibility of collecting the basic police, hospital, and exposure data from departments of transport and giving that function to either an independent transport research institute, or a national statistical institute.
- Make such data freely available for use by all independent research organisations.
- At the EU level, the EU should embark urgently and vigorously upon a timetabled and fully funded programme to achieve consistency across Member States in recording road traffic collisions involving personal injury, estimating the level and pattern of underrecording of collisions, and estimating the amount of use of the roads, together with the assembly of resulting data from all Member States in a common database accessible to all.

Given that data and its use is absolutely fundamental to good research, reducing the inadequacies of the current data collection structure would have a major impact on transport safety research.

4.2.3 Independence and funding

Transport safety research is not a subject which fits within traditional subject boundaries. It bridges civil and mechanical engineering, medicine, psychology and economics. As a result it has no long term history but had its origins in the interests of separate, isolated individuals - statisticians, doctors, engineers, and behavioural scientists. In an institutional sense transport safety research in universities has been negligible until the last two decades.

As a result most early transport safety research was conducted within government agencies, usually subsets of Ministries of Transport. Thus, the public sector had a monopoly on such research, with a tendency to internalise the results and keep all policy consequences to themselves. Such a structure is not conducive of active, high quality research.

The UK case

An exception to this exclusivity of transport safety research being within Ministries of Transport was the situation in the UK in the period before 1970.

At that time most of the public money going to research was channelled through research councils, the Science Research Council and the Medical Research Council being two of the most important. Research priorities and funding were set by independent specialist committees composed of academics, industrial representatives and government officials. The research in transport safety was mainly conducted by the Road Research Laboratory, but funding also went to universities and other research groups. In the early 1970s however, the government of the day decided that because the Department of Transport was the main user of the research findings it would be better if the RRL was integrated into the Department. Funds were therefore removed from the research councils and given to the Department of Transport under this consumer/contractor principle.

This approach had a malign influence over transport safety research. The Department contracted little research outside itself, published little of its results in open, peer reviewed literature, strictly limited access to national databases and used its own organisation to evaluate the effectiveness of its policies.

This policy was reversed in the late 1980s when transport research (including safety) was hived off into a separate agency and subsequently into an independent research company, the Transport Research Laboratory Ltd.

As such, after a period of preferential treatment, the TRL now has to compete with other organisations for government funding, although by virtue of its size and competencies it still gets the majority of Department of Transport research funds. This organisational change has led to an expansion of research in the academic arena as well as other commercial consulting companies, and a general growth of interest and activity in transport safety research.

A superior organisational structure to encourage independence in research is to keep it separate from the operational aspects of transport safety. Research should encompass the evaluation of the operational aspects of transport safety but should remain outside those operations. Research should also of course seek out new countermeasures and aim to develop new knowledge about the nature and origins of traffic crashes and injury.

These aims are best achieved by having independent specialists overseeing the funding arrangements, a multiplicity of research establishments, separation of those establishments from operational agencies, and open, peer reviewed publication of results.

With the development of the EU, there are major opportunities for independent research at the EU level with major efficiencies from the pooling of resources of member states. However, it is vital that the basic principles outlined above about transparency and competency are met at the international level. An EU transport safety institute could fill such a role if structured appropriately.

4.2.4 Commercial interests

An increasing amount of research in the EU is being conducted within the private sector, either within industries such as the car manufacturers and first tier suppliers, or by consulting firms with special expertise. Such organisations themselves are also funding research. Particularly with industries which have a commercial interest in the consequences of traffic safety research there are clear potential conflicts of interest. However, such problems can be minimised by early contractual agreements which specify independence to the researcher over the methodology and the publication of results. The appointment of an independent assessor to the process can be advantageous to both sides, but the ultimate requirement is that the research findings should be publishable, and published in the open literature.

A more difficult issue is the commercial sponsorship of relatively closed end research. The word research is attached to activities which are more aligned to marketing. Such second level research may be of use to the sponsor but has little intrinsic value to the outside world. However, plurality in research, and more research activity, even with tolerance of second order work, is to be preferred to a public sector monopoly.

