

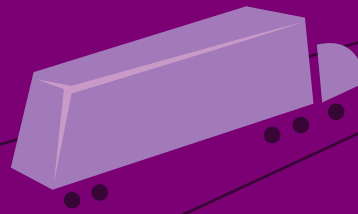


Risk and safety in the  
transport sector

# RISIT

A state-of-the-art review  
of current knowledge

# Contents



Knowledge to improve safety in the transport sector . . . . . 3



Not all safety measures lead to increased safety . . . . . 4

- The transport industry should not copy the oil industry's way of thinking . 6



- Has time run out for the transport sector's cost-benefit analyses? . . . . . 8



Who are role models in traffic? . . . . . 10

Reliable traffic control requires interaction between technology and people . . . . . 12



Deregulation increases the demands on the supervisory authorities . . . . . 14

No one has the overall responsibility for risk management . . . . . 16



RISIT programme committee 2002- 2007 . . . . . 18

## The RISIT research programme – Risk and safety in the transport sector

Text: Bjarne Røsjø, Faktotum Informasjon as Graphic design and illustrations: Birgitte Kolbeinsen, Melkeveien Designkontor  
Print: PrintHouse as ISBN: 82-12-01811-3



## Knowledge to improve safety in the transport sector

Social development is characterised by increasing mobility and a greater desire for safety and reliability in the transport system. It is therefore natural that major disasters in the transport system, such as the Åsta (railway fire with 19 fatalities) and Sleipner (catamaran ferry accident with 16 fatalities) accidents in Norway, will arouse strong interest and lead to new demands for safety.

Almost 350 people annually are killed in transport related accidents in Norway, and more than 80 per cent of accidents with more than five fatalities have occurred in the transport sector. Furthermore, we know that the risk of being killed or injured while travelling is 4-10 times higher than in other activities in the home or in leisure activities.

Based on this, the Research Council of Norway has organised a programme for research into risk and safety in transport (RISIT). The objective of the programme is to produce knowledge which can give a better understanding of transport risks and a better basis for risk management within the transport sector.

Important sub-goals are contributing to achieve the Vision-Zero within transport safety, analysing normative conditions for the transport safety policy, studying transport risk in a wider social perspective and studying how different ways of organising risk management can affect transport safety. The

programme is funded by the Ministry of Transport and Communications, the Ministry of Fisheries and the various administrative authorities in the transport sector, and will be implemented between 2002 and 2007.

In order to make a good start, the programme committee has chosen to develop seven knowledge reviews within important disciplines. This publication provides a summary of the different knowledge reviews. The objective of the publication is to give researchers an insight into the problem areas and to demonstrate the level of knowledge in different central areas. The programme committee also hopes that the publication will help direct attention towards important problems that are of interest in the social debate on safety within transport. All the knowledge reviews can be found on the Research Council's web-pages and can also be obtained from the institutes which have produced the reports. (Most of the reports are written in Norwegian with summaries in English.)



Finn Harald Amundsen  
*Chairman of the Programme Committee*  
12 05 2003





## Not all safety measures lead to increased safety

Not all safety measures within the transport sector actually increase safety. The majority of people have a tendency to compensate for an increased feeling of safety by driving faster or paying less attention to the task of driving. It is very important to know about these mechanisms when planning safety measures, says Torkel Bjørnskau.

- There is a need for more knowledge on what affects people's experience of safety or lack of safety in the transport systems, and how we react to different measures designed to improve safety and the feeling of safety. The aim should be to find measures that can reduce risk and increase the feeling of safety, and which do not – as far as possible – become the object of what we call risk compensation, say Torkel Bjørnskau and Astrid H Amundsen, researchers at the Institute of Transport Economics (TØI). However, it is not always easy to find these measures, as can be seen from the knowledge review entitled *Feeling of unsafety and risk compensation in the transport system*.

- One of the most well-known examples of risk compensation is that people who buy safe, modern cars with four wheel drive and anti-lock brakes have a tendency to counter a great deal of this increased safety by driving faster and taking greater risks. There are plenty of examples of this, says Bjørnskau.

### Traffic lights resulted in more collisions

One of the best documented examples of unsuccessful safety measures comes from Israel and Austria, who some years ago introduced a system of flashing green lights that were designed to warn of the transition from green to amber at traffic lights. The intention was that drivers would see the flashing green light and prepare to stop, but it soon transpired that a large number of drivers accelerated in order to get through the intersection before the lights turned red. However, a number of drivers behaved as the planners had intended and slowed down in order to stop at the intersection. The result should have been predictable - there was a large increase in the number of rear end collisions.

Bjørnskau emphasises that it is important to think through how road users may react to a new safety measure before it is implemented. – The concept of risk compensation describes the fact that drivers tend to change their behaviour in relation to their risk perception. Of course this can go both ways - those with studded winter tyres drive faster than those without studded tyres, but on the other hand, the majority will drive slower if they perceive an increase in risk, he says.

### Perfect compensation is rare

According to Bjørnskau, it is seldom the case that risk compensation totally removes the safety effect of a safety measure, but there are examples where a safety measure has been almost completely compensated for by the drivers. – Some road marking measures have led to drivers increasing their speed so much that the costs more or less outweigh the benefits. Delineators are a good example of this type of compensation.

As yet, we do not know what measures trigger this mechanism and to what extent drivers compensate for the various measures. However, in road traffic we generally find that the measures that improve friction, or reduce the risk of accidents in other ways, are more liable to compensation than measures which are designed to offer protection if an accident does occur. In other words, it is common for people to drive faster if the road friction improves. But no-one is interested in crashing their car even if their car has airbags, he says.

The compulsory ice driving course which was introduced in the Norwegian driver training programme at the end of the 1970s is an example that demonstrates how safety measures can have results that were not anticipated by the planners. After some years, Alf Glad, a researcher at TØI, confirmed that young men who had taken the ice-driving course were more liable to have road accidents in icy driving conditions than young men who had not taken the course. – They probably negated the effect of the ice driving course by driving faster. Proficiency training is a difficult area because it can lead to a greater feeling of mastery over a situation than the increase in the mastery itself, warns Bjørnskau.

