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1 INTRODUCTION

1.1 Project Overview

1.1.1 The INTRO Project

The INTRO (Intelligent Roads) project is aimed at demonstrating how safety, capacity, road operation and maintenance problems can be alleviated by the use of existing and future sensor, communication and processing technologies in a harmonised way, to create and add "intelligence" to road networks.

It is a three-year R&D activity (March 2005-February 2008) with funding under the 6th Framework Programme of the European Commission (Directorate-General for Research).

Further information can be found on the overall aims and activities of the project at the INTRO website: http://intro.fehrl.org .

1.1.2 Purpose of WP1 "Intelligent road systems: Current knowledge and Implementation Strategies"

Work Package 1 of the INTRO project deals with current knowledge and implementation strategies for intelligent road systems, related to safety and capacity improvements. It is a "horizontal" strand of the project, interacting with the three technical work packages (WP2: Novel concepts for surface safety monitoring; WP3: Pavement conditions from intelligent pavements and intelligent vehicles; and WP4: Traffic and safety monitoring) and with the work package on clustering, dissemination and implementation (WP5).

WP1 includes the following three main activities:

- Current state-of-the-art and focused needs;
- Scenarios, structure and potential short-term trends; and
- Implementation strategies including evaluation and cost-effectiveness.

The first of these activities has been covered in Deliverable 1.1[1], which fed into the three technical work packages by reviewing current technologies, practices and experiences, as well as studying the needs of key users, in particular through a series of interviews with road operators and authorities.

The second activity, which is the subject of this report, focuses on a range of possible scenarios for private and commercial road transport and provides a set of "visions" considering technology trends, future needs and circumstances.

[1] R. Opitz, A. Winder et al, ***"Intelligent Road Systems – Consolidated State of the Art and User Needs"*** - INTRO project Deliverable 1.1, October 2005.

Lastly, the activity on implementation strategies will take place towards the end of the INTRO project, and will evaluate the systems developed within the INTRO technical work packages (and best practice elsewhere) in order to formulate recommendations on deployment.

1.2 Scope of this Report

1.2.1 Task Description and Purpose

This task focuses firstly on examining a range of possible scenarios for private and commercial transport including scenario investigations and European future needs analysis for private and commercial transport on road networks. It explores the core challenges in safety, capacity, infrastructure management and economy - short term and long term trends.

Most transport commentators and experts, including partners within the INTRO project, generally accept that the expected overall trend and future scenario for roads will be:

- Increasing traffic on the one hand, combined with higher costs for fuel and road operation on the other; and
- More awareness and higher necessity for improved safety and economy.

Although the degree to which these things will happen is open to debate, and is subject to many social, political and economic factors, these developments will generally lead to a situation whereby road networks will evolve from being an “inactive” pavement or concrete layer to an “interactive and communicative combined material and information road layer” including sensing and intelligence in cooperation with traffic in general and intelligent vehicles in particular.

This review also covers:

- Financial aspects: increasing financial constraints for public authorities responsible for building, maintaining and operating transport infrastructure;
- Trends, including chained dependencies for safety and capacity issues;
- Future visions, in terms of technology trends, future needs and potential solutions and their innovations.

Examples or areas of future Visions considering technology trends, future needs and circumstances are:

- Global and regional access control and capacity management;
- Real-time monitoring, capacity steering models and strategies;
- Optimised life cycle approaches for road networks and bridges;
- Implications and management of road network ageing;

- Integrated traffic safety systems and control strategies;
- Private annual basic free driving contingent models for users;
- Urban and inter-urban road usage strategies;
- Transport mode shifting motivations (long distance transport mainly by rail or sea/waterway);
- Regional self production and autonomous supply cells or areas (re-concentration of dislocated production chains enabling the increase of low level workers employments rate and reducing the "blind value" of unreasonable long range transport);
- Integrated and optimised road and traffic management under all weather conditions.

1.2.2 Scenarios and Trends

"Scenarios and trends" means the perception and (short) description of different situations and related parameters and their dynamics and changes over the time and space.

Scenario planning is a method for learning, developed in order to train military leaders for Cold War contingencies in the 1950s, through constructing a range of distinct narratives about the future, each scenario representing a different reality.

Trends, on the other hand, are based on current and future developments in society, the economy, technology, the environment, etc, and can be used as a base for which to develop scenarios and predict their effects.

1.2.3 Methodology

Although this report draws on some existing information, such as existing trends and policies, it is largely the product of its authors own thinking, particularly as the concept of visioning and scenario building for intelligent road systems on a macro scale has received relatively little attention in previous research efforts. Much of the content of the report emanated from in-depth discussions in a two-day brainstorming meeting in Warsaw in December 2005, in which six INTRO partners participated.

The formulation and awareness of such future possible scenarios is investigated and managed in European countries and its population with different efforts and depth.

One important reference project was the Vision 2030 project[2] for the Highways Agency in the UK, which is responsible for motorways and trunk roads in England. This project had the objective of developing visions for the future mobility needs of people and goods for a 30 year time horizon, as it was recognised by the Highways Agency that issues such as traffic congestion, global warming and environmental sustainability required forward planning beyond the typical 5-10 year horizon. This

[2] A more complete outline of this project is provided in Appendix 2 of this report. See also the Vision 2030 project website: http://www.transportvisions.org.uk

project developed three main scenarios which, although attainment of any of them is unlikely, indicate a direction in which society and governments could go in the next two to three decades. These scenarios, named “Control, Harmonise and Plan”, “Global Economy” and “Sustainable Lifestyle” are depicted in Figure 1 below and are explained in Chapter 3.1 “High Level Scenarios”.

These three scenarios have been used in this INTRO report as a base from which to explore possible structures and trends. Figure 1 summarises the scenarios, trends and visions covered in this report, with the three Vision 2030 scenarios shown as the corners of the triangle. Realistically, the future will not be one of these “extremes”, but somewhere in-between them, within the triangle. This is more fully discussed in Chapter 3.3 “Policy and Scenarios”. Feeding into these visions at the top of the figure are the drivers for change and at the bottom are a set of visions for intelligent road which emanate both from the from the drivers and from the socio-political scenario mix.

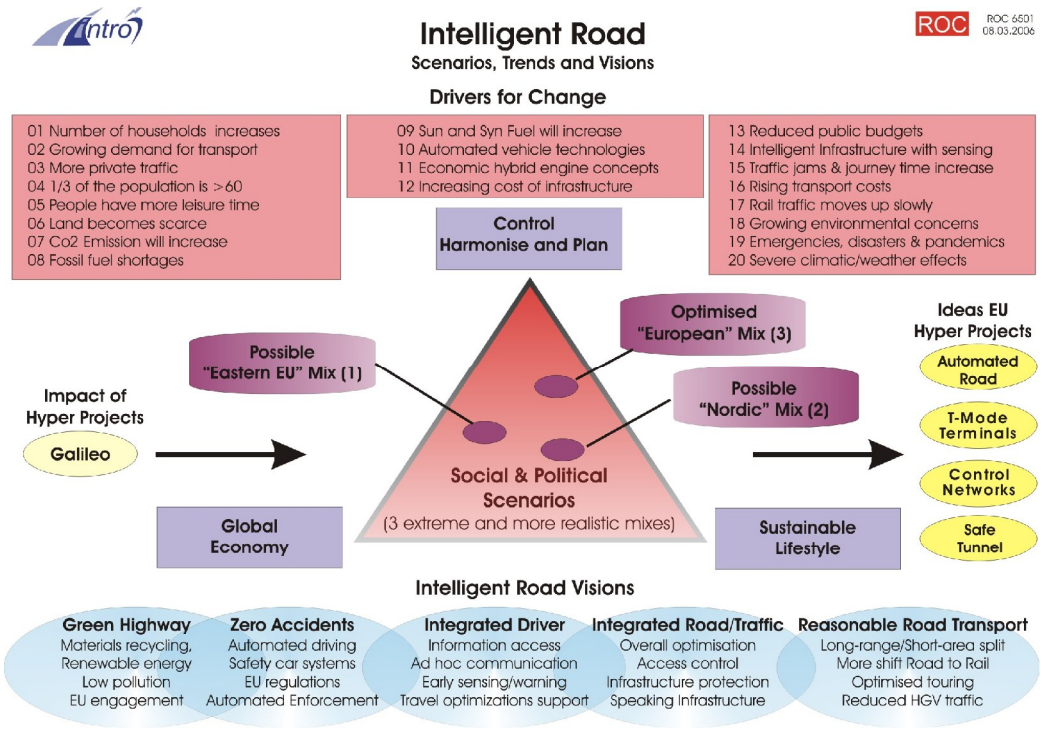


Figure 1. Intelligent road solutions – effects, circumstances, visions and solutions

This report, as part of INTRO WP1, represents a scoping study exploring possible scenarios and likely trends. It feeds into a separate, later, task within the INTRO project (WP5 – Clustering, dissemination and implementation), in which a report on visions will be produced. This Visions report will use the present report as a base and go on to develop a range of more concrete scenario mixes and visions on intelligent roads, based also on national experiences and from focused discussions in a workshop with experts from the INTRO project and external to it (organisation and moderation by INTRO WP5).

2 TRENDS AND DRIVERS OF CHANGE

2.1 Introduction

Time and space is changing, innovation cycles and time constants become shorter, revolution of information technology, the economic status of population is changing (e.g. more leisure travel, - often over long distances, aging of drivers distribution, more unemployed people in Europe). On the other hand, there are few possibilities for increasing road infrastructure in urban areas (and often elsewhere as well, due to environmental reasons). Trends in business travel demand could either increase, due to greater globalisation and businesses covering markets with a wide geographical spread, or it could fall, due to increased use of technology, increased e-working, etc.

This chapter provides a brief overview of some of the main travel and traffic trends in Europe at the current time, before going on to look at main policies at EU and national levels relating to intelligent roads. Future trends in a range of areas (traffic, safety, infrastructure, etc) are then discussed.

“Trends” looks at drivers of change. Different trends in different domains have to be considered in the anticipation of future:

- Technological developments on a microscopic level, miniature sensors (e.g. micro mechanical acceleration sensors), highly integrated processors and wireless communication kits, as single units or embedded in one integrated module;
- Technological developments on a system level, including vehicle design, automated vehicle systems (sensors, actuators and control units) and intelligent infrastructure with sensing, communication and warning; both technological developments will lead more and more to automated or semi-automated driving;
- Technological developments for short range, medium range and long range communication including ad hoc networks;
- Lifestyle and population changes (e.g. developments from the bike to motorbike, to car, to luxury car/multi-car households; an ageing population with more elderly drivers; smaller households and more dispersed families leading to more transport demand, more leisure time and holidays, etc);
- Economic developments and management of energy (consumption and its sources) combined with changes in costs;
- Environmental issues, including regenerative energy usage, as well as increasing temperature (Greenhouse effect) and pollution controls and climate change;
- Safety issues, including accident rates and severity, control measures (technological and legal), education and attitudes, etc;

- Changes in production distribution processes (future more in depth production with full coverage in areas versus dislocated production spread across different geographical locations world/European wide) and freight transport in general depending on the distribution and clustering of labour costs (which was a dominant factor for factory and labour shifting and increased transport volumes).

2.2 Current and future trends

2.2.1 Overview

As visible from today's point of view, several trends (some definite, others likely) can be firstly summarised and presented in Figure 1 "Intelligent road solutions – effects, circumstances, visions and solutions", as follows:

01 Number of households increases
02 Growing demand for transport
03 More private traffic
04 A third of the population will be over 60 years old
05 People will have more leisure time
06 Land becomes scarce
07 CO_2 emissions will increase
08 There will be shortages in fossil fuels
09 Use of solar and synthetic fuel ("Sun & Syn") will increase
10 More automated vehicle technologies
11 Economic hybrid engine concepts
12 Increasing cost of infrastructure
13 Reduced public budgets
14 Intelligent Infrastructure with sensing will become common
15 Traffic jams & journey time increase
16 Rising transport costs
17 Use of rail increases up slowly
18 Growing environmental concerns
19 Emergencies, disasters & pandemics could become more likely
20 Severe climatic/weather effects

2.2.2 Most Severe Trends

2.2.2.1 Energy Change

Conventional fuel resources are finite and sometime in the future petrol and diesel for road transport will become increasingly in short supply, leading to dramatic increases in costs. Scarce fossil fuels could be partially replaced with bio-fuel and synthetic fuel ("Sun and Syn" fuel). Vehicles must use alternative energy sources and be more and more efficient, however although major advances have

been made in fuel efficiency, mass production of road vehicles running on alternative fuel is not yet the case and is unlikely in the short-term. These developments are not yet promoted as necessary.

2.2.2.2 Vehicle Change

Single vehicles have already evolved from being purely “mechanical” to being “electromechanical”, with computer control. This is likely to evolve further to become an “interactive information, communication and sensor/actuator controlled driving system”, increasingly supporting the driver and automating the driving process on different levels (from trip planning to real time driving control). First projects with “Cyber cars” which drive themselves automatically have been tested and are under further development.

2.2.2.3 Road and Traffic Change

Road infrastructure, at least for key parts of the network with heavy traffic flows, are likely to change to intelligence-embedded layers, and infrastructure will be more protected from deterioration (life cycle cost reduction) if automated nation-wide HGV control networks are implemented, together with optimised pavement status supervision and maintenance systems.

Interactivity between vehicles and the whole dynamic traffic flow on different levels will increase step by step to achieve more safe and co-operation controlled driving. The current traffic management centres will be complemented by in-situ and ad hoc traffic co-ordination and control systems, including enforcement of violations.

2.2.2.4 Infrastructure Operation Change

Infrastructure cost allocation and schemes will change: in the future, users are likely to be increasingly charged according to driving patterns, time slots, demand and supply of road space and infrastructure maintenance and operation costs. Marginal cost pricing for infrastructure is part of EU policy and several national governments are already investigating electronic road pricing (beyond that which already exists on toll motorways).

2.2.2.5 Goods Transport (HGVs on roads)

If current trends continue, freight transport and quantities of HGVs on road networks will dramatically increase, unless considerable measures for stabilisation are introduced. The situation on the roads is becoming less and less acceptable to private and commercial drivers, fleet operators and industry (delay, no access, rest areas overcrowded by trucks, increasing rate of fuel use in traffic jams, longer driving time, road works, etc).

It is clear, that a multi scope regulation has to be undertaken on EU level to reduce the negative effects, make road transport reasonable, and shift more long distance transport to other modes (e.g. rail). Stabilisation and achieving the EU’s aim of “modal balance” will be a long term task.

2.2.2.6 Driving Access Change

Availability and access to the road networks, or at least the busiest parts, will eventually change from a more or less open unlimited road system to a limited, rationed or pay-by-use access system.

Governments and administrations may in future limit the number of vehicles (e.g. as is done in Singapore) and introduce personal driving contingents e.g. in km/year, in addition generally restricting the road use in terms of allocated amount of mileage or time slots per person on busy roads (motorways, urban roads, etc) and/or at peak times – such rations or rights to use certain networks at certain times could possibly be bought and sold as tradable benefits.

2.2.2.7 Safety Change

Road safety is a key political issue and the EU White Paper on Transport gives a stated policy aim to halve the number of deaths on the roads between 2000 and 2010[3]. While there has been some reluctance by some countries to implement automated control and enforcement in the past, the reductions in accidents and casualties brought about by increased control and enforcement systems have proved their worth and there is increasing public recognition that some "freedom" needs to be sacrificed in order to significantly reduce accident rates. Increased control and traffic management is almost certain in the future, which will result in traffic flow becoming smoother and safer. Driving would thus become more homogeneous and efficient, and a convergence of main international traffic rules is possible in the future. Co-operative driving and platooning of vehicles are likely to be introduced on a higher level.

Road traffic safety improvements through ITS-based measures may come from intelligent road infrastructure (such as applications within the scope of the INTRO project), from intelligent vehicles and from intelligent control (FAIR project). The optimal solution is to combine all the three – these "three columns for safety" are illustrated in Figure 7 (Chapter 2.2.4).

2.2.3 Traffic

Traffic trends and forecasting is the subject of numerous studies in every country and how traffic evolves in the future depends on a whole range of influences which cannot be fully covered here. This sub-chapter provides a brief overview of current trends at European level in passenger and freight transport, using a small selection of indicators, particularly ones which relate traffic volumes to road supply. Even these are indicative, as there is no single European way of measuring road capacity and the effects of high traffic volumes differ depending on the traffic spread across different routes and by time period. It then goes on to look at possible trends which may result from cost and supply changes, from various policies to control or restrict traffic, and so on.

[3] European Commission, "White Paper – European transport policy for 2010: time to decide"

2.2.3.1 Current Trends: Freight Traffic by Road

Road freight traffic, both in terms of tonnage and modal split, has risen significantly in the EU in the past decade. Figure 2 below, which covers the EU-15 only, shows that tonne-kilometres of freight on Europe's roads doubled in the twenty year period from 1970 to 1990. More recently, the rate of growth in the EU-15 has slowed but only marginally, e.g. there was a 91% increase in tonne-kilometres in the 22-year period from 1980 to 2002. Recent growth has been higher in the New Member States, although precise figures over recent decades are not available for comparison.

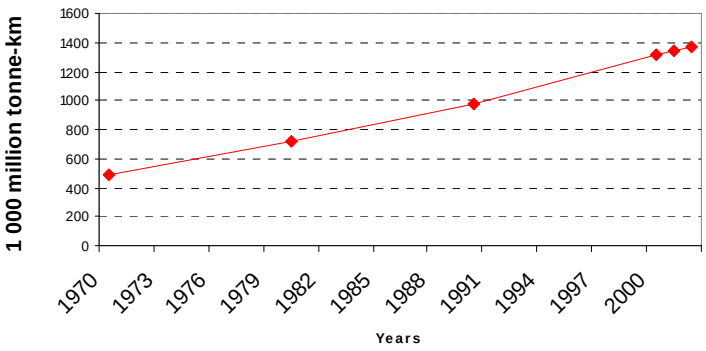


Figure 2. Evolution of haulage on European territory, EU-15[4]

The total evolution of freight haulage for the EU-15 is shown in Figure 3. Although the amount of freight hauled in tonne-kilometres clearly relates to the size of the country, the increases are of interest, with the greatest absolute increases being in the two largest countries, Germany and France, but with a significant percentage increase in Spain, compared to, say, Italy.