Ultimately open publication through the peer review system is the best guarantee of research quality. This is especially important with information explosion on the Internet, and the corresponding opportunity for second level work to be publicised.

4.2.5 Dissemination of research findings

From the above it is clear that all organisations have an interest in the widespread and active dissemination of peer reviewed, high quality research findings. From the organisational viewpoint this leads to the active support of such journals and reports, with independent assessment of content from specialists outside of the organisations. At the EU level there is a clear opportunity for such activity to be supported.

4.2.6 Research and policy formulation

Transport safety is a science. Sound policies are based on known, effective, science-based countermeasures, which in turn are grounded in good research. Hence an active research environment is absolutely fundamental to the development of transport safety policy. The underlying principles are multiplicity in funding of research, plurality in research organisations and free exchange of data and results. Hence the formation of policy by organisations at regional, national and EU levels should have open access to research results but be detached from the research providers. Similarly the evaluation of the results of policies should rest with the research organisations, not with the operational agencies.

The organisational consequences of these principles lead to the strengthening of independent research establishments, programmes to encourage collaborative research between those establishments, the greater use of outside specialised assessors.

4.3 MULTIMODAL RESEARCH AND DEVELOPMENT

This section has focused mainly on the road sector because of its great numerical importance. Synergies between the road and the other modes of rail, air and marine exist in research. Such examples are in the development of accident and exposure databases, and in the technologies of event recorders (such as devices which record crash characteristics) and in accident investigation techniques. Between marine, rail and aviation there are significant opportunities for collaborative research on these and other areas, but such synergies are harder to see between the road and the other modes.

However, cross modal collaboration on specific advances such as data recorders holds promise and open research publication helps that process.

Collaborative research on crash investigation techniques is an area where more specific benefits will arise, particularly by applying the techniques of aviation to rail and maritime accidents. Some types of road accidents, particularly those involving large commercial vehicles, coaches, hazardous materials, and a large number of vehicles in a single event, would also benefit from cross modal analysis. This leads to the need for greater collaboration between accident investigation agencies at national and international levels.

4.4 RECOMMENDATIONS

- Data should be easily and freely available for use by all independent research organisations.

- The responsibility of collecting the basic police, hospital, and exposure data at the national level should be separated from departments of transport and should be given to either an independent transport research institute, or a national statistical institute.

- In the road sector, at the EU level, the EU should embark urgently and vigorously upon a timetabled and fully funded programme to achieve consistency across Member States in recording road traffic collisions involving personal injury, estimating the level and pattern of underrecording of collisions, and estimating the amount of use of the roads, together with the assembly of resulting data from all Member States in a common database accessible to all.

- To encourage independence, research should be kept separate from the operational aspects of transport safety. Research should encompass the evaluation of the operational aspects of transport safety but should remain outside those operations.

- Research findings should be publishable, and published in the open literature. From the organisational viewpoint this should lead to the active support of journals and reports with independent assessment of content from specialists outside of the organisations. At the EU level there is a clear opportunity for such activity to be supported.

- Research aims are best achieved by having independent specialists overseeing the funding arrangements, a multiplicity of research establishments, separation of those establishments from operational agencies, and open, peer reviewed publication of results.

5 RECOMMENDATIONS

Safety policy planning, legislation and evaluation

- The responsibility for transport safety should be a shared responsibility.
- The distribution of responsibilities between the actors should be clarified according to their competences and responsibilities.
- The creation and implementation of a policy should be thoroughly planned and should include a well considered target setting.
- Targets should be challenging but still realistic.
- Transport safety policies should make clear the means to reach a target.
- Policies and targets should be constantly followed up, monitored and evaluated.
- Transport safety performance indicators should be widely used in evaluating policies.
- The process and the results of the evaluation should be open and translucent.
- The evaluation should preferably be performed by external resources.
- The evaluation should result in recommendations for improvement.
- The leadership should consider the recommendations and react openly on them.
- The leadership should be responsible for the implementation of accepted recommendations.