### Increased control leads to less attention

Torkel Bjørnskau emphasises that risk compensation is a well-known concept within road transport, but is not discussed in other transport sectors. – Nonetheless, it is obvious that this phenomenon also occurs in rail, air and sea traffic, but we know less about how this manifests itself in these areas. However, there is much to indicate that increased control and safety measures in control rooms, where train or air traffic controllers work, lead to the personnel removing some of the gains in the form of reduced attention. This is most relevant within air- and rail traffic, while within sea traffic, so much responsibility still lies with the captain that compensation occurs both through reduced attention and through more risky behaviour.

- In recent years, a number of studies carried out indicate that reduced attention is an increasing problem also among motorists. The explanation may be that modern cars are so comfortable that it is much easier to fall asleep behind the wheel. It is difficult to measure this effect accurately, but what is certain is that new cars do not reduce the risk of accidents.



People tend to feel safer if they have a certain degree of control, such as when behind the wheel of a car. However, in reality it is significantly safer to travel by air than by car.

However, they do provide better protection for drivers and passengers if an accident does occur, says Bjørnskau.

### Safety and risk are different things

The researchers at TØI are also interested in that there can be a major difference between real safety and perceived safety within the transport sector. For example, most people feel that cars, buses and trains are relatively safe forms of transport, while ferries and aeroplanes are seen to be less safe. – In reality it is significantly safer to travel by air than by car. People tend to feel safer if they have a degree of control, such as sitting behind the wheel of a car, explains Astrid H Amundsen.

There is some degree of risk of an accident connected to the use of all forms of transport, but the perception of this risk varies from person to person. – The perception of risk can often be different from the actual risk, and it is important to draw knowledge about the subjective feeling of risk more firmly into the planning process. It is difficult to get more people to use bicycles if they perceive that this is unsafe, and parents will hardly allow their children to walk to school if they per-

ceive the route to school as unsafe. Increased knowledge about these connections can be very beneficial in the planning process, for example by focussing more on the factors which actually create the feeling that you are more or less safe. As yet, little is known about this, says Amundsen.

#### Astrid H Amundsen

Astrid Helene Amundsen has a Cand. Scient. degree and is a researcher at TØI's department for Safety and the Environment, working with the programmes Risk Analysis and Cost Calculations and Traffic, Health and the Urban Environment.

#### Torkel Bjørnskau

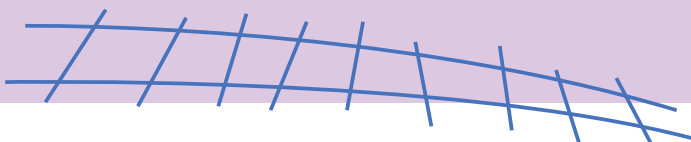
Torkel Bjørnskau has a Dr. Polit. degree and is a researcher at TØI's department for Safety and the Environment, working with the programmes Traffic, Health and the Urban Environment, and Traffic Safety and the Interaction between Road Users, Roads and Vehicles.

## Summary of results

- The media's portrayal of accidents affects the way in which people assess risk. The effect is probably relatively short-lived.
- Cars, buses and trains are perceived by the majority of people as the safest forms of transport, while ferries and aeroplanes are seen as less safe.
- Women and the elderly feel less safe in traffic than men.
- It has been well documented that in road traffic, a number of measures lead to risk compensation. When road users feel sufficiently safe, they use safety measures or safety equipment entirely or partly for purposes other than increasing safety.
- Within civil aviation and railway operations, there are few incentives for trading safety off against increased speed or intensity.

## Challenges ahead

- Torkel Bjørnskau and Astrid H Amundsen, researchers at TØI, established that current knowledge about the feeling of unsafeness within different branches of transport is inadequate and in part so outdated that a broad-based literature survey is required to study both current knowledge and earlier research.
- There are a number of examples where measures to increase safety within the majority of branches of transport may have unintended consequences that have the opposite effect. There is a need for more knowledge on what types of measures are most effective with regard to creating safety without incurring risk compensation.
- There is a tendency within all four branches of transport to automate increasingly more of the operation, management and control of transport. There are grounds for scepticism toward this development, because even the most motivated of people cannot remain alert for long periods if the tasks consists primarily of checking whether the automated system is working.



## The transport industry should not copy the oil industry's way of thinking

The four branches of transport – road, sea, rail and air – have very limited experience with risk-based management. It now looks as if the oil industry's understanding of risk and safety are rapidly being adopted by the transport sector, but the results would be better if the sector developed its own system, advises a research group from RF – Rogaland Research.

The four RF researchers' Terje Aven, Marit Boyesen, Gottfried Heinzerling and Ove Njå's report *Risk–Acceptance Criteria and Acceptable Risk in the Transport Sector* is a knowledge review that shows that the transport sector in general has very limited experience with regard to risk based management, and that especially thought processes on acceptable risk and use of acceptance criteria is not fully developed. – Cost-benefit analyses and environmental impact analyses are being used, but risk analyses and risk acceptance criteria are not really used, says Ove Njå.

Njå points out that the oil industry has used risk acceptance criteria for a number of years, and that the oil industry's thinking is now beginning to spread to other areas in society. – However, our advice is that the transport sector needs to be careful about applying the practice which has prevailed in the oil industry without further consideration. Many people are asking whether the practice used in the oil industry is appropriate. The oil industry operates with quantitative risk acceptance criteria which are not necessarily the most appropriate when it comes to safety and the effective use of resources, says Njå.

### **The experts have too much power.**

The RF researchers criticise the oil industry's traditional view that risk is an objective characteristic linked to the activity under consideration. This "objective" characteristic can often be measured using historic figures, which are then used to say something about the future risk of fatalities or other types of accidents. – This view creates a sharp distinction between the actual/objective risk and the perceived risk. Situations may easily arise where the experts think they have the exclusive right to the truth while the layman's experience of risk is said to be guided by feelings or other irrational emotions. In our opinion, this is an outdated way of thinking about risk and safety, says Njå.

Instead, the RF researchers are launching a knowledge and decision-oriented perspective where there is no objective risk.