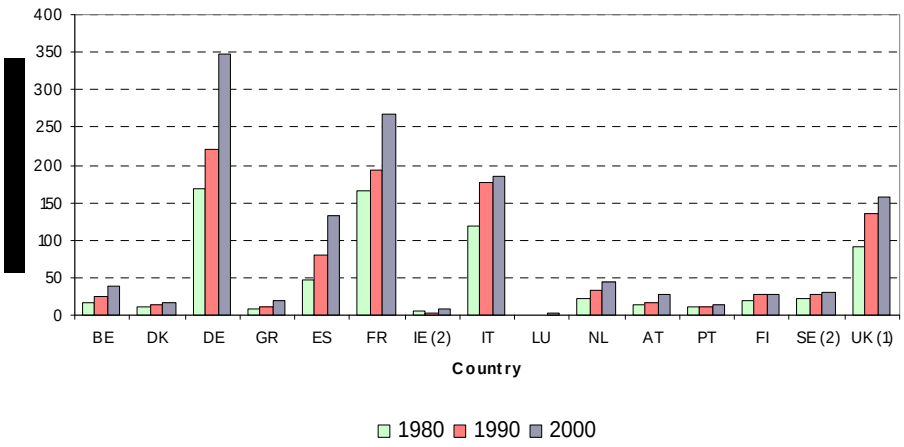


Figure 3. Evolution of haulage on national territory, EU-15[5]

[4] Source: EU Energy and Transport in Figures, Statistical Pocketbook 2004

Key to Figure 3:

(1) national operators only
(2) national haulage by national operators only.
UK data refers to Great Britain only

Increases in percentage terms are however clearer in Figure 4 (p 16). Increases of over 100% from 1970 to 1990 have been experienced in all EU-15 countries with the exceptions of Sweden and the UK (although data from these countries are for national operators only, therefore the increase in cross-border haulage in Europe since the 1970s would imply that total figures would be much higher). The massive increase of freight transport on the roads of Luxembourg, particularly since 1990, is a special case, given the small size of the country and its location on a number of trans-European corridors, as well as having the lowest fuel prices in Western Europe, thus inciting hauliers to route via Luxembourg where possible in order to fill up cheaply.

The next greatest increases in percentage terms have been in Spain and Greece, reflecting the economic transformation of these countries since the 1970s, as well as, possibly, the relatively weak position of their rail networks. The major increase in Austria from 1990 to 2002 is clearly due in no small part to the opening up of borders with its eastern neighbours since 1990.

Although comparable figures are not available for the New Member States or other European countries over the same timescale, increases in road freight transport in the former communist countries in recent years has been significant. For example, in 1998 the (then) candidate countries already exported more than twice their 1990 volumes and imported more than five times their 1990 volumes. Eventually, the rate of increase will begin to slow down, as is now happening in many western European countries, as the level of demand stabilises, and increased fuel costs, congestion and competition lead to carriers becoming more efficient (e.g. more return loads, less empty running), although increased electronic commerce, allowing customers to order goods from a long way away and thereby increasing freight transport by road, means that countries with rapidly changing economies such as those in Central and Eastern Europe will continue to see significant increases in freight haulage in the coming years.

As an example of freight traffic previsions in New Member States, the volume of HGVs (number of trips) in Poland (excluding Warsaw) is expected to rise by 75% from 2005 to 2015, and by 104% from 2005 to 2020. Within Warsaw, the forecasted rises in heavy goods traffic are 29% (2005-2015) and 43% (2005-2020)[6]. Other data from the respective national ministries of transport predict a 57% rise in freight tonne-km from 2005 to 2020 in Poland, 29% in the Czech Republic, 47% in Hungary and 35% in Latvia. Significant increases in some Western EU countries are also expected, e.g. a 37% rise in road freight tonne-km in Germany from 2005 to 2020, 34% in France and 27% in Denmark[7].

[5] Source: EU Energy and Transport in Figures, Statistical Pocketbook 2004
[6] Source: W. Jastrzębski, "Traffic Modelling and Forecasting" – BPRW S.A., March 2004
[7] Source: Eurostat. See Appendix 1 for details.

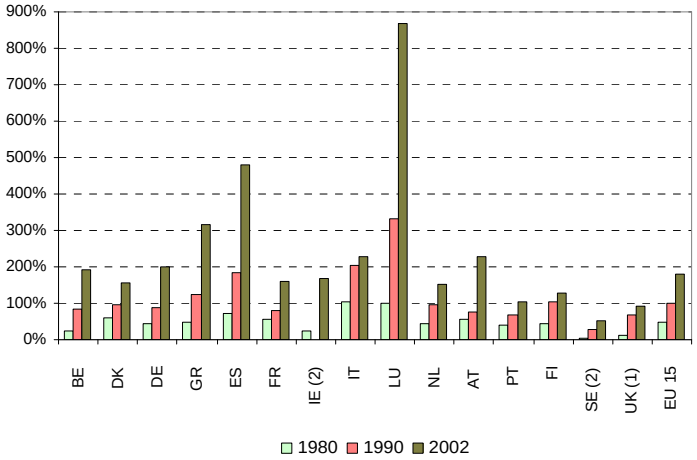


Figure 4. Percentage of Haulage (tonne-km) Increase on National Territory since 1970 (EU15)[8]

Key to Figure 4:

(1) national operators only
(2) national haulage by national operators only.

UK data refers to Great Britain only

Figure 5 gives a broad indicator of road network use (and likely congestion or capacity problems) for the EU-15 by comparing the freight tonne-kilometres hauled on national territory for each Member State with the length of the road network.

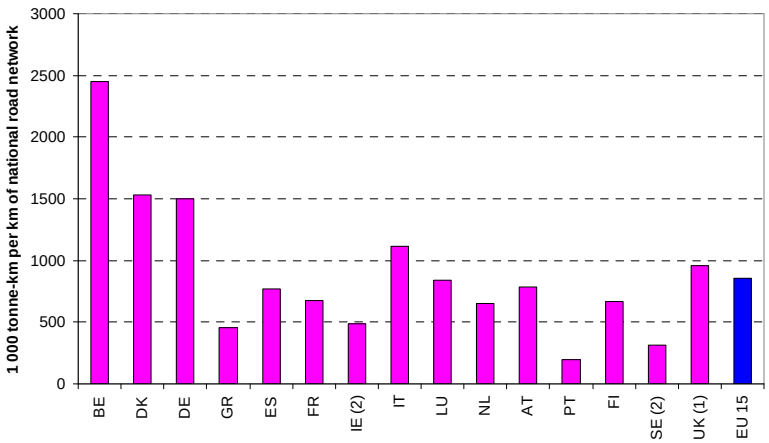


Figure 5. National freight haulage (tonne-km) by total length of the national network (Year 2000, EU 15)[9]

[8] Source: EU Energy and Transport in Figures, Statistical Pocketbook 2004.

The road network is taken to be motorways, primary and secondary roads, but minor (local or municipal) roads have been excluded, as some countries have a dense network of small roads which carry a very small proportion of traffic. Although these figures are only indicative (the definition of what is a primary, secondary and minor road varies by country, and is generally based on which authority is responsible for the road rather than the quality of the road, its capacity or the amount of traffic it actually carries), the density of traffic in Belgium is the greatest, unsurprising as this is the most urbanised of the EU-15 and has the densest motorway network, as well as significant port and transit traffic. Freight traffic is least dense in the more peripheral countries: Portugal, Sweden, Greece, Ireland and Finland.

2.2.3.2 Current Trends: Private Car Traffic

A comparison of passenger-kilometres by car with the length of the network per country, similar to the figure for freight in Figure 5, is given in Figure 6 (data available for 20 of the EU Member States). Again, Belgium has the most intensively used road network, followed by Denmark, Italy and the UK. Several New Member States (Czech Republic, Hungary and Slovenia) have a low density of car traffic on their networks, although this is not the case in Slovakia. Although this figure is only indicative (e.g. it does not distinguish between the capacity of different roads or the spread of traffic between densely trafficked and lightly trafficked parts of the network), it gives an indication of the level of increase in passenger car traffic which might be possible in countries such as the Czech Republic and Hungary if car ownership increased to EU-15 average levels (e.g. from 357 per 1000 persons in the Czech Republic or 249 per 1000 in Hungary to the EU-15 average of 491 per 1000).

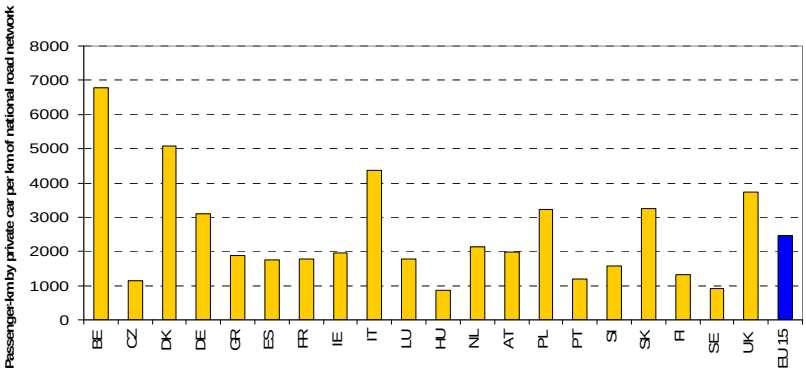


Figure 6. National passenger traffic by car (passenger-km) by total length of the national network (Year 2000, EU 20)[10]

[9] Note: "National network" comprises motorways, primary (national) and secondary (regional/provincial) roads, but excludes local roads. Source: EU Energy and Transport in Figures, Statistical Pocketbook 2004.

[10] Note: "National network" comprises motorways, primary (national) and secondary (regional/provincial) roads, but excludes local roads. The following 5 EU Member States do not feature in this graph (due to the lack of corresponding data): EE, CY, LV, LT and MT. Source: EU Energy and Transport in Figures, Statistical Pocketbook 2004.

Forecasted increases in passenger car traffic are generally higher than for freight traffic by road. Again, in Eastern European countries where economies are changing the fastest, car ownership and use is increasing at a rapid rate, for example in Poland (excluding Warsaw), the number of car trips is expected to rise by 76% from 2005 to 2015, and by 130% from 2005 to 2020. Within Warsaw, the forecasted rises in car trips are 40% (2005-2015) and 63% (2005-2020)[11]. In Slovenia, the rate of car ownership is now higher than the average for the Western European (EU-15) Member States.

Although in countries which are experiencing rapid economic growth, particularly in Eastern Europe, increases in car use are partly due to modal transfer from public transport, as more people own cars, in Western Europe, particularly those countries with a well developed public transport network, increases in car ownership are less dramatic and increases in car use generally result from more and longer trips rather than transfer from other modes. The major causes of increased car usage are:

- Increased and longer distance commuting by car, caused by high accommodation costs in cities and citizens' desire for an improved quality of life;
- Increased trips for shopping/leisure and commuting to businesses located out-of-town in zones which are difficult or inefficient to serve by an attractive public transport service, such as industrial parks, shopping centres and leisure complexes located close to motorways;
- More wealth and leisure time leading to greater car use for day trips and holidays;
- A more dispersed social structure caused by increased mobility and wealth, where people's families and friends do not necessarily live in the same town or region and the car is increasingly used for social visits;
- An increase in older drivers: an average 70 year old today (born in 1936, learned to drive in the late 1950s or 60s) is much more likely to be a car owner and driver than a 70 year old in 1985 (born in 1915, probably did not learn to drive in the 1930s, etc). This trend is increasing due to longer life expectancy and the trend for people to retire in more rural areas where a car is necessary.
- More motorways and better quality interurban roads "shrink" distances, so people think nothing of visiting distant locations for a simple purpose (e.g. to buy something), that would have been considered a major expedition two or three decades ago.

Interestingly, the first five of the above bullets relate to social, demographic and economic changes completely unrelated to road infrastructure and transport policy. Market economics, and particularly the free market in property prices and the ability of large enterprises to invest in out-of-town sites, have been the major factor in increasing car use in Western countries in the last two decades. In countries such as those in Eastern Europe, where such changes in property prices and land use are now taking place, the effect on road traffic will be similar.

[11] Source: W. Jastrzębski, "Traffic Modelling and Forecasting" – BPRW S.A., March 2004

2.2.3.3 Future Trends: General

Without government controls and regulation (both transport-related, and in other areas such as land use), traffic will continue to increase at a rapid rate, checked only by the capacity of the road networks (i.e. increases will stop once there is regular gridlock on busy networks). ITS to improve traveller information and capacities, such as Variable Message Signs (VMS), internet, information by mobile phone and future Galileo-based applications, can help in terms of advising drivers to avoid problem areas, but ultimately road ITS will only delay the point at which saturation is reached and incite drivers to choose alternative routes (or alternative departure times, or even alternative destinations), thus spreading congestion to other routes and time periods, rather than reducing traffic or congestion.

2.2.3.4 Future Trends: Freight Traffic by Road

Goods traffic by road will continue to increase in spite of government and EU measures to promote other modes, and particularly intermodality with rail and waterborne transport. Decentralisation of production and relocation of businesses to areas where land and/or labour is cheaper, or where taxes are lower, will continue as long as transport constitutes only a small part of the total industry costs (which is the case almost everywhere except for heavy industrial production, and even for heavy industry there is often considerable long distance transport of bulk loads). The opening up of Europe, the expansion of the EU and the reduction/elimination of trade barriers are major factors in increasing long-distance international freight transport, almost all of this by road. Even if prices and wages across Europe eventually converge, there will still be major differences (even within individual countries there are major discrepancies).

Intermodality measures coupled with deterrents such as lorry charging set at high levels can reduce this expected increase insofar as long-distance freight transport is concerned. On the other hand, there is no practical alternative to road over shorter distances and increases in home shopping (by internet, etc) will only lead to more goods vehicles on the roads, albeit mainly smaller vehicles (vans).

Stricter enforcement of laws such as driving time restrictions do not reduce road transport, but cause temporary capacity problems such as the saturation of motorway rest areas by lorries due to drivers needing to take their obligatory break. There are also parking capacity problems near borders due to differential restrictions on HGV circulation (weekend bans) in different countries, and unless different Member States and regions can agree on common restrictions (or a relaxation of restriction), this problem will continue to increase. Replacing lorry bans with different charging levels may be one solution, e.g. allowing lorries to drive in France at weekends but charging them much more to do so.

2.2.3.5 Future Trends: Private Car Traffic

In addition to congestion and gridlock, one other factor which could eventually reduce traffic in a free-market environment is rising fuel costs as fossil fuel reserves become depleted. Without government intervention however, changes are unlikely to be great in the medium term, as fuel costs, even with rapidly rising prices, still represent only a small part of the overall costs of road use (most costs are fixed: vehicle costs, insurance, maintenance, etc), although they are perceived by users as the main

cost (as fixed costs are paid whether the vehicle is used or not). Fuel price rises also affect public transport, with many fare rises in Europe being due to fuel cost rises. Therefore, without government intervention, fuel cost rises will not make public transport more attractive compared to the car.

A reduction in road traffic can only be achieved by action on the part of Governments and other public authorities. While some individuals may opt for a “green” car-free lifestyle, this will only be a small minority. Other people will only change if forced or incited to do so. Future trends therefore depend to a very significant extent on how radical and proactive governments can be in taking action to change travel habits. Obviously in any democratic society, governments are reluctant to adopt extreme measures such as tolling or restrictions if they are not popular with the public. The motoring and road freight transport community is politically vocal throughout Europe (as has been seen with fuel price protests, lorry blockades, etc) and major political parties fear losing votes to their rivals over such issues.

One of the most common methods of traffic restraint, with the benefit of also raising revenue, is road tolling. In most areas where this has been implemented (mostly motorways, major bridges and tunnels), the aim has been to pay for capital investment rather than to reduce traffic. For a private or semi-private toll road operator, it is not in their interest to reduce their traffic. There are also shifting effects where tolled roads are avoided and alternative routes used, as has been seen in the case of recent increases in HGV traffic on German federal and state roads parallel to motorways, following the introduction of heavy vehicle electronic tolling on the motorways.

Traffic demand can only be suppressed by area-wide tolling (e.g. for a city) or corridor-based tolling (where motorways and parallel alternatives are both tolled). The former has been implemented on any scale so far in London and some Norwegian cities and the current test run of road tolls in Stockholm City might be mentioned. The latter is proposed, for example, in Slovakia. Restraining demand by closing roads or zones to general traffic and allowing only access to authorised users (e.g. deliveries, residents, essential services, etc) is another strategy, as has been implemented in central Rome.

While the urban road pricing in the UK and Norway have generally been regarded as successful, and several other cities are planning schemes, there is still a political reluctance to introduce tolling on roads which are at present free to use, or introducing traffic restrictions on a wide scale. This is exemplified in the 2005 referendum on road user charging in Edinburgh, where citizens firmly rejected the City Council’s proposal for a road user charging scheme. The key issue is that, in a democratic society where most voters can drive and own a car, policies on traffic restraint or charging are likely to be rejected if put to the vote, even if people realise that some radical action is necessary to curb congestion.

In urban areas and key interurban corridors, the “carrot” of fast, efficient and cheap public transport can be used to incite modal shift. Once an effective alternative is in place, greater traffic restrictions can be easier for citizens to accept (for example the pedestrianisation of large parts of the centre of Strasbourg following the construction of the tram network in the 1990s. However this requires

significant investment and in areas of more dispersed housing and economic activity, an efficient high-intensity public transport service which is more attractive than the car is impossible to provide.

Given the political will, adding intelligence to roads (both urban and interurban) can promote modal shift through information provision (publicising park-and-ride sites, etc) and intelligent charging (higher fees for roads which follow a public transport corridor or at peak times, low fees or no fees where there is no attractive alternative public transport service, or at periods when public transport does not run, such as at night).

Car pooling, the shared use of a car, in particular for commuting to work, often by people who each have a car but travel together to save costs, is one of the "soft" measures promoted by governments. Measures include special facilities for car-poolers, including high-occupancy vehicle (HOV lanes) lanes specifically for multiple-occupancy cars. Given that most cars are designed for a maximum of 4-5 persons but only are occupied by 1 person, car pooling has a great potential to improve the capacity of congested traffic corridors in cities, with minimal investment in infrastructure. Higher occupancy rates also can reduce consumption of fuel. There are also recent increases in public passenger transport use, following a long decline, particularly in Western Europe, where more people are using public transport by choice (i.e. they have a car available). This is particularly the case in countries like Austria, Switzerland, Germany and the Nordic countries, where car ownership and living standards are high but public transport is well used and attractive. In other countries, such as France and Spain, major investments in high quality (rail-based) urban public transport are succeeding in encouraging car users to change mode and in the long run, given a willingness on the part of authorities to provide and fund attractive and cheap public transport, the rest of Europe could move towards the Germanic/ Nordic model whereby wealth and high car ownership does not necessarily mean more traffic.

However, while multimodality and improved public transport is a stated policy goal of most governments, for political reasons the emphasis is mostly on "soft measures" and "carrots" rather than "sticks". Without some form of restriction or pricing, together with tighter rules on land use planning, traffic will continue to increase and ITS will only delay the point at which the system breaks down and provide better crisis management for operators rather than solve any problems. As a significant amount of public transport is by bus (the majority in most cities), this will adversely affect public transport performance too unless there is a very high level of bus priority measures: for a car ownership there will be no incentive to take the bus as they will end up in the same traffic jam.