Safety Design and engineering

- Addressing the entire transport system in engineering design. A systems approach has benefited transport safety to a high extent, most obvious in aviation. Engineering design approaches should incorporate higher systems levels and non-technical aspects in all modes of transport.
- Acknowledging different types of potential use. Based on a diversity in rationality, the engineering design process should incorporate users and other operational stakeholders in the design of transport systems. Participative design approaches facilitate user-friendly designs of complex transport systems. To facilitate sustainable and cost-effective countermeasures, the development of a multi-user design interface is encouraged.
- Cross fertilisation across modes and engineering design schools could provide a most cost-effective option to substantially reduce the overall number of casualties and injuries in European transport systems. Cross-modal disseminating of best practices from engineering design experiences in aviation, shipping and railways towards the road safety system is required.
- Avoiding a lowest common denominator by introducing performance based regulations and transfer of generic scientific knowledge and engineering design principles across domains and modes of transport, such as in the areas of ergonomics, reliability, quality assurance, management, organisation and governance as well as incident handling, rescue, emergency and salvage aspects.
- Establishing an independent quality management for the design of transport infrastructure, such as road safety audits, in order to balance

transport safety objectives against other competitive goals.

- Establishing professional and scientific agencies to organise the drawing up of guidelines and issuing of certificates in order to achieve a qualified level of expertise and safety performance throughout the modes of transport. In order to adequately assess the safety performance of a transport system, the assessment should be conducted on the integrated system instead of isolated components.

Organisation management and operation

- Safety is implicated in everything that an organisation does. Safety is an aspect of the system as a whole – therefore a systemic approach to managing safety needs to be taken.
- Organisational processes concerning planning, internal supply chains, personnel planning and rostering are all directly implicated in the safe functioning of organisations. Critical issues for safety include the effective co-ordination of these functions across organisational boundaries, the provision of feedback and flexibility to meet operational needs and the distribution of decision making to ensure that operational requirements can be fully addressed. The organisation of work, including rosters should respect human characteristics and limitations.
- Transport operations frequently involve the functional co-ordination of several organisations in the same transport system. Safety functions also need to be co-ordinated with specific administrative arrangements to allow a systemic approach to safety to be developed. Where large, often public, transport corporations are broken up, care needs to be taken that the active management of safety is not compromised by substituting formal legal requirements for active management processes, and by undermining a systemic safety management strategy. Contractual relationships, particularly between prime and sub-contractors, should be transparently compatible with safety requirements, and enforceable, at all stages of the transport value chain.
- Many transport operations exhibit a ‘double standard’ of performance in which the official operating or task procedures differ routinely from the way in which the operation is actually carried out. The safety implications of violations of procedures are hard to assess as such unofficial action is not normally open to official scrutiny. Such actions may represent appropriate ways of working or be symptomatic of organisational problems, as well as being implicated in incidents. It is important to find ways to adjust such procedures to actual user needs.
- Organisations are responsible for the transport activities of their staff associated with their work and should take active steps to reduce the risks of that transport activity and to promote safe and environmentally sound travel.
- The need for independent quality and safety systems is well recognised in regulations for the approval of transport organisations. Safety cases provide a more stringent requirement to demonstrate management capability. It is important to ensure that these requirements lead to active management through ‘living’ documents, despite the administrative burden of developing and maintaining them.
- Monitoring the actual operation of a transport operation or its maintenance

is a difficult and elusive task, but necessary if the 'double standard' of task performance is to be addressed. Systems for auditing organisational processes, which assess their ability to deliver the requirements for a safe operation, need to be developed or adapted from other industries.

- It is also necessary to develop and implement 'ecologically valid' methods for auditing and assessing the way in which transport operations are actually carried out. Such systems require trust and the institution of measures to protect crew and operational staff from inappropriate blame and victimisation, if such staff are to be active partners in improving the safety of the operation.
- Incident management needs to be seen as an integrated process which delivers safety improvements in a transparent way. Procedures for reporting incidents need to be strengthened – in particular by making available systems for the confidential reporting of safety issues and events. Investigation and incident management processes need to be strengthened both through the creation of an organisational climate that fosters learning from in-depth investigation and through the development of professionally competent investigation teams in transport organisations. The transition from recommendation to implementation needs to be examined and strengthened as this appears to be a weak point of the process. Transparent systems for the monitoring and evaluation of the implementation of recommendations from accident investigations should be developed both within organisations and, for public investigations, by national authorities.