– This perspective is based on the fact that a risk calculation is an assessment which must always be seen in relation to the person who is expressing it, the basis for the opinion, historic

and social contexts etc. The report states that using this kind of approximation, one cannot talk of objective or actual risk, but we can distinguish between historic measurements and evaluations of the future risk.

The greatest danger with the oil industry's practice is that it gives too much power to a small group of experts, who implicitly have the power to decide on a form of objective risk. We recommend instead that the actual decision makers are brought more firmly into the picture. Assessments of what is adequate from a safety perspective are of a political nature and should not be decided through a mechanical use of risk acceptance criteria where the analyst may not see the full scope of the choices that are made, says Njå.

### **Road, rail, air and sea**

The number of road fatalities in Norway over the last decade has been between 300 and 350 people each year. Despite a long list of measures designed to increase traffic safety, it has proved very difficult to reduce the number of accidents. The RF researchers have the impression that the links between the requirements at the upper and lower levels in road traffic have not been considered, but that requirements are instead developed parallel to the development within technology, needs and society. Risk as a concept and as a management tool has no distinctive tradition among the Norwegian road authorities or even amongst the international road authorities. There is a minimal amount of accessible research literature found in the area of road traffic and acceptable risk.

With regard to shipping, the existing legislation contains no requirements for risk to be a part of the decision-making basis within the industry. Safety requirements are traditionally designed as minimum standards for equipment and operations, where risk based thinking has been virtually absent. Processes for implementing evaluations of risk as management tools for planning and operating shipping, have been introduced on both the European and the Norwegian side. In Norway this has resulted in a separate directive on risk analysis and acceptable risk for inland ferry traffic. This practice is also in the process of being extended to other forms of shipping. There has been significant research carried out internationally into shipping safety since the mid 1990s. This has resulted in the development of a methodology for safety analyses and assessments, and will now be required by the industry as part of their safety management.

The RF researchers confirm that there are major challenges within the railway sector connected to research and development of new information and communications equipment that can be integrated into, and adapted to, the railway safety standards. Significant areas will be the development of high-speed technology, signalling and operation communications and operation monitoring.





*The transport sector needs to develop its own system for risk-based management, says a research group from RF – Rogaland Research.*

Air traffic in Norway is amongst the safest forms of transport with a low accident risk, parallel with the growth in passengers and freight over a number of years. Norwegian air traffic is to a large extent integrated into European and international development, and this integration will increase in the future because of transport and communications policies. There are no relevant laws and directives found concerning risk acceptance or other quantified objectives of acceptable risk, for either the railway- or the air sector.

### Input into further research

The RF researchers have identified six areas of particular importance for future research and knowledge development:

**Comprehensive thinking and principles:** Which perspective on risk and safety shall we adopt? How shall we express our uncertainty about the “world”?

**Risk analyses:** The existence of decision making situations is a requirement for risk and vulnerability analyses. There is a need to survey existing decision-making situations and processes.

**Risk indicators:** The majority of risk indicators used today are based on statistical material that shows the frequency of undesirable incidents. It is important to supplement this type of indicator with a more pro-active attitude where the focus is on the future.

**Risk communication:** Risk analyses can contain large quantities of data, calculations and results. One should consider the possibility of using graphics/visual tools to explain risk in a simpler and more comprehensive way.

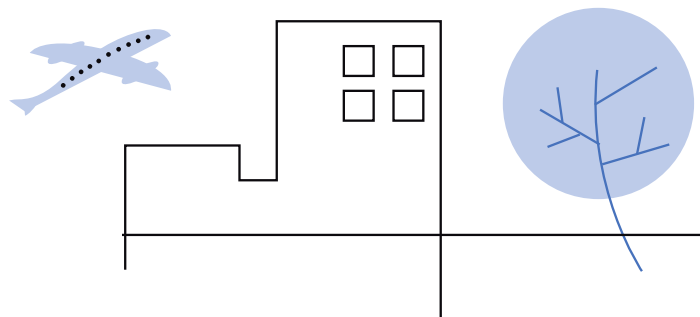
**Risk acceptance criteria and performance requirements for the emergency systems:** It is a challenge to devise a structure

which brings the main objectives and the risk acceptance criteria together with more detailed requirements for solutions, barriers and emergency preparedness. At present, the connection between requirements and measures is uncertain.

**Decision analysis:** Risk analyses, risk indicators and possible risk acceptance form the basis for decisions. There is a need to see these factors in a wider perspective that includes assessment of the various advantages and disadvantages of alternative solutions and measures.

### Ove Njå

*Ove Njå is Associate Professor in safety at Stavanger University College. He is attached to civil engineering programmes at Master's degree level. Njå is also a senior researcher with RF-Rogaland Research.*



# Has time run out for the transport sector's cost-benefit analyses?

- Time has run out for the cost- benefit analyses used in the transport sector, with regard to both the type of data collected and the methods of evaluations. There is reason to ask whether it is justified to use the current cost-/benefit analyses as a basis for decisions, says Kjartan Sælensminde, a researcher at TØI.

Cost-/benefit analyses are used within the transport sector as a basis for comparing different development projects and prioritising those that are to be implemented, but according to Kjartan Sælensminde of the Institute of Transport Economics (TØI), the analyses that are carried out today are based on major methodological weaknesses.

- A good cost-/benefit analysis must be based on the population's preferences for changes in the effects that are included in the analysis. However, the preferences for changes in travelling times, traffic safety and environmental conditions which are included in current analyses, for example in the road sector, are largely based on hypothetical willingness-to-pay studies that have major methodological weaknesses. In brief, an important weakness is that the evaluation of travelling times, traffic safety and the environment, is done in a context which is different from the context included in the cost-benefit analyses, says Sælensminde.

## Unclear socio-economic profitability

In the TØI report *Evaluation of Transport Safety – a Knowledge Review for the RISIT Programme* - Sælensminde describes the valuations used by the authorities in different countries in cost-benefit analyses of transport projects. He also discusses the basis for differentiating the evaluation of safety between different branches of transport, indicates weaknesses in current knowledge and outlines the need for new evaluation studies.