2.2.3.6 Future Trends: Network Operations, Maintenance and Traffic Management

From the road operator's perspective, the interviews carried out in Task 1.1 of the INTRO project (see Deliverable 1.1[12]), confirm that all operators deal with this problem today. But depending of their operating financing, they do not have the same vision. While the network is subject to toll collection, the operator is not trying to reduce road freight by trucks, as this traffic is generating an important revenue stream (exceeding the pavement maintenance costs they impose). On the other hand, public

operators financed in other ways than toll collection are often not able to sufficiently fund the desired level of maintenance of their network that is becoming increasingly stressed by HGV traffic.

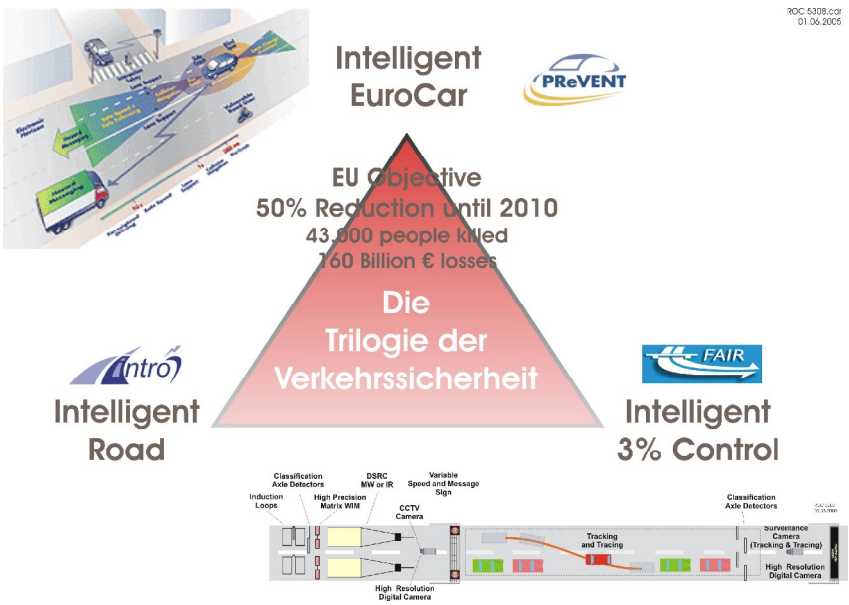
As long as there is a differential set up in some countries, with a mix of public (free) and private (toll) roads, there will be major differences in the level of maintenance, safety and "intelligence" between them. In some private concessions, the concessionaire is awarded a parallel piece of existing infrastructure as well as a motorway to be constructed, and are responsible for both. This "packaging" of ordinary roads with toll motorways, or letting concessions on a regional network basis, could increase in the future, as a mechanism for allowing cross-subsidy from "profitable" motorways to improve maintenance and quality on the "classic" network.

2.2.4 Safety

The awareness of traffic safety requirements in Europe is increasing and has now become a high level political, social and economic objective. Different programmes and public (eS*afety*) and industrial initiatives are started and this is expected to lead to more enforcement in the future. Road traffic safety improvements through ITS-based measures may be based on three aspects, coming from:

- intelligent road infrastructure (such as applications within the scope of the INTRO project);
- intelligent vehicles; and
- intelligent control.

The optimal solution is to combine all three elements – these "three columns for safety" are illustrated in the following figure. Drivers education and behaviour must not be forgotten and is the fourth the parameter (not content of this report).



[12] R. Opitz, A. Winder et al, ***"Intelligent Road Systems – Consolidated State of the Art and User Needs"*** - INTRO project Deliverable 1.1, October 2005.

Figure 7. The “Trilogy of Road Safety”

The desired effect will be for traffic to become more smooth and safe due to increased controls and traffic management. The three elements are different in their implications, short and long term effects and time horizon (source ROC).

As a first realisable initiative with a high active power, **integrated networks of automated control station**s are expected to be used to supervise the traffic in specific areas over longer distances, using a number of criteria and measurements, as illustrated by the figure below.

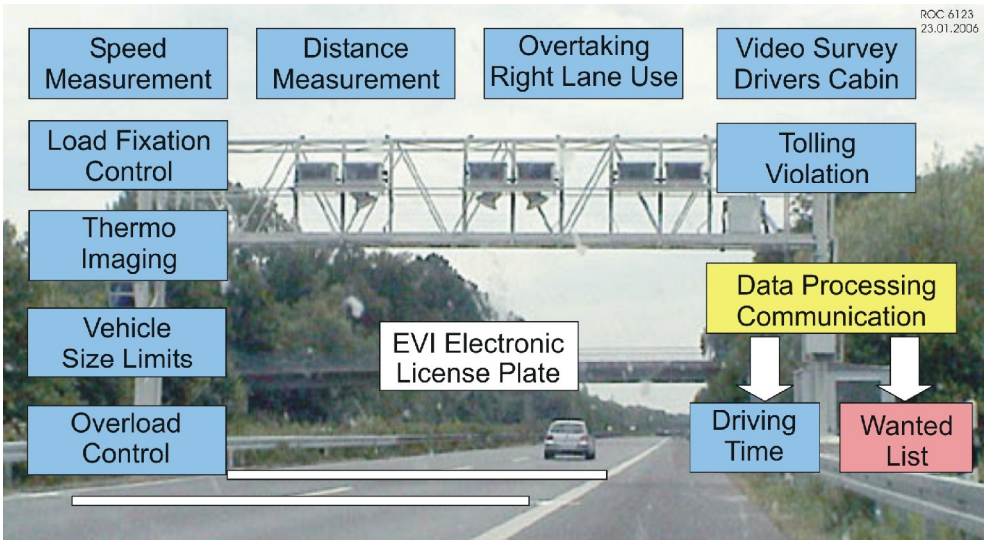


Figure 8. Possible automated control and enforcement system (FAIR project)

Vehicles will be more intelligent and support the driver or finally automate the driving process even in co-operation with other vehicles. This will make driving safer, more homogeneous and efficient, and traffic rules will be more respected due to widespread automated enforcement and/or driver aid systems. Co-operative driving and platooning of vehicles is likely to be introduced on a higher level and automated lanes/roads could be introduced.

Although purely in-vehicle equipment is not within the scope of the INTRO project, systems such as alco-locks, fatigue or sensory deprivations detectors (monitoring eye movements), improved passive safety devices and speed limiters are likely to increasingly appear in vehicles. They may in future be made obligatory in new vehicles. Another, less prescriptive, solution would be that their use will be encouraged by means of offering lower insurance premiums to drivers of cars with such safety/control equipment.

Infrastructure will become more intelligent – if current trends continue, the use of sensors and floating car data information giving the status of the road conditions and optimising maintenance will become widespread. Firstly more analysis of the relation between road infrastructure / facilities and road accidents is required, that means a better and transparent correlation of road parameters (skid

resistance, crossfall, gradient, texture, roughness, curve radius, etc) belonging to a certain accident locality.

Increased Road Safety Audits (RSA) and Road Safety Inspections (RSI) are possible:

A Road Safety Audit is a formal safety performance examination of an existing or future road or intersection by an independent audit team. Road Safety Audits can be used in any phase of project development from planning and preliminary engineering, design and construction. RSAs can also be used on any sized project from minor intersection and roadway retrofits to mega-projects[13]. The benefits are: Safety evaluation of plans and alternatives before realisation; Ensuring new planning and refurbishments are optimised with regard to safety aspects; Prevention of subsequent adjustments or renovations; Highest possible safety for all traffic participants[14].

A Road Safety Inspection is a safety check on existing road sections by conducting accident analysis and uplifting plenty of parameters[15]. Benefits are a minimisation of accident risk on existing roads; Detection of problem areas before accidents happen; Analyses of the road infrastructure (measuring of road parameters) for detailed crash-causes-research.

Traffic Management

A traditional approach to accident analysis is to look at the problems that occur at so-called “black - spots”. Black-spots are sites where accidents occur most frequently. The positions of these black spots are calculated from accident data. The criteria that determine what site qualify as black spots differ from country to country and are generally becoming stricter.

Standardisation and loading of data (e.g. involvement of age groups of road users, registration numbers of vehicles, traffic volumes, etc.) for transparent for more significant statistics and analysis is required and will be improved.

However, research and actions in the future are unlikely to focus just on black-spots. In Austria, for example, 23% of car accidents causing personal injury happen at black spots. Hence 77% of the accidents are ignored by just the researching the accidents happened on the black spots. It is plausible that groups of similar accident sites exist, of which none is a black spot. Such a group of almost identical sites together could be called a “virtual” back spot, which is not seen as a black spot by traditional accident research, because it does not identify these sites as similar.

More automated measures and control is likely to be introduced (traffic management content will change from “nice to have” indications, information and recommendations to a professionally supervised and controlled traffic system with efficient enforcement of violations:

[13] www.roadsafetyaudits.org
[14] www.unfallforschung.at
[15] www.nast.at

- Variable speed limits: Much more practical than trying to set a single speed limit for some stretches of road, is the concept of variable speed limits indicated by signs controlled by a computer automatically or operated manually. These signs can be programmed to reduce speeds during conditions of low visibility, slippery roads, heavy traffic, etc. Variable speed limits are already appearing on major roads throughout Europe and in the future all major roads could have this facility.

- Intelligent Speed Adaptation - ISA is a system of in-vehicle speed limitation. For it to be effective, it requires that the vehicle is accurately located and provided with information about the speed limit on the road. This can be achieved through a combination of a Global Positioning System and a digital road map. It also requires a link with some or all of the elements of the vehicle's power train: throttle, ignition, fuelling system, gearbox and brakes. This link is similar to the system of Adaptive Cruise Control, common on many new vehicles in Japan and recently launched by a number of manufacturers in Europe.

- Highway markings and traffic control devices: e.g. “smart” traffic signals with sensors can delay a green light, when the speed of an oncoming vehicle on a side street is too fast to permit it to stop, and delaying the green light can avert a collision. Stop signs and give way (yield) signs that broadcast an alert tone over a motorist’s audio system can warn the driver that he or she is about to “run” the sign. Electronic rumble strips can warn fatigued, inattentive or otherwise impaired drivers to stay in their designated lane or prevent them from travelling the wrong way on off-ramps and thus avert serious and fatal crashes. All of these systems are likely to be deployed more and more on intelligent road networks.

- Intelligent Vehicles and Highway Systems: It will eventually be possible on dedicated express lanes in urban areas to virtually put a vehicle on “autopilot” during commuter rush hours. Built-in radar and other electronic devices will keep vehicles from following one another too closely and even control speeds to prevent the speed variation that is the cause of most speed-related crashes. This new technology has the potential of halting dangerous high-speed pursuits, spotting stolen vehicles, and directing lost motorists.

- Section Control: Subsequently a camera system equipped with an infrared flash unit takes a picture of the license plate. At the same time the system records the time of entry and the date. The information gathered is then evaluated by an OCR (Optical Character Recognition) software. Section control has already been deployed in some countries (UK, Netherlands, Sweden, etc) and is likely to replace traditional speed cameras in future on sections of major road and motorway.

- Continuous long range traffic supervision and control is likely to be the main scenario in the future[16].

Driver Education

Education has always been, and must remain, a vital component of traffic safety. Traffic safety education has been reinforced in the past and this will no doubt continue (shaping of opinions about traffic safety). Along with harmonised regulation engineering, clear practices in the EU and enforcement procedures, the following measures are foreseen:

- Driver Education for younger drivers (who have the highest accident rates) and older drivers: This will teach how to cope with co-operative driving scenes, in expectable situations and on the other hand with declining vision, hearing and reflexes. Motor vehicle licensing authorities in the future must make more frequent use of periodic driver re-examination of older drivers, and make greater use of medical review boards.

- As trans-European traffic increases, the complexity, number of rules, divergence, different reasoning, interpretation, lack of measurability, etc caused by different road and traffic legislation in each country will need to be addressed. Reasonable EU core traffic regulations and harmonised fining of violations have to be generated. This is already happening, for instance, with cross-border violations (bilateral agreements, and a European Memorandum of Understanding in process[17]).

Effects of safety trends

- The number of accidents and causes is expected to be reduced and the severity of accidents will decrease (number of persons killed and injured).

- Cars become even safer (currently improved and good passive safety will added by active preventive safety). The next car generation will become more driver-friendly, assisting, informing and dramatically changing driving procedures.

- Some European countries are already more “advanced” and progressed in the steps of introducing safety concepts. All European countries in the future should be as safe as the best ones (Sweden and UK). European initiatives will promote introducing safety concepts and systems. For the safest countries the Swedish “Vision Zero”, the aim to have nobody at all killed on the roads is the final top priority objective.

- Costs for motor insurance should decrease and not permanently increase, as accident reduction motivation reduces insurances. However, they will not fall to a very low level, as insurance companies live from accidents and increased safety is not necessarily in their own financial interest.

[16] See FAIR project: www.project-fair.de

- People and politicians are increasingly accepting control and automation as the price for higher safety and lower driving costs (even if there is opposition to a new measure, this is increasingly falling away as safety benefits are beintg realised). The introduction of automation will be increasingly promoted and co-ordinated by the EC due to very diverted and different national regulations, practices and introduction schemes.

2.2.5 Financial Aspects

2.2.5.1 Road Authorities and Operators

Planning, construction and operation of road networks and traffic infrastructure and assuring safety (police, rescue services) requires high financial investment and ongoing financial sources. Different financial schemes and business cases are practised.

Different possible trends have to be considered:

- Public investments in infrastructure have been reduced in recent years due to decreasing budgets;
- Road infrastructure network in most EU countries is aging and in the second part of their life cycle and has to be upgraded or renewed;
- Privatisation of road infrastructure can increase the costs (profits for investors), however privatised roads are often in better condition and have lower traffic volumes
- The status of public road network infrastructure might not be able to be conserved in future professionally if not privatised;
- Over-regulation of planning procedures for infrastructure and too many expert reports and studies has to decrease;
- Negative inertia by stiff and restrictive administrations and oversized/old regulations. In Germany €25 million per motorway-km are required, impressively: this includes 15M€ for planning and initial audits;
- Payment schemes for private road operators have to be transparent and to be synchronised;
- Cost allocation schemes have to be analysed and presented in a transparent way: who pays for what, who causes what and who gets what and why;

[17] VERA project – "Video Enforcement for Road Authorities": http://www.veraprojects.org

2.2.5.2 Road Users

Road users generally cannot influence the different costs (fuel, taxes, tolling charges, parking charges, insurance) and in most cases have to accept them (or choose an alternative mode). Financial aspects for road users thus become more and more important (private car drivers, commercial operations of lorries and buses). Increasing travel and transport costs accompanied with less private/company financial sources will have strong effects.

Fuel consumption of new cars per kilometre will continue to decrease and be a major design parameter for the car industry (more efficient engines, hybrid motor concepts and lighter cars) and driving behaviour will be optimised (smooth and foresighted).

Fuel prices, also fuel efficiency of vehicles (cost of driving 100km now compared with 10 years ago, and what the cost might be in the future) are also important parameters.

Public free-roads may become increasingly blocked by congestion and roadwork sites (accidents, road construction works, repair). Losing time and energy and indirect losses will not be accepted by the future driver at such a level.

2.2.6 Infrastructure

The main infrastructure-related trends are as follows:

- Core infrastructure elements and great part of the motorway network are becoming life-expired (particularly bridges and tunnels may achieve the end of their life cycle);
- The state of the road network infrastructure cannot be realistically maintained to a good level of quality given current resources;
- Privatisation of road elements or networks is based on financing demands;
- Money is available for better services and ITS for tolled road infrastructure, but scarce for public road networks, leading to a discrepancy in maintenance and quality between the two types of network;
- Current accident rates are not acceptable and have to be decreased substantially: infrastructure improvements are one way of achieving this, but in many cases lower speed limits are imposed instead of physically treating accident black-spots;
- Permanent monitoring of “lifelines” in terms of safety and usability (maintenance/natural disaster/terrorism) is becoming a key issue for the EU’s road network, with a specific emphasis on monitoring key infrastructural elements like tunnels, bridges and major highway connections, to ensure constant operation and to detect and treat any problem or incident.

The concept of monitoring is now progressing into every aspect of human life. The management of the infrastructure is one of the more recent fields of monitoring, assessment and structural control. Today's monitoring technology supports science and development and subsequently conquers practical applications. Nevertheless any new technology raises further questions and enables practical solutions for given problems.

Technology Management in the field of construction is a precondition for the successful market introduction of new and innovative developments. The long way from the idea to the commercial application shows hurdles consisting of a lack of references, a lack of codes and recommendations, as well as the insufficient information and awareness of decision makers.

Structural Assessment Monitoring and Control, by the year 2020, is expected to play a central role in all aspects of any sustainable infrastructure. The technology will substantially expand on the current concept of "Individual Application" to new paradigms, to be summarised in the following vision statement: *"Europe's infrastructure is sustainable maintained by an environment that enables user friendly, safe, secure and economic management of critical infrastructure systems".*

This vision statement demands that the starting point of the design of future systems and services should be consideration of society's basic needs and interests.

- The hardware will develop from isolated systems into integrated sensor networks towards fully embedded systems. Robust reliable and cheap sensors will be embedded everywhere.
- The methodology will develop from the current isolated methods towards harmonised methods that allow integrating various sources of information and end in standardised methods open to a wide range of users.
- The use of the technology, which is currently performed by experts only, will develop into common software tools and end into embedded freeware in every application supporting decision-making.
- The application will develop from isolated projects with targeted interest towards an integration of all disciplines and ending in full system integration.

The monitoring systems may be characterised as below:

Sensors and Sensor Networks

- Embedded Systems including devices, middleware, software and tools for the construction of intelligent subsystems capable of monitoring and controlling a broad range of structures, appliances and industrial systems, including roads (and also other transport, communications and power infrastructure).

- Standard Hardware is required to gain comparable structural information, enabling comparison between different structures. For example, digital inspection tools are expected to replace the current visual inspection.
- An underlying Neural Network takes care of methods to automatically detect sensor defaults, system failures or environmental exceptions.
- Wireless Sensors with an infinite life, are capable of surviving in harsh environment, have improved accuracy and do not need batteries or external magnetic fields for power supply, relying on harvesting vibration energy to sense information and to wirelessly transmit data.
- Auto Adaptive Systems consider the conditions of the particular structure and environment. The learning system will improve its performance over time.
- Mobile acquisition and assessment systems concentrate on a mobile acquisition unit including sensors, GPS facilities, a converter, onboard computer and a module for immediate assessment included in the software. The connection can be done through wireless transmission means to any control room or Internet Protocol Address.
- Intelligent instrumentation systems allow distributed data collection on large structures. This includes smart interconnection and power autonomy solutions, as well as intelligent interfaces to data networks, including internet access. The measuring network can, for example, collect at least 32 channels of data from over 1 km distance with a sampling synchronization of better than 1 ms.
- Structural damage can be detected by industrial Continuous Monitoring Systems (CMS). These are useful mainly for level-1 damage detection.
- Periodic Monitoring Systems (PMS) integrate the technology for level-2/3 damage assessment. Embedded CMS only covers the needs of relatively recent, long-span, high-cost bridges and that the condition assessment of older, more common bridges requires a Periodic Monitoring System. Such a system can be deployed for a limited time and can move from bridge to bridge. Such system is currently not available.
- Monitoring of non-accessible parts of structures: Novel technologies like acoustic emission, guided mechanical wave propagation, topographic imaging and flexible piezoelectric fibre sensors can be developed and deployed.
- Sustainable Instrumentation, Digital Inspection and Smart Sensor Development based on nano-scale PZT-fibre and film technology: A standard technology is expected to be developed in the future that will enable application to all kinds of structural systems and comparison of them.