Information, education and training

- In relation to information, education and training Member States should consider to what extent the existing arrangements do follow a systemic approach.
- The European Union should act as a catalyst for the enhancement of an appropriate "training" infrastructure.
- The European Union should encourage the establishment of international standards with a generic accreditation and support a harmonisation of standardised qualifications.
- Aspects concerning management, administration and policy are not yet fully developed in each Member State in the educational and training sector. The EU could act as a platform to exchange information and experiences in that field in view of the development of "best practice" guidelines.
- A targeted approach is essential to address the users of the transport system, mostly the road sector where the majority of the accidents occur. Furthermore, an appropriate communication approach is needed, to improve the effectiveness of the information received by the users. The EU should continue acting as a platform to collect and exchange experiences about effective information campaigns taking into account differences in culture and mentalities.
- School education, especially road safety education, should involve explicit time tabled curricula for each grade. Particularly important topics are walking to and from school, using school or public transport and training courses for cyclists and light motorised two-wheelers.

- The European Union should encourage the non-governmental sector to participate more actively in the educational process.

Research and development

- Data should be easily and freely available for use by all independent research organisations.
- The responsibility of collecting the basic police, hospital, and exposure data at the national level should be separated from departments of transport and should be given to either an independent transport research institute, or a national statistical institute.
- In the road sector, at the EU level, the EU should embark urgently and vigorously upon a timetabled and fully funded programme to achieve consistency across Member States in recording road traffic collisions involving personal injury, estimating the level and pattern of underrecording of collisions, and estimating the amount of use of the roads, together with the assembly of resulting data from all Member States in a common database accessible to all.
- To encourage independence, research should be kept separate from the operational aspects of transport safety. Research should encompass the evaluation of the operational aspects of transport safety but should remain outside those operations.
- Research findings should be publishable, and published in the open literature. From the organisational viewpoint this should lead to the active support of journals and reports with independent assessment of content from specialists outside of the organisations. At the EU level there is a clear opportunity for such activity to be supported.
- Research aims are best achieved by having independent specialists overseeing the funding arrangements, a multiplicity of research establishments, separation of those establishments from operational agencies, and open, peer reviewed publication of results.

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APPENDIX 1: ORGANISATIONAL POLICY ON TRANSPORT SAFETY: THE SWEDISH NATIONAL ROAD ADMINISTRATION

A1.1 TRAVEL POLICY

Scope

The travel policy applies to all trips undertaken on official business and paid for by the Swedish National Road Administration. Any deviation from this policy can be made only by decision of the Director-General.

Responsibility

It is the responsibility of every individual employee to arrange his/her official business travel in a way that is economical, safe, environmentally sound and which suits his/her personal needs.
The heads of division are responsible for drawing up a uniform application of the policy for their staff, detailing how travel is to be conducted in order to ensure the fulfilment of the policy requirements. This will be based on the particular conditions existing within each division.

Efficiency

Business trips shall be undertaken in the most cost-effective way possible, taking into consideration the individual employee's needs and ability. This demands travel planning so that the needs of the individual and the operations can be co-ordinated and fulfil the requirements on efficient travel.

Safe and environmentally sound

Business trips shall be arranged in a way that is as safe and environmentally sound as possible. The responsibility for the road transport sector assigned to the Swedish National Road Administration means that the Administration is required to induce other players to assume their own responsibility in this respect. It is therefore very important that we can show the way by setting a good example. This is ultimately a question of credibility.

Knowledge

An awareness shall be developed about how each and every one of us can contribute to safe and environmentally-sound traffic through our own actions in different situations.