- The proven weaknesses in the valuation of time, safety and environment, are so great that the benefit in the analyses must in all probability be at least two to three times higher than the costs before it can be concluded that a project is

socially and economically profitable. In the majority of cost-/benefit analyses carried out in the transport sector, the benefit is not much higher than the costs and conclusions regarding socio-economic profitability cannot therefore be made, says Sælensminde.

Furthermore, the uncertain relative values for time, safety and environment mean that decisions on the choice of route location in the road sector, which have traditionally been regarded as well-suited to cost- benefit analyses, may also be wrong. For example, conclusions cannot be drawn from cost-/benefit analyses in this type of decision if there is a variation in the degree to which these benefits are included and altered in the different choices of route location.

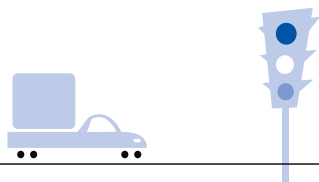
## Americans are worth their weight in gold

Sælensminde's report covers 22 countries that use cost-/benefit analyses to varying degrees in their planning work. The report shows that there are enormous differences with regard to valuating a traffic fatality. Americans value a human life at US\$ 3.7 million (approx. NOK 27 million), while Norway takes second place with around NOK 15.4 million. Then New Zealand, Great Britain, Sweden and Canada closely follow, while countries such as Portugal and Spain lie at the other end of the scale.

- This does not really show what a human life is worth, but what figures the authorities use when they calculate which road projects are socio economically profitable. It is typical of the countries that set the highest values, such as the USA and Norway that they have included loss of benefit in the form of pain and suffering in the cost of life, explains Sælensminde.

- We have documented the methodological weaknesses in the current practice, and thereby the most important condition for carrying out better evaluation studies in the future is in place. However, it does not help adjusting current values by doing another, more refined price adjustment, through updating literature studies or other minor adjustments. Time has run out for today's evaluations, with regard to both the type of data collected and evaluation methods, says Sælensminde.

Kjartan Sælensminde's conclusion is that there is a need for new valuation studies which in principle should be based on how the population benefits from the different measures.

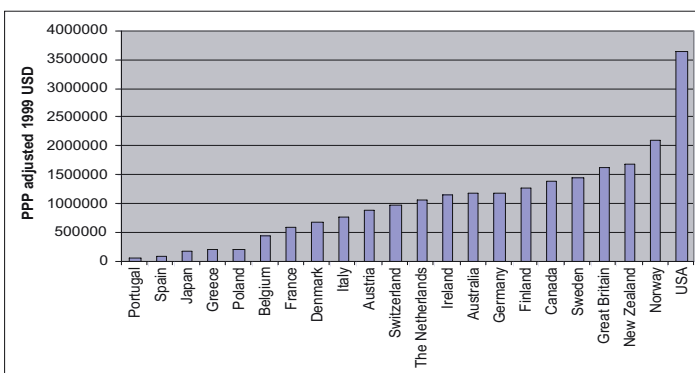






The cost-benefit analyses used in the transport sector to compare different development projects, is based on major methodological weaknesses, says Kjartan Sælensminde. (PHOTO: KJELL WOLD, STATENS VEGVESEN)

– Broad-based research into valuations should be initiated with the intention of applying them in cost-benefit analyses in the transport sector. The main objectives of such research must be to achieve the methodologically most valid valuations in a way that can cover all branches of transport.



The table shows the official valuation of each traffic fatality in the 22 countries that use cost-benefit analyses in the transport sector. The figures from 1999 are given in US dollars and are adjusted for differences in purchasing power.

### Kjartan Sælensminde

Kjartan Sælensminde has a Dr. Scient degree and is a researcher in TØI's department for Safety and the Environment.

## Three types of costs

Costs related to traffic accidents are often divided into three components:

- Direct costs such as damage to vehicles and property, emergency services costs, medical treatment, burial costs etc.
- Loss of production for society as a result of people being injured or killed
- Loss of benefit in the form of pain, grief and suffering

## Three methods of valuation

Methods for valuing a human life can be divided into three main categories:

- Human capital methods, which find the net or gross production loss as a result of death and injury, plus any direct costs
- Proven preference methods which are based on the individual's preferences in real markets, such as insurance or compensation in legal cases, or political preferences expressed implicitly through political decisions.
- Contended preferences which are based on individual preferences in hypothetical markets.

## Who are role models in traffic?

- We do not know enough about who the most important role models in traffic safety are. Nor do we know enough about how to go about developing a risk culture where people take more responsibility and contribute positively towards protecting their own and other's safety and feeling of safety, says Lillian Fjerdingen, a researcher at Sintef.

Thereby Fjerdingen calls attention to one of the five research areas which are proposed in the Sintef report *Safety culture in Transport*, which she has written with a research colleague, Terje Sten. Amongst other things, the report points out that safety culture in the transport sector is a relatively new concept, about which little is known.

- Research into safety culture within transport, as within other branches, has been sporadic and not collated. Air traffic appears to have achieved the most with regard to getting a grip on safety work, while within the railway sector a few interesting studies have been carried out which highlight different aspects of the topic. Few studies have been carried out within road transport and shipping, says Fjerdingen.

### Different safety cultures

The result of the sporadic research is that safety work takes place without well-founded priorities.

- All branches of transport are dependent on an infrastructure which considers safety. When two passenger planes almost collided over Meråker in 1997, and almost causing Norway's worst ever air disaster with potentially over 200 fatalities, the cause was that at an air traffic controller in Trondheim had cleared two planes to fly towards each other on the same flight path. The collision was avoided, but only due to the fact that the two aircrafts' navigation systems had small deviations in relation to each other, explains Fjerdingen.

In the Sleipner accident in 1999, lack of lighting on the Blok-sen rock and the Lighthouse Authority's role were subject to a heated discussion, and after the rail accident at Åsta in 1999 there was a great deal of discussion in the media whether permanent train radio links between the railway control centre at Hamar and the train drivers could have avoided the accident.

### Cultures and sub-cultures

- The infrastructure and the co-operation between infrastructure and players is a relevant theme for research on safety in the transport sector. The different safety cultures are an important element in this. While air transport, and to some extent shipping, have taken inspiration from the Armed Forces, the drivers behind the wheels of the big lorries have a work cul-

ture that is characterised by individuals who have organised themselves to varying degrees, says Fjerdingen.