Environmental Issues

The objective is to define and formulate the Effect of the Environment on structural condition. The effects of temperature, humidity, exposure to sunshine and a number of other environmental factors influence the lifetime behaviour of structures. The objective is to find and discriminate the distinct relations between a site and environmental effects. A transferable methodology shall be developed and stored in the history database. Simple input from meteorological stations should be enough for future applications.

Safety and Security

Online alert systems as safety relevant applications (it means identification of critical situations due real-time data evaluation, risk assessment as well as predictive modelling) may be established. Knowledge based systems such as a rapid, flexible data mining, pattern recognition and machine learning system that integrates analytical data mining methods for prediction, discovery and deviation detection with data and information visualisation tools.

Life Cycle Monitoring

The link from singular to Integrated Systems can be made by an electronic decision support system based on neural computing technologies. In this context, health monitoring will be similar to human health management, serving as the backbone of an integrated asset management programme at the systems levels from civil infrastructure to automotive bodies.

2.2.7 Chained Dependencies

Events happening on roads as a result of traffic, violation of regulations, environmental influences and changing conditions, ageing of structures and materials and more, are often not stand alone effects and can cause by dependencies a sequence of severe follow-effects.

An impressive example of such “dependency chains”, mostly with negative implications, is the case of overloaded axles of vehicles:

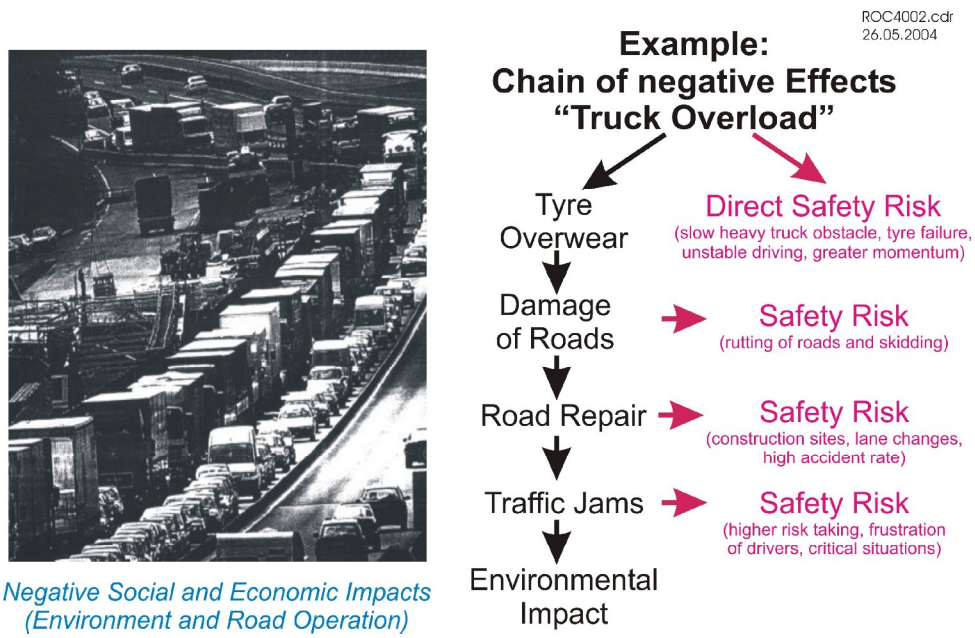


Figure 9. Impacts of overloaded HGV

Transportation by trucks on European roads must be made safer e.g. by future intelligent and self protecting roads. As an absolute minimum, freight traffic should operate legally (now 5-10% of the HGV are overloaded e.g. in Germany and many other countries).

Case example Germany:

If you consider, that 250 000 HGV and 50 000 other heavy transport vehicles are driving on the German road network at any one time, this means that approximately 30 000 overloaded vehicles operate permanently on this network of roads, tunnels and bridges. The negative effects of these violations are impressive:

Road network destruction € (per annum)	costs >2.400.000.000 €	(potential >600.000.000 €)
Accident costs € (per annum):	costs >4.600.000.000 €	(potential >900.000.000 €)
Loss of fines for violations	costs >1.000.000.000 €	

(estimated figures, partially based on the TOP TRIAL project)

Many severe accidents are caused by overloaded trucks (50% of motorway accidents including fatalities involving trucks). Particularly overloaded trucks play an important role (kinetic energy, reaction time, braking distance, tyre wear).

The direct safety implications of overloaded trucks are due to instability, excessively low speed on mountainous roads, tyre failure and excessive momentum. Trucks that are loaded beyond the level for which they were designed have a reduced stability and resistance to overturning which can occasionally have fatal consequences. They can have insufficient power to travel at normal highway speed when climbing hills which can cause frustration among following drivers. This can result in risk

taking and dangerous driving behaviour by the frustrated drivers. Tyres can fail prematurely when overloaded which can cause loss of control of the truck.

All accidents involving trucks are exacerbated if the truck is overloaded as this increases the momentum. The increased momentum increases the braking distance and greatly increases the consequences of accidents and the probability of more vehicles being involved in multiple-vehicle "pile-ups".
Apart from the direct safety implications of overloading, there is a chain of negative effects, which indirectly affect road transport safety. This sequence of indirect adverse effects is illustrated in the diagram above. Overloading hugely affects the rate of deterioration of road pavements. In addition to the implications for cost and sustainability, this contributes significantly to a reduction in safety.
Pavement rutting occurs prematurely in pavements. In combination with rain and frost, this constitutes a significant safety risk for all highway vehicles. Basic transport infrastructure deterioration processes are in many cases, only calculated using simplified measures such as tonnage carried or equivalent standard axles. To accurately calculate costs for different types of transport infrastructure and different types of user, it is necessary to improve some existing models and develop new ones.

Premature pavement deterioration means that repair and replacement needs to be carried out much more frequently than otherwise. This generates further safety risks.

Construction and maintenance activity in the vicinity of "live" traffic is risky for construction personnel and for traffic. The traffic diversion generally results in large numbers of lane changes as two lanes converge into one, three into two, etc.. This also increases the risk of accidents.

2.2.8 Control

Traffic control is almost certain to be improved and extended to automated networks to achieve safety goals. First measures of automated speed control networks already show impressive results and harmonised nationwide systems are being introduced in some countries, such as the fully automated speed control system in France.

Driving according to reasonable (this has to be achieved) regulations will be standard. Drivers have to understand and to follow the regulations. The pressure of increased detection and enforcement will show very positive effects on safety, driving behaviour and economy. Permanent automated traffic control (100% of passing vehicles over 24 hours) in areas suffering the highest accident rates will most probably concentrate first on:

- Speeding (local, sectional, continuous);
- Overload of vehicles and axles;
- Toll violation;
- Slow overtaking of HGVs by other HGVs;
- Illegal overtaking;

- Tail gating (distance keeping); and
- Erratic driving (e.g. through fatigue or alcohol).

Other factors, such as vehicle status (brakes and tyres) and seatbelt wearing could feasibly be detected and enforced by intelligent infrastructure in the road surface and gantries respectively, although these are likely to be longer-term applications. Traffic control is using more new technologies, achieve an efficient multi purpose control combined with practical operation processes for:

- **Effective traffic control and enforcement measures** with the objective to reduce accidents and to **improve traffic safety**;
- **Smoother traffic flow** and **increased traffic throughput** accompanied with more **co-operative driver behaviour**;
- **Protection of the traffic infrastructure** like roads; tunnels and bridges concerning deterioration;
- **Cost saving** related to repair and maintenance of the road network.

Future control and enforcement includes the design of a optimised concept for automated traffic control and fining of violations including registration and reporting to a central database.

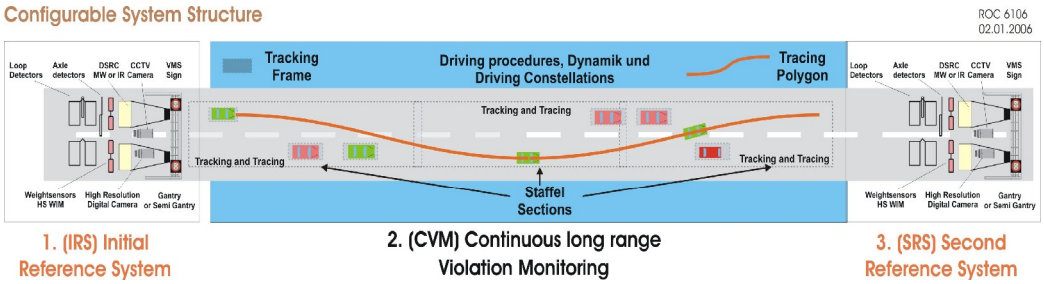


Figure 10. Possible automated continuous violation control[18]

Driving behaviour and violations can in future be monitored and controlled by “virtual police” (VIPs) for complete sections using an electronic regulation knowledge base. VIPs transferred in the car support drivers and assure legal and safe driving. Signs will become active and informative to drivers and cars. This will require an international legal EU base for enforcement (which is underway). Electronic number-plates could be introduced and readable by roadside infrastructure (see Figure 11).

[18] Source: FAIR project: www.project-fair.de

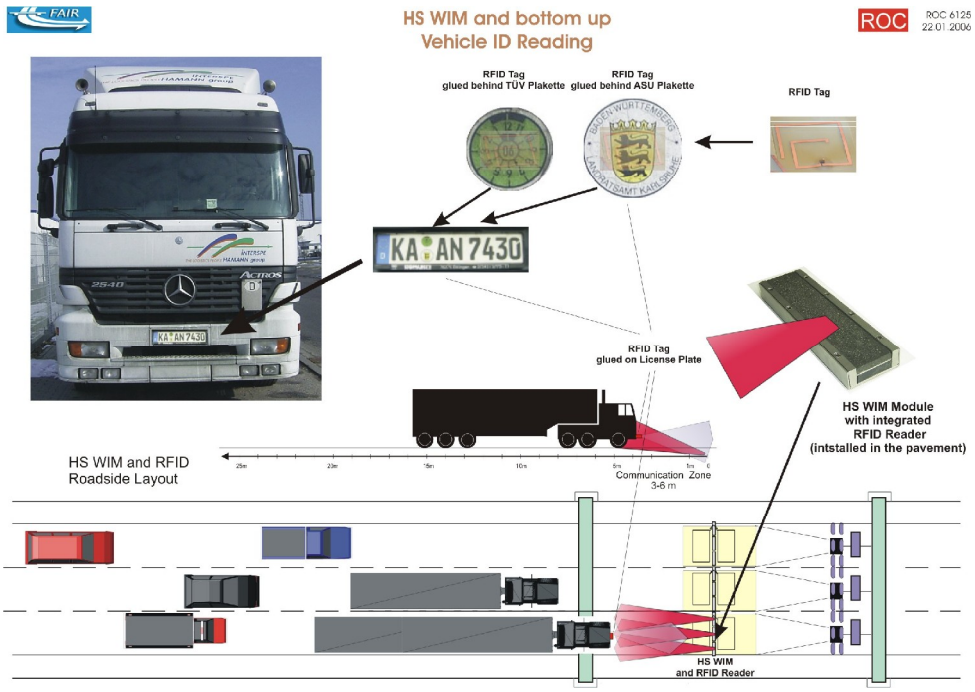


Figure 11. Electronic vehicle identification and dynamic automated weight control[19]

Section control is already deployed in several countries and this is a first step, extending the philosophy of single location controls. A impressive enlargement of the enforcement capabilities and implications to safety and economy will be the introduction of continuous long range controlled roads and networks covering multiple violations.

Speed limits in Europe could be harmonised in the longer term, although this would require overcoming numerous political and institutional hurdles.

2.2.9 Energy and Fuel

2.2.9.1 Background

Since 2000, the EU has started looking into the issue of replacing traditional transport fuels (gasoline and diesel) with alternative fuels for two reasons:

- security of energy supply (oil reserves are finite and are in geopolitical unstable areas of the world);
- reduction of greenhouse gas emissions (fossil fuel combustion accounts for 30% of CO2 emissions in OECD countries).

[19] Source: FAIR project: www.project-fair.de

In its Green Paper: Towards an European Strategy for the Security of Energy Supply (2000), the Commission expressed its aim of a 20% substitution of traditional automotive fuels by alternative fuels by the year 2020.

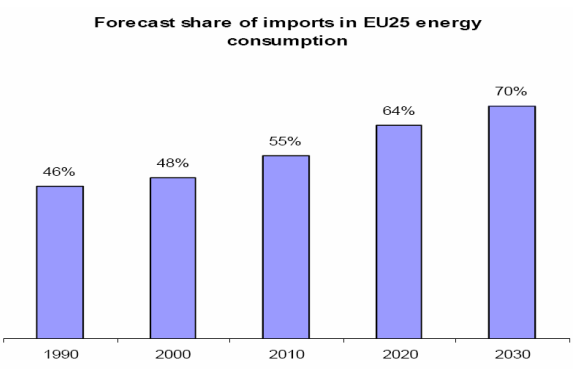


Figure 12. Forecast share of imports in EU-25 energy consumption

In November 2001, the Commission presented a communication on alternative fuels, identifying three potential alternative ranges of fuels as promising (see under 'issues').

At the same time, the Commission presented a proposal for a directive on the promotion of the use of bio-fuels for transport and a proposal for a directive giving member states the possibility to introduce reduced excise duties on mineral oils from bio-fuels.

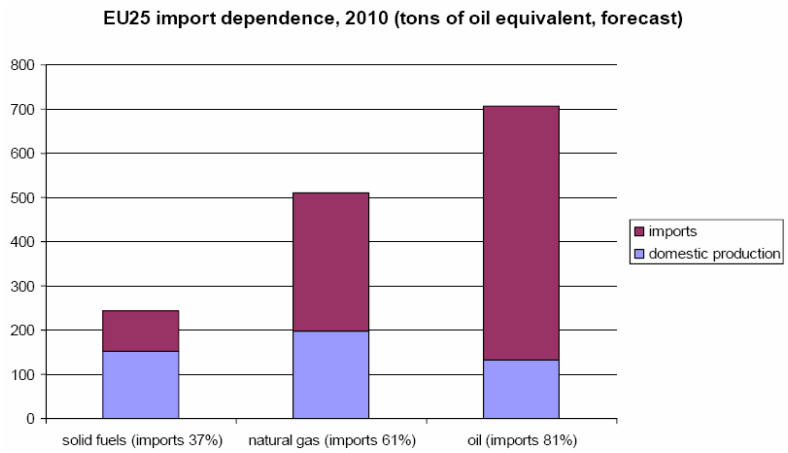


Figure 13. EU-25 import dependence, 2010 (tonnes of oil equivalent, forecast)

The Commission also set up a Contact Group on Alternative Fuels, which published a final report 'Market development of alternative fuels' in December 2003.

On hydrogen, the Commission established a high-level group on hydrogen in May 2003 and started a Technology Platform on hydrogen and fuels cells in January 2004.

2.2.9.2 Issues

Replacing 20% of conventional fuels by alternatives poses a lot of major **challenges**:

- the alternatives have to deliver the same kind of ease-of-use, safety and reliability to the car owners, at reasonable prices;
- alternatives need to have a lower environmental impact than the current fuels;
- they need to have the same level of energy efficiency;
- for alternative fuels to penetrate the markets, they need to have acceptable levels of investment in infrastructure and equipment.

In view of those criteria, the 2001 communication identified **three alternative fuel solutions** which could together reach 20% substitution: **bio-fuels, natural gas and hydrogen**. It also pointed to one technology solution (hybrid cars), which could offer the degree of fuel saving comparable to what alternative fuels have to offer.

Bio-fuels

- Produced from biomass (plant oils such as sunflower, sugar beets or other crops, organic waste): biodiesel and bioethanol
- Advantages:
  - less carbon dioxide emissions and less other pollutants
  - biodegradable
  - new markets for agriculture, especially attractive for new member states
  - can be used with existing technologies and no new infrastructure needed
- Problems:
  - higher costs than traditional fossil fuels: it would take an oil price of €70/barrel to make bio-fuels break even with conventional fuels
  - limited availability of land for energy crops if they were to replace fossil fuels

The 2001 bio-fuels directive has set an indicative **target of 2% bio-fuels share in each member state by 2005**. By **2010**, the target to replace traditional fuels by bio-fuels rises to a **minimum of 5.75%**. Member states, however, have difficulties transposing the directive. On 16 March 2005, the Commission issued letters of formal notice to nine member states which did not even communicate their targets.

Natural Gas

- Can be used with conventional gasoline engine but special storage and injection equipment needed
- Advantages:
  - clean, high octane number, lesser CO2 emissions (but not compared to diesel)
  - reduction of noise
- Problems:
  - has security of supply issues (but less than oil)
  - investments for refuelling stations needed

The Commission has proposed the following **targets** for the introduction of natural gas as transport fuel: **2% by 2010, 5% by 2015 and 10% by 2020**. The main challenge will be the establishment of new distribution infrastructure. The Commission set up a contact group which will give advice on what types of vehicles to use, which geographical areas, how to establish refuelling stations

Hydrogen

- Hydrogen can be used in fuel cells or as fuel for the conventional gasoline engine, but as hydrogen is not an energy source, but an energy carrier (like electricity), it requires other energy to produce it.
- Advantages:
  - can be produced from a large number of other energy sources as hydrogen is the most abundant element on the earth
  - advantages as to security of supply and greenhouse gas emissions are dependent on energy source used (if produced from coal eg then the GHG emissions will increase)
  - allows storage over time
- Problems:
  - storage of sufficient hydrogen fuel in cars is still a challenge
  - costly investments in distribution infrastructure will be needed
  - vehicles still very expensive

The Commission estimates that no substantial market penetration will take place before 2015. **A 2% target by 2015 and 5% by 2020** have been set in the Commission's 2001 Communication. The Commission is also co-financing a large demonstration project (CUTE[20]) with 27 hydrogen-powered buses in 9 cities in Europe.

[20] http://www.fuel-cell-bus-club.com

Other fuels and technologies

Electric cars: problems: size and costs of batteries; recharging issues make them suitable for short-distance motoring only, still very expensive.

Hybrid cars: has two 'engines' (combustion and electric, switches to most efficient mode depending on circumstances (e.g. Toyota's Prius) - advantage: fuel savings in urban environment, much less fuel-efficient on motorways. **Methanol and Dimethylether (DME):** both produced from natural gas. Methanol has lower overall efficiency than natural gas and is toxic. DME is replacement for diesel and burns cleaner (but expensive). **Diesel fuel from natural gas:** Gas-to Liquids (GTL) and Biomass-to-Liquids (BTL) have potential but still major challenges (GHG emissions and land resources).