Valuation

Everyone working at the Swedish National Road Administration shall learn to place high value on safe and environmentally-sound transportation. It is equally important to understand the power of setting a good example, meaning that we all can contribute to the fulfilment of the Swedish National Road Administration's goals on road safety and the environment through our own actions.

Actions

When we plan and make trips, our actions are to be a tangible demonstration of our knowledge on the subject. Our ambition shall be to make travel increasingly safer and more environmentally sound. The basis for this work is the different prerequisites behind the various activities in which we are involved.
In preparation for every trip, the different alternatives for making it as efficient, safe and environmentally sound as possible are to be investigated. Where there is a conflict between these objectives, a balance must be made based on local conditions. However, road safety and environmental aspects can require having to make sacrifices, sometimes at the expense of efficiency.

A1.2 REQUIREMENTS CONCERNING EFFICIENT, SAFE AND ENVIRONMENTALLY-SOUND TRAVEL

The following is a short guideline for the work on applications of the travel policy within the various divisions of the organisation, with examples of the requirements that can be placed on planning and conducting official business trips so as to be able to satisfy the requirements in the travel policy.

Work method

It is presumed in the travel policy that each division will elaborate applications that describe in closer detail how travel will be planned and conducted in order to satisfy the demands of the policy.

Minimum requirements:

One exception is the minimum requirements regarding rented cars, company cars and private cars used regularly for business trips.

Knowledge and values

It is the intention of the policy that action be based on knowledge and values. Internal regulations imposed without general support in the organisation risk poor adherence, while anyone who has been convinced that it is important to travel in a certain way will do so regardless of any regulations.
The first step towards implementing the type of travel intended by the policy is thus to increase the general knowledge and understanding of the importance of efficient, safe and environmentally-sound travel. This must be done in a way that involves all employees at the Swedish National Road Administration, either by division or in small groups.
If the employees in a division have agreed upon a certain way to conduct business travel, this can be made into a rule to be followed.

Follow-up

Regular follow-up of the regulations and agreements is important for being able to steer travel routines in the right direction. Compliance with the regulations and agreements shall be encouraged and commended, as shall all individual initiatives that support the intentions in the policy. Active commitment on the part of the heads of division is thus necessary.

Requirements, norms and values

Consider alternatives to travelling

Examine whether it would be possible to communicate in other ways, e.g. via telephone meetings or conferences, video conference, telefax or regular mail instead of travelling.
On short stretches, walking or cycling could replace travelling by car.

Travel agency bookings

Bookings should be made through the travel agency that can offer assistance in fulfilling the requirements in the travel policy. Bookings should be made well enough ahead of time so that advantage can be taken of any discounts or reduced fares.

Co-ordinate

Plan ahead so that several matters can be conducted during the same trip.

Car-pooling

Car-pool if at all possible. This also applies to travelling to and from work.
A chartered plane can sometimes be cost-effective if several persons have the same destination.

Compare prices

When calculating costs, attention must be paid to all the components involved: transport, accommodation, daily allowance, business travel supplements, working hours and travel times. The crucial factors determining how a trip will be undertaken are price as well as safety and environmental considerations.
One condition for getting a good price (e.g. APEX tickets) can sometimes entail being away over a Saturday night. If the total cost can be reduced through staying away longer, the Swedish National Road Administration can pay the extra hotel and per diem costs for a maximum of two nights.

Conferences

When planning conferences and meetings, the choice of venue shall take into consideration the travelling involved for all participants. It must also be possible to get to the venue in a safe and environmentally-sound way. Hotels and conference premises should be adapted to disabled persons and have an environmental programme.

Use public transport

Public transportation primarily by train, is often the best alternative considering both efficiency as well as road safety and environmental aspects. Airport buses should be used instead of taxis if possible.