This is not to say that one safety culture is worse than another. – The main impression is that air traffic is the safest form of transport with regard to the frequency of serious incidents, partly because the industry has a tradition of systematically following up near-misses. However, it has also been revealed that there are sub cultures where attempts are made to cover up unfortunate incidents, because no-one wants to become a scapegoat. The railways are also traditionally a safe system with few accidents, but in recent years we have seen a number of examples in Norway which show that this system is also vulnerable, says Fjerdingen.

In comparison, road transport has a large number of accidents, but major accidents with a large number of fatalities seldom occur and do not receive the same attention in the media. The media focus more on accidents that are regarded as dramatic (fires, drowning), or where large numbers are killed (major accidents).

### Private players are a safety problem

Lillian Fjerdingen and Terje Sten emphasise that the transport activities in general are not carried out behind closed company doors, but in a society which is also open to other players. – Thus, safety is to a large extent dependent on how these other players act. Air transport is the most closed in this respect, while road traffic is the most open with a very large element of private players such as car drivers, motorcyclists, moped riders, cyclists and pedestrians. The variety of individual players represents significant safety problems also for the organised players, i.e. the transport companies, says Fjerdingen.

Another important factor is the legal requirements and the authorities' supervision with regard to safety. Here the transport companies in the road sector are in a unique position, in that no specific requirements are laid down for setting up a system for safety management. The Norwegian Public Roads Administration, which is responsible for such supervision, does not carry out system supervision in the same way as in the other transport branches, but currently only deal with control of vehicles.

### Transport models are not clear

A number of researchers have pointed out that commitment amongst the top management is very important in creating a good safety culture, and this also applies to air transport, shipping and rail traffic. However, the situation is not so clear on the roads. – We do not know a great deal about who the role models are for traffic safety on our roads, but a large number of players such as individuals, organisations, the Church, businesses, the media, advertising, sport, politicians, the legal system, schools etc are sending out signals, says Lillian Fjerdingen.





“The Kings of the Road” – The drivers behind the wheel of big lorries have a working culture that is characterised by individuals who have organised themselves to varying degrees, while air transport and to some extent shipping have adopted many initiatives from the Armed Forces. However, it is not clear who are the most important role models with regard to traffic safety. (PHOTO: GEIR BREKKE, STATENS VEGVESEN)

## Future research

In the report, Fjerdingen and Sten propose that research be carried out in at least five areas:

- Measuring safety culture in the transport industry: At present there are no measuring instruments for safety culture, but some foundation work has been carried out. There is a need for a clearer distinction between safety structures/-safety systems and safety cultures.
- Safety structures and safety culture in road transport companies: Problems are today largely dealt with retrospectively through external controls, and there is therefore a need for a more pro-active approach. The research project should illustrate problems connected with regulations, safety management and safety culture in transport businesses. Furthermore one should focus more on the role of the supervisory authorities.
- Our social risk culture: How should we go about developing a risk culture where people take responsibility for the interpersonal reliance and contribute positively to their own and others' safety and feeling of safety? For example, there is little information on who has the most important role as dispatcher of the messages that affect the populations' sense of responsibility. There is also little information as to what extent the “dispatchers” are aware of their message and of its significance.
- Safety cultures within unorganised traffic: How do attitudes to rules and regulations as cultural phenomena appear? What differences exist between the different European countries? How can knowledge about these attitudes be utilised with a view to developing, introducing and implementing rules and regulations?
- Responsibility and safety culture in different areas of the transport sector: The responsibility for accident prevention work is distributed between the authorities and players/businesses. The distribution of responsibility varies from one transport sector to the next.

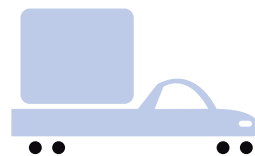
## Safety culture – what is that?

Safety culture became the subject of serious attention after the Chernobyl disaster in 1986 and other major accidents such as the spaceshuttle Challenger (1986), the fire at Kings Cross underground station in London (1987) and the fire on the Piper Alpha oil platform (1988).

- After the accident at the Three Mile Island reactor in 1979, the American nuclear power industry became painfully aware of the significance of factors such as leadership and organisation. Safety culture also became a vital theme within sea transport after the major ferry disaster involving the Herald of Free Enterprise, the Scandinavian Star and the Estonia. Yet despite the fact that safety culture has been referred to in the research literature for a long time, the research input in this area has been fragmented, without a common theoretical approach and understanding, and has little connection to the understanding of the organisational conditions which lead to accidents happening, says Lillian Fjerdingen.

### Lillian Fjerdingen

Lillian Fjerdingen has a Cand. Jur. degree and is a senior advisor and group leader at Sintef Civil and Environmental Engineering, Department of Roads and Transport.





## Reliable traffic control requires interaction between technology and people

- Knowledge of the interaction between people, technology and organisation in traffic control centres is decisive for increasing safety within the transport sector. Through a well constructed research programme, Norway can effectively contribute to significant new knowledge, which can be converted into practical results in both the short and the long term, says Kjell Haugset, a researcher with IFE (Institute for Energy Technology) in Halden.

Air, rail and sea transport all have long traditions in using traffic control centres to control and monitor traffic and in recent years the importance of road traffic control centres has also increased considerably in Norway. 31 road tunnels are monitored in Oslo alone, along with a number of other stretches of road. – However, the development of traffic control centres has largely been technology driven, and there are many examples where new monitoring and control technologies have been adopted without checking for any negative consequences with regard to safety. There is a tendency to put greatest focus on effectiveness when new technology is adopted, warns Kjell Haugset.

### Strong industrial-psychological environment

The RISIT report *Human Reliability Issues in Traffic Control Centres* is written by Salvatore Massaiu, Kjell Haugset and Thorbjørn J Bjørlo, all researchers at IFE. The report is based on many years of research related to the interaction between people and technology.

The IFE environment at Halden has a significant international position as a knowledge environment with regard to improving safety in nuclear power plants through improvements in control rooms and these experiences are now being transferred to the offshore industry and the transport sector.