Liquefied Petroleum Gas (LPG): cheap and environmentally-friendly.

2.2.10 Environment and Climate

There is a two-way relationship between roads and the environment. The first is well-documented: the ways in which roads and traffic affect the environment. Issues include air pollution and associated global warming, noise pollution, severance, visual effects, groundwater and water run-off pollution, unburnt fuel, particle matter (from exhaust, tyres, brakes, etc), the destruction of natural habitats, landscapes and ecosystems by road building, and the depletion of energy resources. These issues are considered by all European governments.

The second is how the environment and climate can affect transport, and in particular roads. Many parts of Europe are subject to severe winter conditions and roads need to be designed, constructed, maintained and managed accordingly in order to prolong the life of the infrastructure and uphold the safety of users. Often the most severe problems occur on roads in areas where severe winter weather is uncommon, as the infrastructure and its management are not adapted to such conditions. Other severe conditions include high winds (particularly dangerous on exposed sections such as bridges, where high sided vehicles are concerned), flooding, and breaking up of the road surface due to extreme heat in summer.

Global warming is causing climate change, one effect of which is more frequent severe weather, such as storms, heatwaves, etc. A climate change study by the Scottish Executive[21] in which implications for managing the road network in Scotland were studied, predicted the following (selected examples only):

- In Aviemore (central Highlands), the number of days experiencing sub-zero winter temperatures may fall from 54 days per year now to 46 days in 2020 and 36 days in 2080. In Glasgow, a fall from 40 days now to 31 days in 2020 and 20 days of sub-zero temperatures in 2080.

[21] Galbraith, RM. et al, “Scottish Road Network Climate Change Study”, Scottish Executive, 2005

- Extreme storm rainfall could increase by between 4% and 13% by the 2020's and between 10% and 30% by the 2080's.
- Average winter snowfall in Scotland could reduce by 20% to 40% by the 2020's and 50% to 90% by the 2080's.
- Extreme wind could increase by 2% by the 2020's and 5% by the 2080's.

The implications of climatic changes such as these include:

- Road surface drainage failures;
- More flooding of rivers and streams blocking or damaging roads;
- Deformation of road surfaces due to high temperatures
- Road infrastructure (signs, gantries, etc, including ITS infrastructure) damaged by high winds and creating a hazard.

While intelligent road infrastructure can help predict climate-related problems (weather monitoring, etc) and warn road operators and drivers (of high winds, icy road surfaces, etc), in certain locations the intelligent infrastructure itself could be damaged or destroyed. The appropriate infrastructure therefore needs to be chosen for the conditions and adequately protected.

Regarding road traffic's negative impact on the environment, a range of government legislation or incentives are foreseeable in the future to deal with this by encouraging mode-shifting, more fuel-efficient driving, etc, such as:

- Road user charging and other demand management measures (traffic restrictions, etc);
- More taxes on polluting vehicles, or banning them from certain sensitive areas, including automated enforcement of emissions;
- Stricter enforcement of speed limits;
- Traffic signal control to improve traffic flow and give priority to public transport or multi-occupancy cars.

2.2.11 Intelligence

Roads will become more than concrete and bitumen - intelligent roads and embedded communication services will be integrated. Cars will be safer, more adaptive and co-operative in driving and autonomous (cyber cars). Driver information and instructions may be presented within the vehicle instead of on roadside signs, e.g. legal speed limit adapted to the conditions and vehicle type displayed in-vehicle, rather than a global speed limit for all shown on signs. Intelligent roads may be restricted to equipped vehicles only. This is also an incentive to buy/use new vehicles (more

environmentally friendly, etc), but also potentially divisive (rich/poor divide) and increased profits for car manufacturers (more new cars).

Intelligent Road in layers (private transport, commercial transport, pedestrian walking zones, automated underground transport lorries, communication channels) may be introduced.

Other new concepts are self monitoring capability (combined and integrated approach for road, vehicle and user), early warning capabilities, self protecting pavement (load and traffic limits based on status and environment conditions), self repairing pavements, opening and closing of elements

The road of the future could be a sort of “Google Road”: Real-time driving support by dynamical orbital top down views with selectable zoom functions, resolutions and points of views:

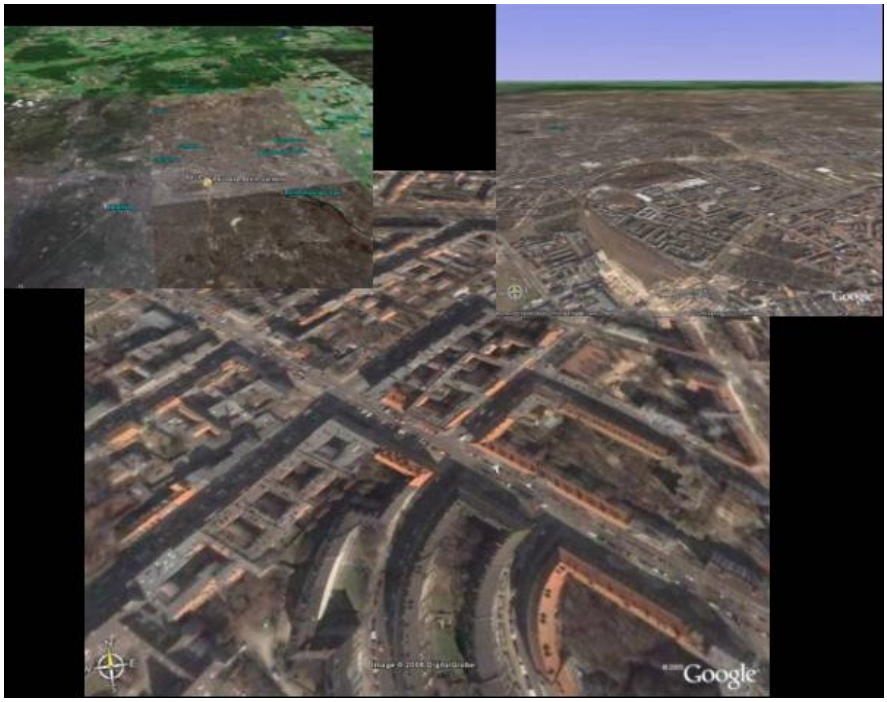


Figure 14. Satellite traffic monitoring and guidance (Source DLR)

2.3 Technological Drivers of Change

Drivers of change may be behavioural (lifestyle changes), consumer/market-driven, technology-driven, or changes imposed by government or environmental conditions. This chapter concentrates on changes brought about by technological advancements (the other drivers have already been presented in Chapter 2.2). Technological change is usually developed either to satisfy user desires (e.g. improved specification of cars, including on-board services) or government objectives (such as enforcement or pricing). The different effects of current and expected technologies, developed in general or specifically for traffic and ITS are expected to be:

- Higher data rates and better access;
- More precise positioning and navigation;
- Individual connectivity in real-time and covering all road areas;
- Cheaper and better sensors - extended usages for multiple functions;
- Automated operations supporting drivers.

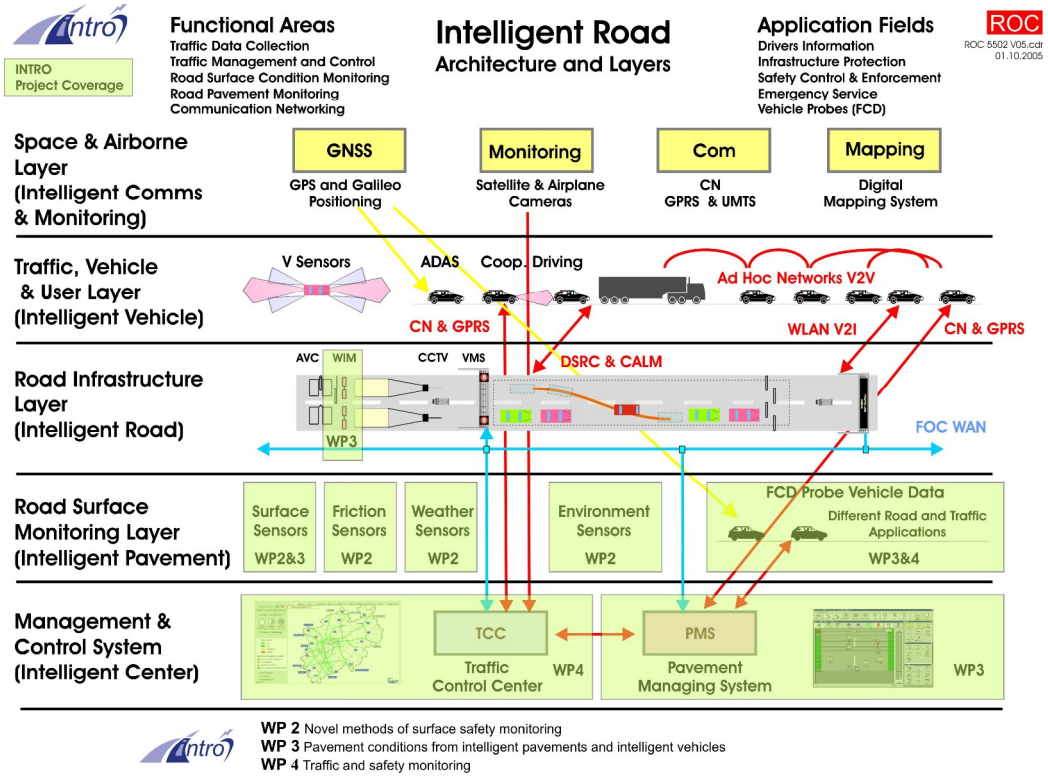


Figure 15. Technological drivers for intelligent roads

These new and upcoming technologies will influence future intelligent roads and their traffic in operation. The historical “concrete or bituminous” road will become a well managed and maintained

traffic and information channel, including more and more communication, information and sensing layers.

2.3.1 Sensing and Processing

Sensors for vehicles and roads have made impressive progress in recent years. Progress means higher performance, high level of integration, embedding of sensing and direct processing on one chip, better interfacing and cost reduction by improved production procedures and enlarged quantities.

Future cars will be equipped with short, medium and long range sensors covering different detection areas and enabling the necessary resolutions in time and space. Distance-keeping, obstacle and object recognition will be enabled by various sensor technologies like radar, laser scanner and camera systems.

Friction coefficients are detectable by cars with intelligent tyres or combined braking behaviour analysis.

HS WIM (High speed weigh in motion) sensors and systems will deliver more precise and reliable data of “truel oad flow over the pavement” and truck and axle overload.

Acceleration and vibration sensors and its spectral analysis will support these technologies. In addition these sensors will allow the pavement deterioration analysis (e.g. by floating car data) online and collection in a central database.

Road and pavement sensors consist of surface monitoring sensors, friction sensors environment sensors and data provided from vehicles (FCD).

Sensing of road signs and their information will also be established in the future.

The processing power will benefit from improvements of other markets and the ongoing extended use of micro controllers, bus systems and new architectures like those used for drive by wire (this is important for future automation and advanced driver support enabling the electronic control and management of the vehicle functions.

2.3.2 Communication

Communication technology (GSM/GPRS, UMTS, DSRC MW, CALM-IR) is the mayor key technology for intelligent roads and its innovations. Information will be exchanged between vehicles and roadside and ad hoc communications (V2V and V2I) networks will be added temporarily to fixed installed wireless communication systems.

General standards will be used for in-car communication and exchange between the car and the infrastructure. DSRC and CALM are the most interesting standards under development. The future will be the management of this huge amounts of upcoming information provided and its reliability.

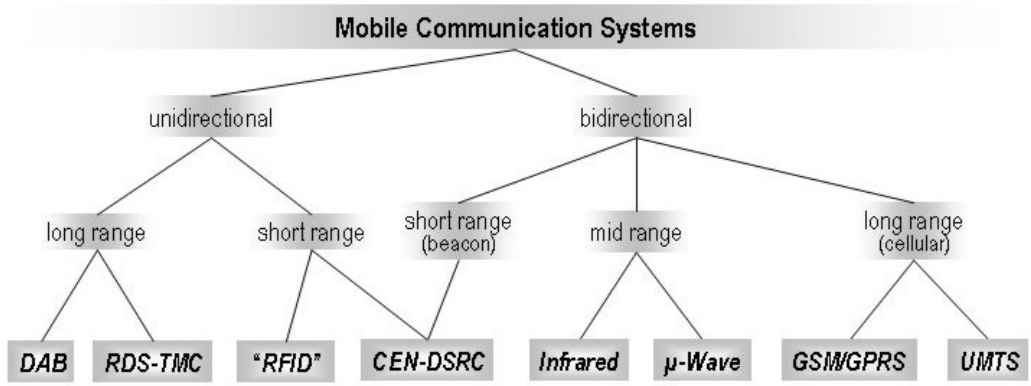


Figure 16. Communication media[22]

2.3.3 Remote Identification and Positioning

Identification of vehicles, dangerous goods and drivers (including driving/rest time for HGV) is still on an antique level. Different identification technologies based on image processing, RFID application, digital tachograph and OBU interrogation will facilitate the supervision and enforcement of violators, the supervision of driving and rest times for HGV drivers and the wanted list applications.

The second application area for ID technologies will be the automated payment of tolling and parking fees.

Positioning and Navigation: This technology is already a good standard, and it will achieve a new performance level mainly by the new ambitious Galileo system.

2.3.4 Advanced Driving Support Systems

Introducing new ADAS or redesigning existing ADAS is a long process, and many different aspects have to be taken into consideration. Ambitious international and national projects (examples are Prevent, Invent and more) are already reported in the first INTRO deliverable.

ADAS will be the pre-phase for automated driving. Trials for automated driving were done by the EU project Cybercars and by the American "Grand challenge competition". An adequate European spectacular competition initiative is still missing.

Most important is whether the system is useful with respect to traffic safety. It is a known phenomenon that systems that were meant to increase safety were exploited, which reduced the net safety gain by higher development and systems costs. In certain cases safety was actually reduced by the introduction of the system. A thinkable scenario for drowsiness warnings, for example, is that people

drive fatigued longer than before, because they will only stop when they have been warned for being drowsy the third time. Similarly, for a low friction warning system it is thinkable that drivers rely on the warnings and therefore drive faster on average, until the warning comes.

Another important aspect is that it has to be made sure that the driver is “kept in the loop”. This applies mostly to systems that intervene actively, instead of only warning the driver. The driver must always know that she is the one responsible for what the vehicle is doing, and the system should not take over so much that the driver does not know in which state the system is any longer. With some restrictions this also applies to systems that only warn, because the driver still has to monitor the road with full attention. No system can work without false alarms or misses, and any system can fail. Therefore it is important to consider the contradiction of wanting to assist the driver and at the same time reminding her that she has to be attentive anyway.
One should not forget that acceptance has to be considered when dealing with ADAS. A system that the driver considers unacceptable will either not be used at all or misused. If the system has to be paid for it is very important that drivers find it attractive enough that they are willing to spend money on it. Two aspects that are closely related to acceptance are the reliability of the system and the design of the HMI. Both will be discussed below.

The more drivers can rely on the system, the more they will accept it, because then they really will feel that they are supported. It is clear that no system will work perfectly under all conditions, but for each application it must be considered carefully whether it is most important to maximise hits (the system gives the right information at the right time) or correct rejections (the system does not give any information when it is not supposed to). Maximising hits will increase the occurrence of false alarms (the system will give information even when it should not, e. g. it will warn for low friction when traction is good), while maximising correct rejections will lead to an increase in misses (the system will not give any information when it should, e. g. it will not warn for low friction even though the road is slippery).

Another aspect which is important for acceptance and general use of the system is the design of the Human Machine Interface. The presented message must be easy to understand and clear, and it should not be confused with other messages that possibly demand other reactions. There are three modalities through which messages can be relayed to the driver. The visual channel is nowadays used most often. Auditory alarms are quite useful if the warning is intended to be “annoying”. Another option is the use of haptic/kinesthetic warnings, like brake pulses that are being tested for collision avoidance warnings, or vibrations for warnings of lane departure.

Several methods exist to evaluate different aspects of ADAS and their HMI. They range from simple check lists over questionnaires, focus groups, closed road studies and short field tests to (in rare cases) long term field studies. O and what the driver is exposed to, which means that several test participants can be examined under the same conditions. Additionally, more data can be collected from a simulator than from a vehicle driving on normal streets. It is necessary that the driving

[22] Source: EFKON

simulator is validated, which means that it has been made sure that drivers behave similarly in the simulator and in the field under similar conditions.

Systems that are being tested these days are for example collision avoidance systems and lane departure systems. Unlike before, when the visual channel was the favoured mode of representation, now haptic warnings are gaining ground.

Generally it is good practice to try to learn about natural reactions and to adapt the warnings accordingly. Here haptic/kinesthetic warnings can play an important role in the future. Especially with lane departure, drivers get more and more used to rumble strips, that are installed on some roads, and they learn to react correctly to them. An in-car lane departure warning can exploit this and use an HMI (a vibration) that resembles the feeling and sound of driving on rumble strips. A low friction warning could possibly make use of a certain feeling in the steering wheel or of a seat gliding in a way a car does on a slippery road.

Apart from the just described “immediacy” that occurs by matching the stimulus to the expected response and the advantage that the visual channel is relieved by moving warnings to other channels, there exists another advantage for haptic systems. They can be felt wherever the driver is looking, and they do not have to be noticed by the passengers, which can increase acceptance substantially. One example is a system that warns drivers that they have been distracted. If the driver is warned discreetly (like by vibrations in the seat or a short tightening of the seat belt), she might be much more inclined to use the system as when all passengers get to know that she had been distracted.

A number of new ADAS are focused on critical situations (collision warnings, lane departure warnings, distraction, low friction warnings), which makes it difficult to test in reality how well they work. As mentioned above, this is even a problem in driving simulators, because they are not validated for those situations, and even though people do not get harmed when they crash in the simulator, this situation is usually avoided when planning experiments. There have been suggestions to couple different driving simulators to let people interact in a safe environment, which is an interesting approach if it is possible to provoke critical situations, because real behaviour from all involved partners can be studied. A disadvantage with this approach is, though, that the whole scenario is much less controlled, and therefore it is not easy to recreate a similar environment for more than one participant. An idea could be to let several simulators drive together to collect real behaviour in certain situations, and later on “plant” this behaviour in the interacting cars in one simulator. Then controllability will remain as before, and it is made sure that the simulated cars react in a rather realistic way.

Driving simulators are improved constantly, and especially for applications with a large haptic component (like low friction situations) it is important that the haptic feedback of the simulator is realistic. Here advanced moving base simulators, which can move both laterally and longitudinally can be very helpful. The more the “feel” of a simulator resembles reality, the more do the reactions of the driver resemble reactions in the field.