Safe, environmentally sound cars

The Swedish National Road Administration’s requirements concerning a safe and environmentally sound car today are that it shall:

- offer passengers good protection against both frontal and side impact collision, which is considered to be fulfilled if the car complies with the up-coming EEC directives
- have an air bag at the driver's seat
- have a kerb weight of between 1000 - 1500 kg (applies to private passenger cars)
- have a head restraint for the seats being used
- be equipped with a seat belt adjuster, at least in the front seat
- have three-point seat belts, at least for the seats occupied
- have winter tyres when the roads are slippery
- be environmentally classified
- have low fuel consumption, for 1-2 occupants, the petrol/diesel consumption should be less than is shown in the following table (driving cycle 93/116 EEC) in order to fulfil the Swedish National Road Administration's environmental requirements.

	Year	**1998**	**2000**
PETROL	litres/100 km	8.6	8.1
DIESEL	litres/100 km	7.7	7.3

Furthermore, it is good if the car is equipped with an engine pre-heater and a real-time fuel consumption gauge.

Car rental

If a business trip is to be undertaken by car, there could be good reason to use a rental car, either for economical reasons or because the employee's own car does not fulfil the environmental and road safety requirements. The size of car chosen should suit the trip, number of persons involved, the amount of luggage, etc. The cost and exhaust emissions level should be in proportion to the size of the car.

Minimum requirement:

As of 1 January 1998 all rented and company cars must fulfil the road safety and environmental requirements presented above. Company cars that have been procured for the transportation of people only shall meet the requirements that applied during the year of purchase.

Private car

Minimum requirements:

The road safety and environmental requirements on private cars used regularly for business trips will gradually become more stringent. The following minimum requirements apply at the Swedish National Road Administration as of 1 January 1999. The car shall:

- have a kerb weight over 1000 kg
- have three-point seat belt at the seats occupied
- have winter tyres when the roads are slippery
- meet the 1989 vehicle emission requirements

As of 1 January 2000 the drivers' seat shall also be equipped with an air bag.

Safe driving

Safe driving presumes that traffic rules are followed. Defensive driving adapted to the situation also enhances safety.
Nonchalance and carelessness regarding applicable laws and regulations is common out on our roads and there is a widespread tolerance amongst members of the general public for certain types of traffic offence. Such tolerance is unacceptable in any Swedish National Road Administration employees travelling on official business.
Since talking on a mobile telephone while driving can be highly unsuitable, such telephones must be used with discretion. If the telephone is used frequently while driving, a hands-free solution should be found. Otherwise, it is better to pull over to the side of the road while carrying on a conversation.

Environmentally-sound driving

Use a high gear when driving and keep an even speed without any sudden accelerations and unnecessary sharp braking. Use an engine pre-heater with a capacity up to +10ºC and a properly set timer. Avoid unnecessary driving with a roof rack or box. Use environmentally classified products.

Motorcycle and moped

Motorcycles and mopeds are classified as the most dangerous kind of vehicle to drive. Moreover, the exhaust from some models, particularly those with two-stroke engines, contains a lot of substances that are hazardous to human health. These vehicles should not be used on official business other than when absolutely necessary.

Bicycle helmet

A bicycle helmet is not compulsory when cycling but does reduce the risk of injury by about 40% in an accident. It is compulsory when cycling on official duty and should also be so when cycling to and from work.

First aid

The first person to arrive at the scene of an accident should stay and offer assistance. Knowledge in the administration of first aid increases the chances of being able to make a worthwhile contribution. The Swedish National Road Administration should provide employees with the opportunity to participate in first aid training.

Hotel

If possible, choose a hotel that has implemented an environmental programme. All the hotels with which the Swedish National Road Administration has signed an agreement have an environmental policy.

Travel to and from work

Trips undertaken to and from work are not comprised in the travel policy. Based on its sectoral and working environment responsibility, it is in the interest of the

Swedish National Road Administration that these trips be conducted in as safe and environmentally-sound a way as possible. To encourage and commend work-related travel that promotes safe and more environmentally-sound traffic is an important task in every division.

Contracts for efficient, safe and environmentally-sound official business trips

Since most of our trips are booked via our travel agency or are based on different contracts, requirements on environmental and safety considerations will be included when initially procuring services. This makes it easier for the individual employee to conduct his business trips in an efficient, safe and environmentally-sound way. As existing contracts gradually become renewed, more stringent safety and environmental requirements will be included in the terms.