- Within the nuclear power industry we have clearly seen that a high degree of automation in the control rooms creates a tendency for the people working there to become less independent. One consequence of this may be that it becomes more difficult to intervene when the automatic systems fail, and there is good reason to believe that the same phenomenon can occur in other traffic control centres, says Haugset.

Haugset therefore advises against too much faith in automatic control systems that reduce the role of people in controlling traffic operations. – Safety is primarily dependent on the interaction between people and technology, and secondly that the organisation around the people is functioning well. Here at IFE

we place great emphasis on the concept of MTO (Man - Technology-Organisation), which stresses that the interaction between the three elements is decisive for safety, says Haugset.

### The four forms of transport

The traffic centre is generally a centralised control room where different information about traffic, such as speed, direction, density, weather and driving conditions, is given to the controller. The controllers in the different transport sectors have varying degrees of responsibility for controlling traffic, but in all traffic control centres it is the people who are responsible for the decisions that are taken. Haugset also points out some of the characteristics of the traffic control centres within the four different transport sectors.

Air traffic is the sector which has focused most on human reliability, both with regard to air traffic controllers and pilots. At the same time, the industry is faced with major challenges in the years ahead. Among other things, there are plans to organise air traffic in Europe so that in the future planes will follow the shortest route between two points, instead of using corridors as at present. This means that planes will have to cross a number of other flight paths, which can have both positive and negative safety aspects, says Haugset. Air transport is the only transport sector which has focused on developing special models to give quantitative descriptions of the reliability of traffic controllers.

Within shipping, the large increase in traffic density, combined with a growing element of fast-moving vessels, has led to the establishment of a number of traffic control centres, with the task of monitoring and assisting traffic in areas of particular risk. The staff in the shipping control centres primarily has an advisory function, while the responsibility for the individual ship lies with the captain.

The traffic centres comprise an increasingly important safety resource. – The greatest challenge within shipping lies in the fact that the development of new types of fast ferries has created an entirely new situation for captains and navigators, notes Haugset.

Within rail transport there has been considerable activity to improve rail safety by adapting the rail control centre and the controllers' tasks to the person carrying out the tasks.

Even though speeds are increasing also within rail transport, the development is not as extreme as for fast ferries. – A safe handling of rail traffic, such as trains and commuter lines, is completely dependent on the decisions made by the traffic controllers on how traffic is to be controlled, based on the information he has received. Analyses of incidents show that the risk for future accidents can be reduced by enabling the traffic controller to carry out his tasks more effectively, says Haugset.



*The interaction between people, technology and the organisation is decisive for safety, say researchers at IFE. (ILLUSTRATION: IFE)*

The road traffic centres (VTS) are characterised by the fact that they control traffic only to a limited extent. They influence traffic operation through information and co-ordinate the input of the emergency services in the event of an accident. Norway is divided into 5 VTS areas, one for each region. Through the road traffic centre in Oslo, more than 30 tunnels are now monitored along with other stretches of road. – Stressful situations arise in the event of accidents and the controllers’ conduct is therefore decisive for the outcome. To achieve optimal operator conduct the most important elements are the competence requirements placed on the controller, the information about the traffic situation available in the centre, and how it is presented, says Haugset.

### **Optimising interaction**

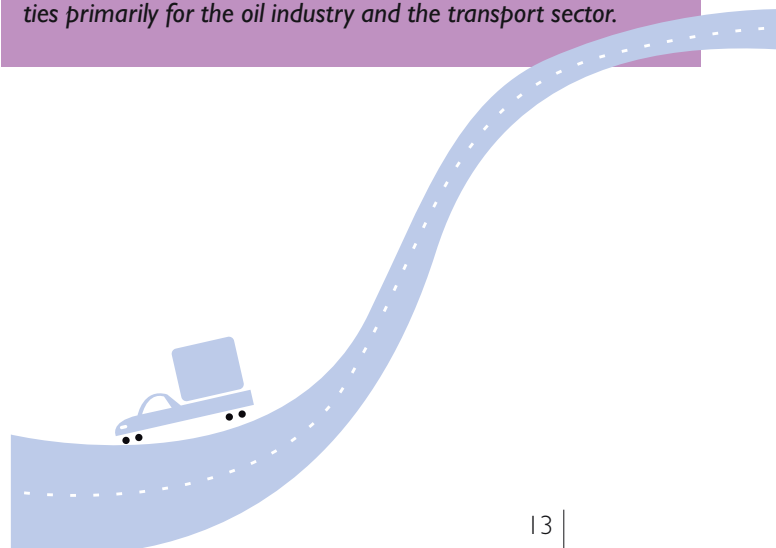
The activities in the VTS must be based on relevant knowledge about traffic. The controllers’ education and training, their workload, access to relevant information, interaction with other staff, the complexity of the situation at hand and access to procedures for dealing with the problem are examples of factors that affect the individuals performance capability in the centres. These factors will to a greater or lesser degree decide whether a critical situation can be avoided or whether it will develop into an accident.

- The safety challenge in traffic control centres is optimising the interaction between the individual, the technology and

the organisation as described by the MTO concept., People constitute the most central safety factor in the control centres in the foreseeable future, and the environment must therefore be organised so that the controller can maintain safety in the best possible way. In order to achieve this, more information is needed about human performance and reliability, concludes Haugset.

### **Kjell Haugset**

*Kjell Haugset is Research Director in the Safety-MTO sector at IFE. His main responsibility is the establishment of new activities primarily for the oil industry and the transport sector.*





## Deregulation increases the demands on the supervisory authorities

The EU is in the process of carrying out a comprehensive deregulation within areas of the transport sector, which will also have major consequences for Norway. – This will put increased demands on the supervisory authorities. Deregulation and increased competition can, in principle, increase the risk of accidents, but proactive supervision can contribute to the risk decreasing instead, says Stig Ole Johnsen, a researcher at SINTEF.

The RISIT report *Deregulation and transport safety within roads, rail, air and sea*, documents that surprisingly little systematic research has been carried out on the connection between deregulation and safety in the transport sector. The exception is air traffic, where American researchers in particular have published a number of reports. The knowledge base for the other transport sectors is relatively poor, as shown in the report by Stig Ole Johnsen at SINTEF Industrial Management, Håkon Lindstad at MARINTEK (Marine Technology Research Institute) and Tor Nicolaysen at SINTEF Civil and Environmental Engineering.