As new ADAS often are quite safety critical it is very important to control adaptation effects and how they influence traffic safety in the long run. Here either long term field studies with a limited number of participants or possibly simulator studies, in which the same test person has to drive with the same system again and again over time can be considered. Also extended tests on closed course tracks are a possibility.

2.3.5 Control and Enforcement

High resolution and automatic digital recording of vehicles, license plates of violating drivers was the first practised technology to improve speed violation enforcement and to overcome the wet film registration (not easy and only with high efforts to operate), even it took years to get the approvals for legal application.

In future tracking and tracing of vehicles driving with video recording and image processing will be the next technological step to supervise vehicles and their driving behaviour over longer distances and continuously.

Section control, which is still in introduction successfully, and in future "Staffelcontrol"

(trajectory generation/vehicle driving behaviour monitoring /co-operative driving analysis)

and virtual police agent systems applying a regulation knowledge base will join for fully automated enforcement.

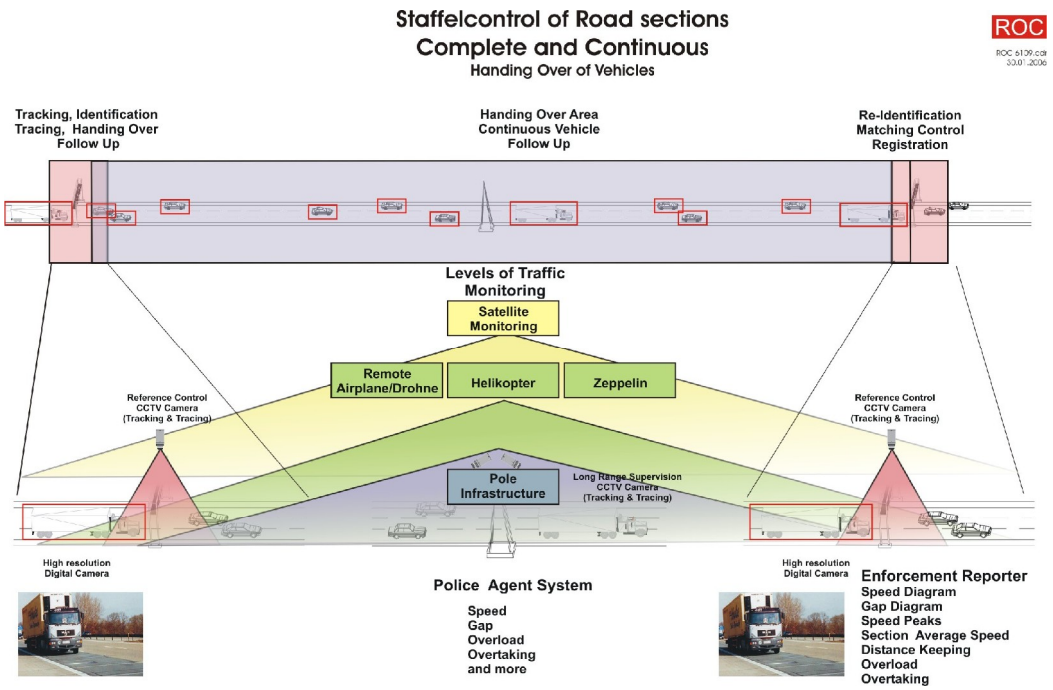


Figure 17. "Staffel" control systems[23]

[23] Source: FAIR project: www.project-fair.de

3 POLICIES AND SCENARIOS

3.1 High Level Scenarios

Scenario development is not about predicting the future, but by looking at a range of plausible future frameworks (concerning transport, government, society in general, the environment, etc) and exploring what the impact of each scenario would be on the road transport sector in general, and the role of intelligent road systems in particular. Scenarios try to describe all the possible situation of external and internal factors influence on the “intelligent road” systems and try to give an answer how the systems demonstrated and recommended by the INTRO project can adapt or react to each of the scenarios.

The question is, how developments caused by mankind (individuals and society in general, as well as the products [work] of humans), and nature, and their interdependencies will influence or promote intelligent roads and their expected functions and performances.

A new and more open thinking is required: Information technologies including new micro scaled sensors, wireless and more powerful communication (even between single vehicles and infrastructure) and highly integrated and low cost processing technologies are entering and dominating the road with strong impacts and opportunities for improving safety, capacity, driving economy and infrastructure management.

The availability and costs of petrol and diesel will also play a more and more important factor and hopefully initiate alternative energy sourcing for vehicles and driving.

On the one hand, intelligent road systems can enhance the freedom of road users, such as by providing personalised travel information and advice, whereas on the other hand ITS is an increasingly important tool for improving safety (to exert greater control over road traffic), reducing “egocentric” driver freedom in general to further the public interests of safety, efficient use of road space and fuel, social and environmental concerns, etc.

The role of intelligent road systems in the future could vary enormously according to degree of control society is willing to accept in order to reduce the negative impacts of transport, and thus whether societies and governments adopt more controls and regulation, or go down a more liberal and laissez-faire route.

Public awareness concerning over 40 000 people killed per year as an ongoing annual disaster has to be raised and its acceptance compared to other man-made or natural disasters (terrorism, earthquakes, floods, etc).

The UK project Vision 2030 (see Appendix 2 for further details) aimed to identify the potential roles of strategic highways in meeting future mobility needs, by identifying the key drivers and factors that will

influence them, specifically social issues, technology, political and regulatory aspects, and macro-economic drivers.

This project produced three rather “utopian” scenarios, as follows:

- **"Global Economy"** - a highly capitalist, market-driven approach where all services and infrastructure are privatised and government regulation and control is minimal. Transport supply is based on ability to pay, thus motorways might have separate priority lanes with a high toll, enabling those who are willing to pay to avoid congestion.
- **"Sustainable Lifestyle"** - a community based way of living which leads to an increased quality of life and a reduced need for travel, with more local working or e-working. Most urban and suburban trips are by collective transport (shared minibuses, etc) or slow modes (walking and cycling), whilst the interurban road network is mainly used for leisure trips. Multimodal journeys are the norm, leading to a high degree of interchange for passengers and freight.
- **"Control and Plan"** - based on greater regulation of movement, which has become a political necessity in order to manage congestion, energy use, competitiveness, safety etc. This leads to widespread driver assistance, speed controls, electronic road pricing, rationing of road space, zero emission zones, etc.

Twelve "Transport Visions" of the possible future of inter-urban transport emerged from this process, which now provide a constructive basis for long-term strategy development within the Highways Agency. These include both good and bad concepts, such as the “Green Highway” (sustainable materials and operation), widespread multimodality, widespread gridlock on the roads leading to severe economic problems, widespread safety controls, priority for freight, unlimited consumer choice, etc.

3.2 EU and National Policies

3.2.1 EU Level

There is no policy or vision at EU level relating specifically to intelligent roads (including intelligent infrastructure, intelligent traffic and reasonable transports), although there are some policy references to ITS for road traffic and automotive in general. The European Commission’s main policy document relating to transport is the White Paper[24], and the following extracts comprise the main references to ITS in this document:

- “Specific action will have to be taken on cleaner, safer road and maritime transport and on ***integrating intelligent systems in all modes*** to make for efficient infrastructure management. In this respect the eEurope action plan proposes a number of measures to

[24] European Commission, “White Paper – European transport policy for 2010: time to decide”, Luxembourg: Office for Official Publications of the European Communities, 2001.

be undertaken by the Member States and the Commission, such as the ***deployment of innovative information and monitoring services on the trans-European network and in towns and cities*** and the introduction of active safety systems in vehicles."

- "***Intelligent transport systems are another opportunity***, and broad provision for them is made in the eEurope plan adopted by the Feira European Council in June 2000 and confirmed by the Stockholm European Council in March 2001."

- "The ***potential impact of intelligent transport systems*** has been assessed both during research and in the early stages of deployment. Journey time reductions of up to 20 % and increases in network capacity of 5–10 % have often been achieved in various combinations. Safety improvements have often been estimated at around 10–15 % for certain specific types of accident (rear-end collisions) thanks to coordinated information and control strategies, while survival rates have also increased thanks to automatic incident detection systems for the management of emergency situations. Only 6 % of road accidents appear to be unavoidable and beyond the reach of improved technology. Lastly, integrated strategies for pollution control and traffic limitation have led to initial estimates of reductions in ground-level emissions. Intelligent transport's most significant impact is probably on road transport, though it helps make other modes safer and more efficient, too."

- "***The trans-European transport network is an ideal candidate for the deployment of intelligent transport***. It is not limited to large traditional infrastructure such as roads and motorways, railways, ports and airports, but also includes the traffic management systems and information, positioning and navigation systems and services which make it possible to operate such infrastructure to best effect. Galileo (…) is an example here of a project acting as a catalyst for the development of intelligent transport.."

- "Six Euro-regional initiatives involving the main players in traffic management in Europe have been receiving EU financial support since 1996; these initiatives are already accompanying the deployment phase in 14 Member States and are placing particular emphasis on the needs of European users. ***It is essential that the trans-European network be equipped with telematic infrastructure/systems for data collection and with traffic control and/or road information centres*** in order to guarantee the quality and reliability of information (e.g. journey times), just as cooperation between managers is indispensable if users are to be offered an uninterrupted high-quality service, whether for local or regional journeys, mass departures during the holiday season or at weekends, or medium or long-distance heavy goods traffic. On this basis, traffic management plans, information services provided before or during journeys, freight management services, breakdown and emergency rescue services and electronic road-charging systems need to be introduced as a matter of priority and their take-off should help greatly to alleviate the effects of road network saturation."

With reference to the last paragraph above, a seventh "Euro-Regional" project has recently been launched with the objective of deploying intelligent infrastructure on the Trans-European Road Network (TERN) linking seven Member States in Central and Eastern Europe[25].

Besides the extensive R&D into ITS for road sponsored by the European Commission, the above mentioned Euro-Regional projects are the main focus of the EU's approach towards intelligent roads. While there are some overall guidelines for European added-value and continuity service for these projects, they do not really constitute a clear policy or vision at the EU level, but rather as a funding stream to assist road administrations and operators deploy ITS on the TERN and to take into account certain trans-European factors. This is exemplified by the fact that proposals for deployments come from the national and regional road operators (administrations or toll companies) and the financial contribution of the EC is limited to 10-20% for ITS deployments.

3.2.2 National Level

Main questions for investigating the national level could be:

What are the national policies or visions for intelligent roads in these countries? (if such a vision exists at all).

What are the aims (e.g. in some countries to restrict traffic and manage demand, in others (e.g. on private toll motorways) to provide a better service to the user and make the road more attractive?

What is the place of ITS in the road strategy? Countries are at different stages (e.g. Greece, Ireland, Eastern Europe: construction of new roads and improvement of existing roads, but in UK, France, Germany, the focus is more on making better use of existing infrastructure).

What is the amount of national budget spent on road construction, road maintenance and ITS deployment: how do they compare over time and between different countries?

3.2.2.1 Belgium

The following information relates only to the Walloon Region[26]. The overall objectives of the region's Directorate-General for Roads and Motorways (DGAR) are centres around 19 themes, grouped into 6 main axes, with precise objectives all relative to a better service to the road user. These are:

Axe 1: Network Quality

- Improvement of maintenance and operating to promote the existing Infrastructure and equipment;
- Installation of weighbridge stations for heavy vehicles.

[25] CONNECT project, covering eastern Austria, the Czech Republic, eastern Germany, Hungary, Poland, Slovakia and Slovenia.
[26] Source : http://routes.wallonie.be

Axe 2: Safety

- Planning of roadwork sites;
- Automated speed limit enforcement;
- Improvement of safety equipment;
- Road safety around schools;
- Adapting the traffic signing.

Axe 3: Mobility

- Develop high technology tools for road network operations;
- Equipment and specific planning of most highly trafficked motorway sections;
- Traffic signal management at junctions;
- Improvement of organisation of works sites.

Axe 4: Comfort and quality of life

- Improvement of the cleanliness of the network;
- Reduction of noise pollution from roads;
- Development and improvement of motorway rest areas;
- Policy of planting and environmental improvements around motorways;
- Definition of tourist and cultural signing.

Axe 5: Networking of slow roads

- Development of the “RAVeL” plan (Autonomous Network of Slow Roads), as much for daily use as for leisure;
- Development of a cycling network along regional roads.

Axe 6: Participative management of projects.

Budget

The following graph gives the Roads and Motorways General Direction (DGAR) budget by issues:

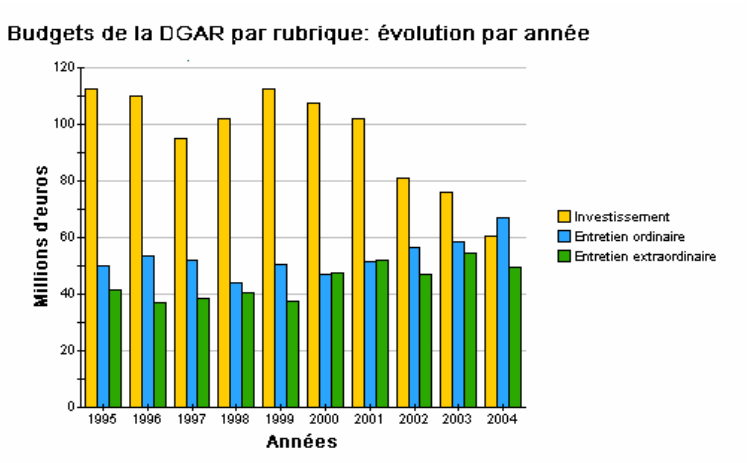


Figure 18. Road Investment/Maintenance budget evolution in Wallonia (Belgium) from 1995 to 2004

- yellow = Investment
- Blue = ordinary maintenance of the network
- Green = extraordinary maintenance of the road surface

For 2004, the budget dedicated to Investment can be split in to three categories of works:

- New Infrastructure building
- Improvement of road safety
- Improvement of quality of life.

The budget dedicated to Ordinary Maintenance permitted to finance maintenance agreements with private companies. It concerns current periodic operations (road surface repairing, road marking renewing, cleaning,…). Winter viability is also concerned by this credits.

the budget of Extraordinary maintenance is dedicated to largest works done without any periodicity. For example rut to repair, total renewing of road asphalt, complete renewing of safety barriers, …)

3.2.2.2 France[27]

French transport policies tackle four major issues that are considered to be of particular importance :

- multimodal information
- freight management
- payment means
- law enforcement.

[27] Sources: http://www.transports.equipement.gouv.fr, http://www.vie-publique.fr

Multimodal information and law enforcement are particularly concerned by ITS.

Multimodal information

The concept behind multimodal transport is to propose the optimum mode of transport for a given journey on the one hand, and on the other hand to provide the user with travel assistance. This concept therefore includes not only information on public transport, but also road traffic and travel information. Its aim is twofold :

- Provide adequate and clear information on the choice of modes.
- Facilitate the use of transport networks.

Within the context of the road management master plan financed by the state, the regional and local authorities (with financial aid), have progressively set up traffic management systems (in-ground magnetic loops, monitoring cameras, counting stations, variable message signs, traffic management and control centres...) on main motorway corridors, state owned motorways and the express-road network of major urban areas. These systems provide travel assistance by improving safety and making optimum use of infrastructure. The data collected are used to detect, alert, manage interventions and traffic and inform users. The organisation of real time information is dealt with in a road traffic and travel information master plan. Service providers will have access to public data related to road traffic information, either free of charge for inter-urban networks or within a contractual context for urban areas. A standard agreement stipulates service providers' obligations in terms of dissemination and notably the free dissemination of messages of interest to the general public. In the medium term, traffic management systems should develop interfaces with the following services :

- incident detection, emergency service intervention (quicker reaction time with adapted devices), in vehicle emergency alert systems
- driver assistance
- multimodal pre-trip information
- co-ordination with signal control systems and public transport management.

Enforcement

The use of new technologies enables road infrastructure managers and control organizations to establish regulations and enforce them. Experimentation related traffic signal enforcement (red lights, level crossings) are being carried out on ten or so sites, before looking into the necessary conditions for an initial deployment phase. Automatic speed limit enforcement is being deployed in the whole country (1 000 sites so far). Furthermore, research and experimentation continue on optional or mandatory speed control systems.

The introduction of the digital tachograph is planned at a European level for 2004. The Ministry will organize the distribution of cards and enforcement controls within the scope of a public service contract, in association with the different administrations concerned and the other European states.

Navigation

Moreover, the Galileo Project (covering the spectrum of the four major issues of French transport policies) is one essential element of the Indicative Pluri-annual French Program (called PPI) in place for years 2001 to 2006.

3.2.2.3 Germany

"Traffic must be more safe and efficient" the new German Minster for research Edelgard Bulmahn announced the key aspects for further research related to traffic. Each year €40 million is invested for R&D in this area. This will include mainly the topics:

- Traffic safety
- Cross border traffic management
- Usage of modern traffic technologies for safety and also for economic competition
- Minimisation of the negative effect of traffic growth on mankind
- Higher traffic efficiency

In Germany in the next 10 years, a 100 % increase of transit traffic is expected.

- (comment: if this happens the currently often over crowded and blocked parking places by parking trucks and resting truck drivers on German Autobahnen rest areas disturbing permanently public traffic flows and access of parking slots will become a more severe and unsolved problem – no solution is seen)

Different R&D initiatives are looking in Germany for future concepts for reducing traffic jams, improving traffic safety and optimising the transport modes distribution.

Key factors for investigation and improvement are:

- Vehicle technologies, traffic technology, information technology, sensing, driver assistance, GNSS with Galileo, vehicle intelligence and its synergy (on car level and trans European)
- New or alternative vehicle engines and drive trains, hybrid systems and alternative fuel and energy cells

The research initiative project "INVENT" was already presented in the first INTRO deliverable. Main innovation will be the use of modern communication technology in vehicles and infrastructure.

Slogan: concepts for the future traffic – Solving traffic jams. Navigation systems support the optimisation and routing process of individual and commercial fleet traffic in future. The separation of the different traffic and transportation demands and systems is a complementary measure. INVENT has available 76 Mio. Euro for R&D of driver assistance systems and information technology application.

German requirements for European traffic policy:

- Efficient and integrated traffic system, assuring the European private driver and commercial industry the necessary mobility.
- Networking and interaction of the different transportation modes
- Fair competition
- Consideration of the social dimension of the traffic
- High safety and environmental standards
- Promotion of safe, environmental protecting and European wide interoperable traffic systems
- European support of civil satellite navigation system for a trans European traffic network

It must be stated, that Germany is still very engaged with the reconstruction and modernisation of the eastern part of the country (neue Bundesländer) after the reunification.