- Experiences from other countries show that deregulation in the transport sector can lead to increased competition and reduced profitability which can, in turn, lead to reduced maintenance and less focus on improvements of safety. Deregulation can also lead to the establishment of new companies and suppliers who lack sufficient experience. A disintegration of responsibility can occur as a result of delegating services to several subcontractors, and existing traffic control services can become overloaded as a result of increased traffic. However, deregulation does not have to lead to these effects. Long-term planning and proactive supervision can contribute towards the positive effect of deregulation being significantly greater than the negative effects, says Stig Ole Johnsen.

### More air accidents, but fewer car accidents

Experiences from the USA show that it is important to look at the overall picture with regard to evaluating deregulation.

- For example, many reports have been produced showing that deregulation of air traffic in the USA lead to cheaper flights for passengers and increased competition. However, several new and relatively inexperienced airlines entered the market at the same time, and some well-documented reports indicate that in the first phase after this change, the risk involved in air travel rose by an average of 8 fatalities a year. However, the same researchers who calculated this increase have also showed that

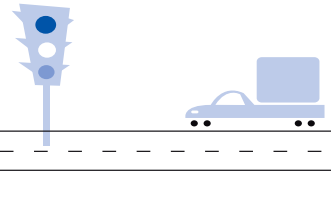
deregulating air traffic lead to more transport being transferred from the road to planes, and that this reduced the number of fatalities on the roads by around 200 per year! These results have not been confirmed by other researchers, but there is good reason to emphasise them, says Johnsen.

The American experiences go right to the heart of the debate on the EU's ongoing deregulation of the transport sector. – It is easy to get the impression that deregulation in the EU is done for ideological/liberalistic reasons, but it is my impres-



*The EU countries' deregulation of rail traffic is based partly on the fact that rail transport has a much lower risk of accidents than road transport. Transferring transport from road to rail can therefore save many human lives. (PHOTO: BJARNE RØSJØ)*





sion that the EU is working toward a deregulation of rail traffic from a genuine desire to increase safety. Rail transport has a much lower accident risk than road transport, and many human lives will be saved if the EU succeeds in transferring large volumes of transport from road to rail, says Johnsen.

### Supervision should be forward looking

The Norwegian authorities will regardless have to adhere to the EU's deregulation and based on this, Johnsen recommends a proactive attitude amongst both politicians and the supervisory authorities.

- International research literature shows that the supervisory authorities in general have a tendency to react and produce new rules and directives in the aftermath of major accidents, while it is more unusual to be proactive. But now we know that there will be comprehensive deregulation in a number of areas in the transport sector and, in my opinion, the authorities now have a golden opportunity to adopt a proactive attitude through what we call Risk-Based Supervision (RBT) and to ensure that deregulation is carried out in the best way possible. For example, if reducing the number of accidents in the transport industry is the goal, then accommodations should be made to transfer more traffic from the roads to the railway. In addition, it is natural to point out measures such as the upgrading stretches of road prone to accidents and tax relief for vehicles with effective safety equipment, says Johnsen.

Deregulation of the transports sector in the EU is also part of the endeavour to create internal markets as open as possible, which also involves an effort to break up the existing national railway monopolies. – Today there are a number of barriers to free competition within the railway sector, both in the form of customs barriers, different technical systems, signalling systems and national legislation. One of the first consequences of deregulation in Norway could be that the Norwegian State Railways (NSB) is challenged on the sections with a large customer base, such as commuter lines in the Oslo area, says Johnsen.

### Better decision basis

Johnsen refers to several examples where deregulation can lead to more work for the supervisory authorities. – When the British railway monopoly British Rail was split into three main groups with responsibility for infrastructure, rolling stock and personnel respectively, the number of sub contractors blossomed. According to the most recent statistics, there are now some 120 private companies supplying services to the British railways, and this figure alone shows how it leads to an increased work load and new challenges for the supervisory authorities. Amongst other things, the large number of sub-

contractors creates the opportunity of a detrimental disintegration of responsibility, says Johnsen.

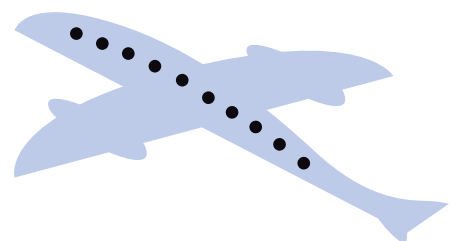
Air transport and the railways face the most comprehensive deregulation, while shipping has been deregulated for a number of years. – Road transport is also generally more deregulated than air transport and the railways, but in recent years, we have seen an increasing number of measures to create greater competition in the taxi and bus industries. This increased competition has led to greater demands for reductions in costs and better utilisation of resources, and a number of studies carried out indicate that this has created an increase in the pressure on drivers in a way which has been detrimental to safety, says Johnsen.

Overall, deregulation in the transport sector could lead to reduced safety margins unless compensatory measures are implemented. SINTEF's report concludes with a proposal to develop more knowledge on the safety-related consequences of deregulation within the transport sector. This is done so that we can obtain a better decision-making base for central players such as politicians, transport companies, owners of infrastructure, contractors, supervisory bodies and others.

Amongst other things, we want to undertake a project that can provide us with a base for proposing a "best practice" in implementing reorganisations to improve safety. We can then recommend methods for changes in organisation connected to deregulation and outsourcing with emphasis on transport safety, concludes Stig Ole Johnsen.

### Stig Ole Johnsen

*Stig Ole Johnsen is a senior researcher with SINTEF Industrial Management, Department of Safety and Reliability.*



## No one has the single overall responsibility for risk management

Risk management in the Norwegian transport sector is organised so that many players at different levels have sub-tasks and shared responsibility for dealing with risk, while no one has the overall or general responsibility. This means that there is a danger of unreasonably large resources being used on relatively small problems, while more serious problems of accidents and risks remain unsolved.

One of the problems which Yngve Skjæveland, researcher at NTNU, points out in the RISIT report *Supervision and Regulation in the Transport Industry*, is the shared responsibility for risk management. Today's risk management has grown out from political developments, which in the 1980s and 1990s in particular, lead to major changes in state management and use of tools in this area.

- The setting up of independent supervision reflected the need to re-take some of the control which had been lost to the market forces. It was also a result of the need for a greater degree of legal competence than the previous directives had allowed for. Increased emphasis was placed in separating supervising functions from the functions linked to development, operation and regulation of transport systems. However, questions have been asked whether this changing role of the supervisory bodies can contribute to a disintegration of responsibility within the state, due to the lines of responsibility no longer being clear enough, says Skjæveland.

- Very little research has been done into the supervision and regulation in the transport sector, both in Norway and internationally. The subject has scarcely been studied at all by researchers in Norway, and therefore we know little about what impact supervision has – or could have – on safety. This area is therefore open to studies into this subject both in depth and on a broad basis, says Skjæveland.

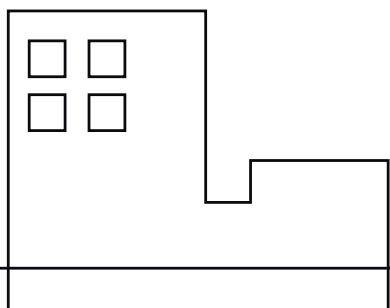
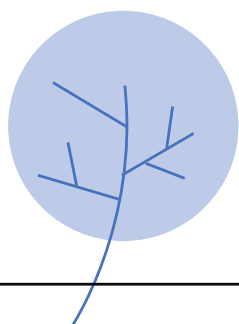
### The Vision-Zero shows the way

Yngve Skjæveland also sees weaknesses in the political discussions which led to Parliament in the spring of 2001 agreeing to the governments' proposal to introduce a Vision-Zero for the numbers of fatalities and permanent disabilities in the transport sector. - Vision-Zero has stimulated re-thinking on how responsibility for safety in a system can be defined, and it will have direct consequences for supervisory organisation and supervisory strategies. However, it is also the case that the zero vision was adopted without giving consideration to how this would be handled by the supervisory and regulatory authorities. Consequently we do not know for sure what the Vision-Zero implies, and due consideration has not been given to what needs to be done with the supervision and regulation in order to achieve Vision-Zero.

- Perhaps the most important point of the Vision-Zero is that it gives a signal that accidents and serious injuries in traffic is not acceptable. If the objective was reducing the numbers killed to a given level, this could be interpreted as a sign that traffic fatalities are acceptable, he says.

### Three guiding principles for evaluating risk

According to Skjæveland, recent research has identified three management principles for risk: a risk-based management principle, preparedness for eventualities principle and the discourse principle. The latter involves decisions being made after a discussion without the use of formal risk analysis. – In cases where the discourse principle is used, strategies must be developed to encourage awareness and trust. Knowledge of the perceived risk must be increased and it is essential to gain the cooperation of those who experience the threat to ensure that doubts and uncertainties are integrated into the political process of handling risk. In choosing strategies and working methods, the supervisory bodies must also decide what form of risk they can tolerate and which form of management principles are realistic. In several cases it may be necessary to use a combination of several management principles, says Skjæveland.





*Today's risk management has grown out from a political development, particularly in the 1980s and 1990s, which led to major changes in government management and instruments* (PHOTO: JORUN SÆTREN, STATENS VEGVESEN)

### **Not enough research**

Skjæveland emphasises that little research has been done in this area, and a number of research subjects should be considered, with different thematic and theoretic angles within a number of subject areas.

- Firstly, it is important to obtain more knowledge about how inspection and regulation works in the transport sector today. Questions regarding organisation and connections to the government are both vital and central. How can resources and expertise be best co-ordinated and utilised in order to make supervision as effective as possible, and to achieve the highest possible level of traffic safety? In this context, questions on deregulation and privatisation, conflicts involving legal competence, democracy and political control are important. We

should also look more closely at what implications the zero vision will have on supervisory organisation and strategies. A comprehensive but important question is what management principles and strategies are best able to achieve the main objectives and which can best safeguard transport safety, says the NTNU researcher.

#### **Yngve Skjæveland**

*Yngve Skjæveland has a cand. philol. degree in History and is a fellow of the Institute of Interdisciplinary Cultural Studies at the Faculty of History and Philosophy at NTNU.*



# The RISIT research programme

(Risk and safety in the transport sector)

## RISIT's programme committee 2002-2007:

**Finn Harald Amundsen** (leader), Department Head,  
*Norwegian Public Roads Administration*

**Marit Boyesen**, Associate Professor  
*Stavanger University College*

**Lena Nilsson**, Head of research  
*The Swedish National Road and Transport Research Institute*

**Kurt Petersen**, Research Director/ Vice Managing Director  
*Danish Transport Research Institute*

**Lise Sandsbråten**, Department director  
*Ministry of Transport and Communications*

**Eirik Sire**, Department Head  
*The Coastal Authority*

**Øyvind Thomassen**, Associate Professor  
*Department for Interdisciplinary Cultural Studies*

## Observers in the programme committee

**Monica Løland Ekenes**, Head of safety  
*The Norwegian National Rail Administration*

**Jon Erik Lindeman**, Head of risk analysis  
*Avinor – Safety staff*

**Trygve Scheel**, Senior adviser  
*Norwegian Maritime Directorate*

## Contact persons at the Research Council of Norway

**Halvdan Buflod**, adviser  
**Bjørg Bergenhus**, Executive Officer

**Web page for the research programme:**  
<http://www.program.forskningradet.no/risit/>





Return address:  
The Research Council of Norway  
PO Box 2700 St Hanshaugen  
N 0131 Oslo  
Norway

ISBN 82-12-01811-3



 **The Research Council of Norway**

**RISIT**

c/o The Research Council of Norway  
PO Box 2700 St Hanshaugen  
N 0131 Oslo  
Norway

Finn Harald Amundsen,  
Chairman of the Programme Committee  
Tel 00 47 22 07 35 00  
finnam@vegvesen.no

[www.program.forskningradet.no/risit](http://www.program.forskningradet.no/risit)