Most important topics 2006:

- Program for more traffic safety
- Harmonisation of social regulations for commercial transports and traffic (digital tacho)
- Reasonable usage compensation of German networks by transit drivers and its financing
- Usage preparation of Galileo satellite navigation and strengthen of European industry in participation
- Avoidance of terror and crime

3.2.2.4 Netherlands[28]

This is the policy document for the national transport and traffic policy for the years 2006-2020. Key policy issues from this 'Mobility Paper' related to intelligent roads:

Reliable travel time

[28] Source: 'Nota Mobiliteit' (The Mobility Paper), see http://www.vananaarbeter.nl/NotaMobiliteit

Transport will become more reliable so that travellers will know what time they will arrive, and transport companies can deliver on time. The entire journey, from door to door, will improve. National, regional and local road, water and public transport networks are closely linked, which is why an integrated approach to entire networks is needed.

Travel times will be more reliable by 2020. In 95% of cases, travellers will arrive at their destinations on time. On the motorways, journeys during rush hour will last no more than 50% longer than in non-peak periods, and on urban ring roads and roads not managed by central government, they will take no more than twice as long. That means that in the rush hour, a 50 kilometre journey on the motorway will take no longer than 45 minutes (i.e. no more than 15 minutes' delay). On urban ring roads and other secondary roads, a journey of 10 kilometres will take no more than 12 minutes (i.e. no more than six minutes' delay). This will be possible thanks to a wide range of construction and utilisation measures, different ways of paying for mobility, area-specific cooperation and maintenance work. Priority will go to the main arteries. Incident management, traffic management and route and travel information will be improved.

Paying for mobility

With the adoption of the report drafted by the national platform for new ways of paying for mobility, a major step has been taken towards generating broad public support for this issue. The government now wishes to introduce pricing at a number of bottlenecks in the road network. The proceeds will be used to take rapid action to relieve congestion there. The government is tempted by the prospect of introducing a kilometre levy, while at the same time reducing road tax. It will be up to the next government to decide on this. First, however, costs will have to be reduced to acceptable levels.

Safety and security

Dutch roads are among the safest in the EU and are becoming safer, despite increased car traffic. A drop in the number of road victims from 900 a year in 2010 to 580 a year in 2020 is possible. The result will be less human suffering, and less harm to the economy. Enforcement is the cornerstone of road safety policy.

Transport of hazardous substances will remain possible on a small scale by using a chain approach to ensure the highest level of safety in built-up areas.

Security and the protection of vital infrastructure will have the highest priority.

Environment

Every national and international agreement in the field of emission reductions for transport by road, rail and waterway will be respected. To this end, innovation and source measures will be needed. In the long term, transition to more sustainable forms of transport will be essential if all emissions, particularly of carbon dioxide, are to be cut back.

The Netherlands will be unable to take timely measures to meet EU air quality norms for nitrogen dioxide in every existing situation. Major European and national source policy efforts, as well as tailor-made solutions at local level, should ensure that this is the case by 2015. Regulations on fine dust will be amended to take account of health factors.

The national norms for noise pollution will apply to new situations, and problem areas, with readings of more than 65dB (Lden) for roads and 70dB (Lden) for railways, will be dealt with and priority given to residential areas. Acoustic quality in the main ecological network will be no worse in 2010 than today, and will have improved in 2020. The main ecological network will be completed by 2018.

Enabling traffic & transport growth

Many trends – demographic, economic, spatial and international – will result in increased transport volume. It is in the interests of society and the economy to keep this growth on the right track, within statutory and environmental policy frameworks.

Role of ITS and intelligent roads

In many of these issues ITS plays a vital role. Sensors, actuators, neural networks, etc, have a function for detection, exchange of information, enforcement, etc. To achieve these policy goals applications will be used like ISA (Intelligent Speed Adaptation), ACC (Adaptive Cruise Control), dynamic speed limits, systems for travel time prediction, incident detection and incident management, dynamic use of lanes, dynamic overtaking prohibition for HGV's, extended green for trucks at traffic lights, monitoring transport of hazardous goods.

ITS is employed for enforcement purposes as well (speed, weight, traffic lights).

Attention is given to more silent road surfaces and roads that require less frequent maintenance.

For tunnel safety a tunnel will be equipped with an automatic fire extinguishing system.

Also many measures will be employed to make using a bicycle more attractive (e.g. comfort).

3.2.2.5 Switzerland[29]

Recently the Swiss Federal Roads Authority published its ITS-CH 2012 Master Plan. One of the focuses is to use transport telematics for managing traffic, routing, regulating and information. The summary of the document is below.

Aim of the ITS-CH 2012 master plan: Summary

[29] Source: http://www.astra.admin.ch/media/pdfpub/2006-01-19_2436_f.pdf, http://www.astra.admin.ch/media/pdfpub/2006-01-19_2435_d.pdf

The ITS-CH 2012 master plan for transport telematics presents the situation as it should be in 2012 and indicates the way in which transport telematics applications on the public highways could contribute to the achievement of the transport policy targets of the Federal Department for Environment, Transport, Energy and Communication (DETEC). ITS is the standard international abbreviation for the term «Intelligent Transport Systems».

These applications are intended to be compatible and interoperable throughout Switzerland and beyond its borders.

The ITS-CH 2012 master plan focuses on road transport telematics, which must be seen as a part of transport telematics including all modes of transport. Road transport telematics has many interfaces with other modes of transport, whether relating to the systems, the types of use or the objectives.

The rapid technological progress in the field of transport telematics opens up an immense potential for optimising traffic management, routing, regulating and information. All of these measures serve directly to improve traffic flows, to strengthen road safety, to reduce the burden on the environment and to deal with exceptional situations. Thanks to efficient data transmission, the use of telematics in road transport permits an improved and faster exchange of data and information between road users, between road users and road facilities and between road users and background systems. Telematics exploit the combined potential of telecommunications and informatics. What is needed now is to seize the opportunities offered and, at the same time, to recognise the limits.

Selected telematics applications on the national road network

To achieve the stated objectives, the Confederation is assuming a number of responsibilities:

The Confederation is responsible for the establishment of a national traffic management system. National traffic management relates to the national roads. The main functions of the national traffic management are traffic routing, regulating, control and information. In principle, the financing of the system is a matter for the Confederation. Traffic management plans are governed by the cooperation between the Confederation and the Cantons.

The Confederation supports multimodal traffic information by enabling the Cantons and operators of other modes of transport to share in the National Traffic Data Exchange and in traffic information on a paid service basis.

Concerning the national interest, the Confederation coordinates the activities of the Cantons, cities, district authorities and private individuals in the field of transport telematics.

The Confederation may take part in the development and pilot testing of transport telematics applications, where they contribute to sustainable mobility in accordance with the federal objectives. When applications made on this basis are being assessed, due account will be taken of the federal interest in the development or the pilot testing concerned.

The Confederation lays down the necessary framework conditions and brings about the prerequisites (standardisation, etc) for the construction, maintenance and operation of transport telematics systems.

As far as personal data are concerned (i.e. data relating to an identifiable person), there must be compliance with the legal provisions for data and personality protection. The ITS-CH 2012 master plan is the strategic expression of the intentions of FEDRO, taking the form of a general concept harmonised with DETEC. The binding regulations of federal law in terms of competences and tasks will be embodied in the particular legislation.

Use of telematics applications on the national road network

When the New Arrangement for Financial equalisation and task allocation (NAF) between the Confederation and the Cantons comes into force on 1 January 2008, the main applications arising out of the ITS-CH 2012 master plan must already be in operation. The project for the implementation of these applications will be known as Transport Management Switzerland (TM-CH). In the field of road transport, it is essential to promote a dynamic balance between the raising of economic efficiency, the protection of the environment and the strengthening of social solidarity. Transport telematics is one of the means by which the need for action stemming from this objective can be met.

The additional costs incurred by the Confederation through taking over tasks in the field of road transport telematics are offset by reduced costs for new roads or road developments, as well as considerable macroeconomic gains in the form of shorter journey times, improved convenience for all road users, accident prevention and the avoidance of damage to the environment. The standardization of the system architecture and the central and peripheral equipment will also lead to cost savings.

3.2.2.6 Eastern Europe

Appendix 3 provides examples of road transport policy contexts and priorities in four new EU Member States: Latvia, Slovakia, Slovenia and Poland. They are not presented in the main body of this report as there is no notable global ITS policy in any of these countries. Many of them are involved in EU research projects which lead to such a policy and ITS is of course being implemented in the New Member States, with a particular emphasis on electronic road pricing in several countries. However these countries are mostly investing in road construction and intelligent roads are a “luxury” which perhaps comes next, once the core network has been completed or upgraded.

In addition, Germany is focused on the extension of the road network for the eastern provinces (Neue Bundesländer) for the next few years.

3.3 Policy and Scenario Mix

Figure 1 “Intelligent road solutions – effects, circumstances, visions and solutions” in Chapter 1.2.3 gives an overview of the approach to scenario building. It starts from the three “extreme” scenarios

developed by the UK project “Visions 2030”, as outlined in Chapter 3.1: “Global economy”, “Control, harmonise and plan” and “Sustainable lifestyle”.

In the centre of the triangle are three more realistic mixes reflecting the ways in which different parts of Europe are developing. It should be noted that these are only speculative, and neither scientifically predicted nor necessarily recommended.

Firstly, the “Possible Eastern EU Mix” lies somewhere between the “Global economy” and “Control, harmonise and plan” scenarios. This reflects the fact that the economies of the eastern countries are rapidly moving towards an open free-market system, perhaps becoming more free-market than some Western European economies, which are seeking to protect themselves and their social model from cheap labour and imports from abroad. Roads in several New Member States are already being built on a private finance basis (e.g. BOT – Build, Operate and Transfer) and the shortage of state funds indicates that more road building, financing, operation and even control could be let out to the private sector. Emphasis is more on economic growth then environmental or sustainability issues (at present). On the other hand, there is still a control element left over from the communist era and a certain amount of strict enforcement is likely (e.g. most Eastern European countries have a blood-alcohol limit much lower than the average in Western Europe, and sometimes set at zero).

Secondly, the “Possible Nordic Mix” comes closer to the “Sustainable lifestyle” scenario, reflecting the fact that social and environmental considerations are important in the Nordic countries, whereas privatisation of infrastructure is less important (social ethos and also greater availability of public funds than in poorer European countries, largely due to high taxes). There is however a strong “Control, harmonise and plan” element, due to the importance attached to safety in the Nordic countries, thus a high degree of enforcement is expected to be maintained.

The third option, the “Optimised European Mix”, could be a goal towards which most of Europe will eventually move. This places importance on sustainability issues but also with a high degree of control, planning and enforcement. The role of the free-market could be reduced, as BOT infrastructure schemes revert to the public sector after their concession period and there is increasing recognition that the state should intervene more in order to promote modal shift, enforce environmental and safety regulations and generally ensure traffic and mobility is managed for the benefit of society. Limited space, environmental and safety concerns and depleting fuel resources could mean that unbridled competition in transport provision, including competing toll roads operated by private companies whose interest is in seeing more road traffic on their networks rather than less, could mean that the current move towards privatisation and deregulation in transport would at some future point be reversed.

The future INTRO WP5 report on Visions would investigate likely moves towards, and preconditions for, these scenarios and other possible scenarios, and look at how Intelligent Road Visions might develop in different parts of Europe.

4 LINKS BETWEEN SCENARIOS AND INTRO

4.1 Surface Safety Monitoring (WP2)

The Combination of different sensor data (infrastructure or in-vehicle based, weather, surface, etc.) will enable the estimations of entirely new real-time safety parameters and performance indicators to be used in traffic monitoring and early warning systems. This will result in better methods for accident prevention. Especially the correlation between friction and stopping distance will be emphasized for surface safety parameters.

Due to real time data acquisition systems and dynamic information systems the road user's safety and the information about the pavement surface condition will improve. The road authorities have access to the information derived from their road-network and can decide and act immediately on sudden changes related to the surface condition and slippery road spots.

INTRO WP 2 is definitely aiming at those objectives seeking to increase safety of road networks by reducing risk of accidents due to sudden changes in natural conditions. The increased driver awareness and the subsequent adoption to safe velocities on low friction road sections will decrease the accident numbers related to surface safety.

The use of real-time weather data combined with road surface and accident data bases will be of use to prevent accidents due to dangerous sections during certain weather conditions. This data will be possible to utilise as a basis for enforced low speed limits during periods of adverse weather conditions. In addition to this parameters directly related to friction and stopping distance are acquired dynamically in real-time as well as produce an up-to-date surface pavement condition image. The parameters give enough valuable information for authorities and users to react on possible risks and hazardous situations. Therefore the use of in-vehicle sensors combined with existing road surface data and weather data is necessary.

Using the network strategies with existing and evolving technology is a way to obtain maximum benefit from a limited number of probe vehicles. Distribution of data will be done by current or future standards like GSM, GPRS or 3G technology and positioning will be supported by the satellite positioning technology.

The parameters and calculations should not be obvious to the driver who should only get aware of sudden changes in road friction by a message or appropriate warning. The usability of a driver information system, warnings against unforeseeable low friction and therefore increases of stopping distance shall be evaluated in this WP using simulator studies.

Therefore an HMI has to be developed to provide this information in the best and less confusing way. Some alternative HMIs, i.e. ways of informing/warning/advising the driver about the prevailing road surface and situational conditions will be developed. A set of selected and prioritised low friction road surface conditions will be identified and implemented. The scenario used for the driver simulator study

will be worked out mainly by VTI, with PRISMA and arsenal research assisting. The comparison of using such a system and not using it, shall point out the possible contribution to improve road safety, by impacting drivers´ behaviour.

4.2 Intelligent Pavements and Vehicles (WP3)

Road status monitoring is expected to increase significantly by means of “in situ” measurements combined with floating car data (fleets of probe vehicles with vibration patterns and other vehicle/ driving indicators from modern in-car sensors) for distributed statistic patterns. Primary and secondary roads are expected to be covered.

This is an important development as hitherto, comprehensive road monitoring infrastructure can normally only be justified on busy and strategic routes (motorway and major roads). On the other hand, secondary roads comprise the majority of most networks, and increased monitoring by means of floating vehicles will be a cost-effective measure, enabling more efficient targeted maintenance, leading to road authorities optimising their resources.

Different innovations are possible and under investigation:

- Cheep new MEMS accelerator sensor (MOTES) in the pavement (battery and WLAN) or in the vehicle.
- FOC (fibre-optic cable) sensors for strain measurement in the road pavement layers.
- Salt measurement for salting effects in lower pavement layers.
- Maintenance and repair measures of roads will be improved by online data and new infrastructure protection strategies.

4.3 Traffic and Safety Monitoring (WP4)

The cost of installing fixed location sensors on road network is very high and the trend is moving towards using mobile sensors such as probe car which is of lower cost, and has the potential to provide a more comprehensive coverage of the road network. Probe car is a vehicle equipped with sensors to collect data on various of road parameters such as road surface condition, pavement condition, location of vehicles, etc.

In the near future with a high proportion of probe car travelling on the road network, it is possible to send all the data collected on-board each vehicle to a server. Algorithms could be developed to estimate the performance of the network such as congestion level, amount of emission and travel time. This information will be useful to the road operator to select the best management strategy to deal with the traffic demand.

More interesting would be the prediction of the traffic condition on a rolling time horizon of say 30 to 60 minutes. This will enable operator to take a pro-active measure in managing the traffic. Obviously synergy of probe car data with fixed traffic sensors and other exogenous data sources such as data from weather monitoring stations, automatic de-icing stations and VIMS can be realized with the use of data fusion. The benefits from data fusion are more accurate information and a more comprehensive information.

Information derived from such system is not only useful to the road operator but they are also useful to drivers as well. For example, information can be disseminated to driver to drive in a certain manner such as reduce speed further when the road is wet or icy, and when incident is detected ahead.

With high resolution probe car data that is data being collected at a high frequency, it may be possible to predict when a sharp drop in speed is about to occur a minute or so in advance. A warning message can then be displayed onboard to alert driver and such information could also be communicated to other vehicles in close proximity.

With a rich and comprehensive data it is also possible to monitor the level of safety on the road network. Situations where the traffic condition is judged as unsafe, measures can be taken to reduce the risks. For example scenarios such as high speed difference between vehicles, high density and high speed situation, and platoon of vehicles travelling at very small headways could mean unsafe situation; and alert could be send to drivers to take extra pre-caution.

WP4 is developing methodologies to use data from various sources to estimate and predict road traffic conditions more accurately to reduce congestion and increase traffic safety.

5 EXAMPLE CASES AND VISION STORIES

This chapter creates and collects a list of topic examples for the next INTRO project report as recommendations.

5.1 Scenario Example Cases

5.1.1 Access and Capacity Control

Driving on many roads is not free anymore, the organised future takes place,. Global and regional access control and capacity management are introduced, using driving contingents. Traffic flow is in total and in detail on a reasonable level adjusted. Restrictions for certain vehicle types and time slots exist. Only 3 litre cars are allowed. Road pricing (tolls) – urban, interurban, global (by satellite) for all roads is introduced. Each person gets basic travel distance vouchers (no payment) and exceeding travel distances are charged in cost levels.

Lanes of motorways are dynamically allocated. Use of emergency lane as a supplementary lane while section being congested is a way to adapt capacity of an existent infrastructure without rebuilding this infrastructure. (example of motorways near Paris). Use of hard shoulder running for buses, lorries, HOVs, etc (American approach of lane reserved for cars with more than 3 passengers, an incitation for people to car-share and decrease traffic).

Incitation to change mode en-route e.g. road pricing, prohibitions or access restrictions for certain types of vehicles, such as public transport. An example is the French “RER Routier” (express bus transit) project, where express buses will run on the hard shoulder (emergency lane) of a motorway approaching Grenoble. The aim is to authorise regional buses to use this lane whenever the main traffic lanes are congested and when no other vehicle (e.g. breakdown) is using the emergency lane. This will improve public transportation quality and then maybe reduce the traffic by changing travel habits. The infrastructure of the emergency lane is being adapted for use by buses (pavement, markings, dynamic signalling, AID).

There is the possibility of sending the information to the driver in advance to let him avoid the situation when he will be blocked by access control during the journey. Use of Access VMS, used in advance, before motorways accesses, to prevent people to access the motorway while already congested. Forecast systems to send the information about possible no access to the road part. Use of small VMS on urban expressway roadside for dynamic speed limitation adapted to traffic, weather, pollution or pavement state. (example of the Gentiane Project for the city of Grenoble, France)

Hazardous goods transport road usages, monitoring and guiding is improved and automated. TMD (Transport de Matières Dangereuses = hazardous goods transport): French experiments with microwave beacons all along the motorway and the junctions, and On Board Equipment to track the trucks transporting hazardous goods.

Big events traffic and access management, e.g. “Championships” is standard.

5.1.2 Monitoring and Steering Strategies

Real-time monitoring, total optimised road traffic capacity steering models and strategies are introduced. Access control is standard, and special or guarantied access has to be ordered and paid.

Monitoring of traffic flows is organised in different levels up to airborne monitoring. Remote airborne traffic control system is installed either in a helicopter, a plane or an air ship. The system with the camera ‘scans’ the relevant motorway by flying over the motorway. The images are sent via down link to the operation or management centre, where the automatic real time image processing takes place.

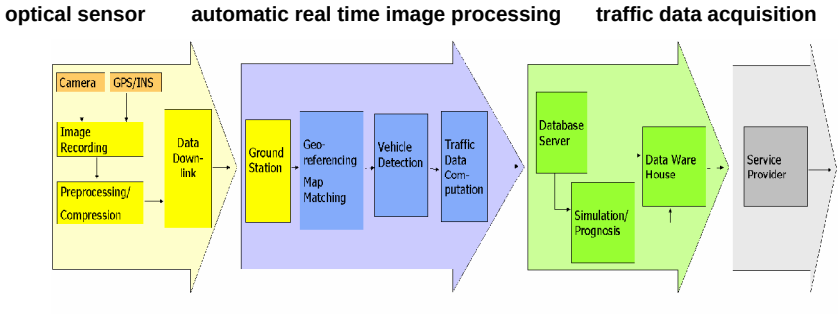


Figure 19. FAIR Project: Airborne Monitoring Approach

(ANTAR© - Remote Airborne Traffic Control Module)

The result of this process is a data set consisting of the coordinates of each single car (WGS84), the driving direction, the speed and a classification of the vehicle. Sending this data set into the database of the FAIR system (tracking & tracing, VIP- Virtual Police Agent) it is able to control for example, right lane driving of HGV by comparing the data with the relevant parameter of the digital map. By tracking the different vehicles it is possible to get information about their actual speed and the intersection related speed. The remote airborne traffic control system could be used as a stand alone system and as a sub-system to validate traffic violations.

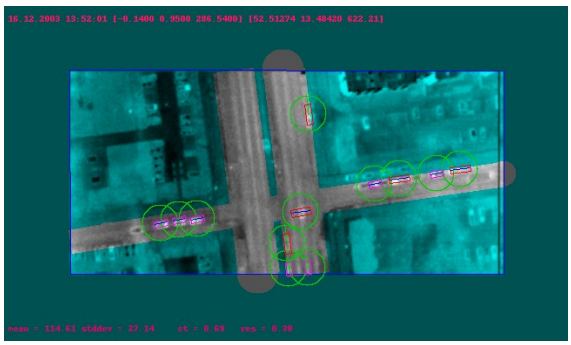


Figure 20. Result of the ANTAR© and Traffic Finder©

Transportkraft (a new traffic variable including weight aspects)New load flow models (traffic and loaf flow) complement the classic traffic management approaches, which are only based on vehicle counts. Current problems of representing traffic flow conditions and their dynamics initiated a very interesting approach: the idea of the “Transportkraft” (transportforce) as a new physical dimension and innovation for representing traffic more realistically including the “load flow” of heavy trucks. An example of the test programs planned are investigations concerning the “Transportkraft” (Franke, Brannolte, 2000).

Borttaget: the

Instead of using only a one-dimensional traffic measurement magnitude as traffic intensity q [vehicle number/time unit] usually applied in many traffic management systems, an extra measurement magnitude with the dimension of vehicle weight [tons/time unit] and the speed over the measuring interval of vehicle[km/h] are included:

Borttaget: as

Borttaget: used

$p_{v[kN]} = \frac{G_{[t]} \cdot v_{[m/s]}}{t_{b[s]}} = \frac{G_{[t]} \cdot x_{[m]}}{t_{b[s]} \cdot t_{[s]}} [N/FZ]$	$p_{T[N/h]} = \sum_{t=0}^{t=3600} p_{v,i[N/FZ]}$ **[**N/h**]** (1) t[s]

where the parameters of this equation are given in Table 1.

$p_{v[kN]}$	“Transportkraft”/Transport force contribution per vehicle	$p_{T[N/h]}$	“Transportkraft”/Transport force per hour
$G_{[t]}$	Vehicle weight		
$v_{[m/s]}$	Instantaneous speed	$t_{b[s]}$	Instantaneous gross time-gap
$x_{[m]}$	Distance	$t_{[s]}$	Time

Figure 21. “Transportkraft” equation and parameters

Such magnitudes will be named transport force, because according to the dimension equation [t*m/s^2] it is physically a force, measured in Newtons. However, it is different from the physical dynamic force. Based on traffic measurements on a highway (including vehicle weight data), a comparison of daily traffic diagrams separated by cars (PKW) and trucks (LKW) between the classical measuring magnitude (traffic intensity q in diagram 1, called fundamental diagram) and the new approach (using the Transportforce equation in diagram 2) is be given below:

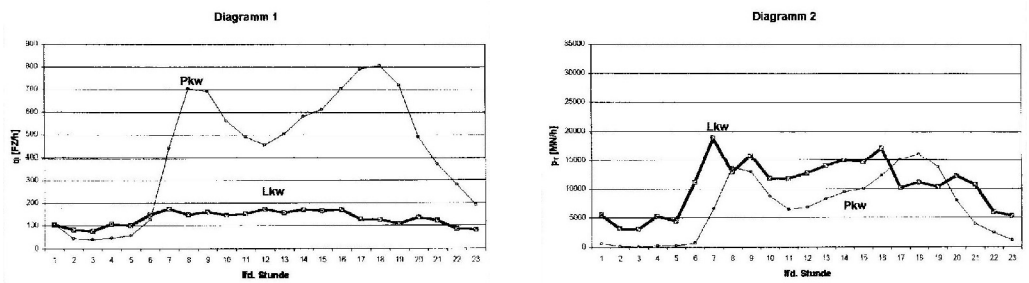


Figure 22. Fundamental Diagram 1 (left hand side) versus Transportkraft Diagram 2 (right hand side)

The X-axis in both diagrams is scaled in 24 hours/day. The Y-axis in diagram 1 represents the "classic" traffic intensity q as used in many traffic control algorithms. In diagram 2 the transport force per hour p T [N/h] is calculated according the Transportkraft equation showing a much higher impact of the truck (LKW) traffic. The daily diagram 2 using Transportforce correlates better than the quantitative vehicle measurement traffic intensity q with the real traffic load and the observed wear of road underground. The use of measurement-magnitude Transportforce will lead to more significant parameters and better decisions in the traffic planning and traffic control systems as well as in the analysis of road wear. Such an approach offers more possibilities for future investigations and research compared with the simply quantitative consideration of traffic-intensity.

Integrated traffic safety systems and control strategies

All Weather Traffic - Integrated road and traffic management (all weather conditions) – automated systems to provide advice or instructions to drivers (or even to close the road), which are triggered by certain weather conditions (fog, strong wind, snow, ice, heavy rain, risk of landslide, etc).

5.1.3 Infrastructure Life Cycle & Asset Management

5.1.3.1 Introduction

An effective and optimised infrastructure protection, management and monitoring system requires rational decision criteria to assign budgets for infrastructure protection, maintenance and repair of deficient pavement or bridge structures or components. The key factor in developing such criteria is the knowledge of the state of the condition of the structure (road, bridge, etc.) systems under management and the deterioration effects.

Up till now a lot of road deterioration modelling, road protection methods and strategies were developed. We can say that this field of research contains pretty much possibilities to be used for pavement/bridge structure renovations or maintenance.

The basic problem is acquiring the data from the structure monitoring to get the information of its present state. As the Intelligent Roads development is now coming, the described problem should be treated as one of it's most important part. Effective, low accident and all weather traffic management is impossible without a good and accessible infrastructure. So the pavement protection, monitoring and management systems should be a part of INTRO future. Modern PPMM Systems will be structured in different layers:

- Protection system
- Monitoring system
- Maintenance system
- Repair system

To assess the state of in-service structural integrity, an on-line and near real-time sensing method is needed to continuously monitor in-service structural response and detect operational anomalies and damages to the structures.

Analogous to periodic health screening and check-up of a human body, the concept of pavement/bridge structural health monitoring evaluates its structural integrity periodically using various inspection methods. The evaluation of structural integrity condition can provide vital information to improve decision-making in infrastructure system management. Early detection of deficient bridge /pavement structures and timely repair and reinforcement can prevent catastrophic failure of the structures, which could result in costly reconstruction, loss of use, and even loss of life. In such a situation even the best and most modern Intelligent Road systems of traffic management would become ineffective and unnecessary cause they will not be able to solve e.g. a bridge collapsing problem.

There are several inspection techniques for the evaluation of bridges or pavement, ranging from common visual inspection to different non-destructive evaluation techniques. These include strain gauge techniques, use of accelerometers, use of dyes, use of acoustic phenomena, ultrasonic testing techniques, rebound hammer tests, load tests, and eddy current tests. In all of these techniques, the critical need is to identify those elements of the structure that have suffered significant reduction in their load carrying capabilities, loose of pavement continuity, etc. Though these methods can provide information regarding structural integrity, they are time consuming to implement and not cost effective in practice. In addition, the sheer number of bridges and roads to be evaluated, and the difficulty in accessing some vital structural components, can add to the problem and limit the use of these methods in common applications.

The emerging technology associated with smart materials and structures, which enhances conventional engineering structures with integrated sensors and actuators, has demonstrated new functionality in engineering applications. Successful examples have been shown in aircraft, naval, and space applications for structural control and damage identification. Recent advances in this research field have shifted the focus from space and naval applications to civil engineering applications. This trend is the response to the great demand to extend the service life of the nation's deteriorating civil infrastructure.

The technology conversion from aerospace to civil structural applications must take into consideration the differences in scale and structural impedance. Moreover, the inevitable harsh environment found in large civil facility construction must also be taken into account during the installation phase. To implement smart material systems concepts for health monitoring of large civil engineering structures such as bridges and roads a sensing technique needs to be developed which uses rugged sensor media that can survive a harsh construction environment and have a service life of several decades.

5.1.3.2 Possible Trends in Infrastructure Monitoring

Bridge structural health monitoring

Many new, complex structures are fitted with structural health monitoring systems. These are designed into the bridge and provide a means for engineers to monitor the performance of key parameters under real environmental and traffic conditions. For a long span suspension bridge the measurements might include deck profile, cable load, hanger vibration, deck vibration, joint displacement and strain. The data could be sent to the management center for building the complex traffic bridge load plans (changing the traffic volume or reduce the heavy traffic)

Bridge monitoring system

These range from simple, battery powered static logging systems to fully automated structural health monitoring systems. The parameters measured can include strain, displacement, acceleration, vibration, pressure, temperature and wind speed / direction. Information also could be sent to the management centre for temporary changing the traffic load.

Wheel impact load detection

The system could use existing bridges as dynamic weighbridges. Each bridge could have a variation of strain-gauges installed on it. Each time a vehicle crosses the bridge, the system records data and immediately determines:

- Vehicle speed, direction
- Vehicle type, formation
- Overloads
- Wheel impacts.

The system can be integrated with other available information, so that vehicle IDs are allocated to vehicle defect warnings. Instead of measuring globally the loads on the bridge structures, new HS WIM sensor technologies under development will allow in depth analysis of axle loads, wheel loads and pressure distribution under different tyres and deflations:

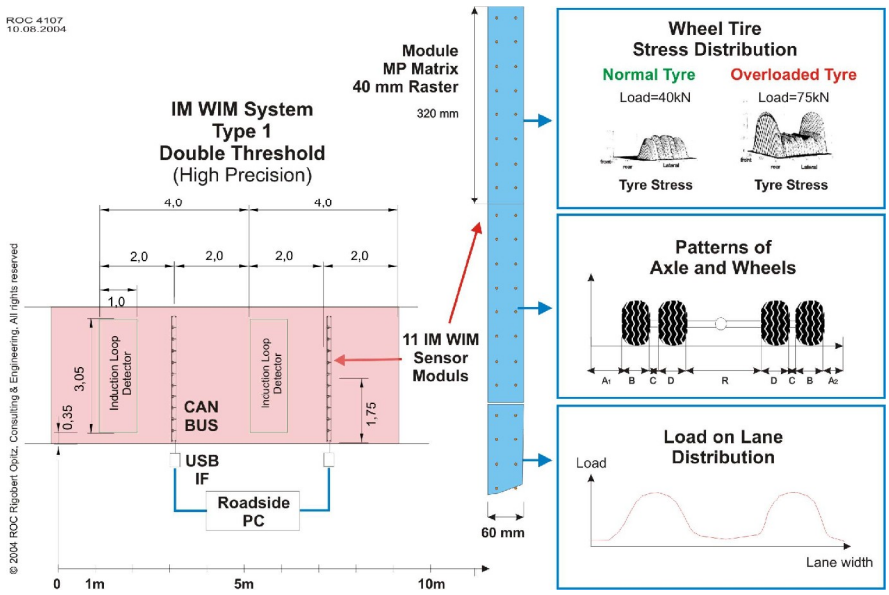


Figure 23. ROC High Speed WIM sensor

In-situ dead load stress determination

Before the carrying capacity of a bridge can be properly assessed, the dead load stress conditions need to be known. This can be particularly important for post-tensioned concrete bridges. There is a big number of techniques for the measurement of in-situ dead load stresses.

Bridge strike detection

A stand-alone system, impacts from over-height road vehicles can be monitored. Alarm messages are sent immediately which identify the part of the bridge that has been affected and how severe the impact has been. This information is backed up with a camera system.

Vehicle and rolling stock monitoring

Regularly installed strain gauges and other sensors on rolling stock components carry out dynamic monitoring. The information obtained can be used in fatigue analyses. Permanent and temporary monitoring systems have been developed for measurement of ride characteristics, vibration and wheel / track interaction effects. These have been provided for major train manufacturers for use

Pavement monitoring

Almost all countries make a pavement monitoring (once or twice a year on the whole network and more often on some parts of it). The information from such a measuring could be used better and stronger in the global traffic management system to change the load of damaged roads or make some closings. As for the length of the whole network now it is impossible to have the full automatic pavement state monitoring system on all roads.

5.1.3.3 Possible Techniques

Laser

Non-intrusive load capacity measurement is a pressing need. One technology, to solve this, is a laser measurement system for bridge load testing. The system uses a computer-controlled mirror to aim an invisible, eye safe, infrared laser beam at a point on the bridge. The laser measures the range to the point on the bridge and reports the three-dimensional spherical coordinates of that point, relative to the local origin set by the laser system.

The system can repeat this measurement at different points on the bridge hundreds of times in a few minutes. The system has a measurement range of about 30 meters and an accuracy, resolution and repeatability of a fraction of a millimetre. The system does not require special targets and works well on ordinary steel, concrete and timber surfaces. Using this system it is possible to rapidly measure the three dimensional deflection response of a bridge to a heavy truck.

The system can also be used to rapidly and quantitatively measure if any part of the bridge has moved since the last time the bridge was scanned, with an accuracy, precision and repeatability of a fraction of a millimetre.

Cordless transmission

The measurement and characterization of the random, variable amplitude cyclic stress that brides are subjected to is an essential measure need. Technology has been developed to help manage fatigue. Numerous examples of portable, battery powered, data acquisition systems now exist. These systems offer very high dynamic range, very low noise and adaptive digital spread spectrum radio network telemetry capabilities.

Using this technology it is possible to rapidly instrument a bridge at fatigue prone or critical details and measure what happens under traffic and wind loading. As the cordless data transmission techniques become more and more popular and cheaper the possibility of using such a system in the global traffic/infrastructure management is very promising.

GPS/Galileo

Another proposal is connected with Galileo project which could be also used for a structure GPS monitoring. The use of kinematics GPS is ideal for monitoring these structures, as it allows these deflections to be measured at rates of 10Hz or faster, resulting in 3D movement data for specific locations on the structure. In addition, the resulting movements are in absolute terms, and the equipment requires minimal setting up and calibration. Other current methods (such as the use of accelerometers and/or strain gauges) require much more installation, and at best result in relative displacement data.

Using GPS, the resulting data give 3D coordinates with corresponding time. This means that it is also easily possible to derive the frequency of the movements. Typically, the first natural frequency of such long bridges is less than 1.0Hz; second and third order frequencies have been detected as well. The overall advantage of such monitoring is not only that a real-time deflection monitoring system is possible, analysing the real-time deflections and comparing these to the limitations of the bridge, but also the frequencies of the movements can be analysed and compared with predicted values.

GPS derived data can be used to validate predictive models of the structure and further to this, the constant comparison of the models with the real movements can be used as a means of analysing structural health. Earlier trials in bridge deflection monitoring showed that carrier-phase GPS can detect sub-centimetre movements and calculate the frequencies of these movements. Currently, we are carrying out such work with dual-frequency surveying grade code-and carrier-phase GPS receivers.

Fibre-optics

The feasibility of smart materials technology for civil infrastructure application has been investigated in recent years. Anther one of the most promising examples is the health monitoring of concrete structures, such as buildings, bridges, dams, and others, using embedded fibre-optic sensors. The fibre-optic sensor may indeed have potential benefits in health monitoring application of concrete structures, but its physical configuration may not withstand the harsh environment found during the construction phase. Moreover, its long-term in-service survivability for required time span of several decades might be questionable. Therefore, fibre-optic sensors might not be as feasible as initially envisioned for real-world, full-scale civil engineering infrastructure application.

5.1.4 Transport Mode Shift

Transport mode shift motivations are clear and reasonable: long range transports will be shifted from the road to the train. Long range transports must be reasonable.

5.1.5 Managing Emergencies and Disasters

The future will not be as stable and quiet as today or in the last decades. How “intelligent roads” have to deal with different types of possible natural and man-made disasters and unpredictable scenarios:

NBC disaster - What supplies monitoring and supervision by intelligent roads?

Information management generation and provision strategies are required, the road is the channel for crime, pollution and distribution of illness and possible pandemics. Statements of the police: Roads are the channels of crime! What can be improved?

Nuclear Radiation – Chernobyl Lesson

The possible scenario of mobile radiation must not be ignored. Monitoring of radiation and radioactive polluted materials is necessary. (Radiated trucks and goods)



Figure 24. Dynamic radiation control of HGVs (already introduced)

Radiation control gate can be applied (and is partially installed in some countries) on the following places:

- Border controls
- Customs checkpoints
- Defence systems
- Nuclear facilities
- Steel works

Objects of inspection could be:

- Wagons
- Trucks
- Ships
- Cargos
- Hand Luggage

The Radiation Control Gate has to serve as a high-sensitivity device for reconnaissance and testing natural and artificial radiation sources. The detector of the Control Gate is a scintillation probe with high sensitivity for gamma and neutron radiation.

Pandemic Impact

Biological epidemics will find their way and will be spread ver the road network too. Transports of animals on roads have to be controlled adequately (BSE, Sheep…) More scenarios will be described in the next INTRO deliverable of WP5.

Terrorism and Crime

Infrastructure objects (Tunnels, Bridges) may by subject to terrorism.

Nature

Different catastrophes have to be considered more and more:

Icy roads and increased Snow falls, Land slide, Interrupted electrical energy supply by stroms, Water floods, Storms, Earthquakes

5.2 Vision Stories (Examples)

5.2.1 Possible Vision Story Topics

Here a collection of topic for vision stories should be started and elaborated for the next INTRO deliverable: Visions. Some examples are given below:

5.2.2 Private Car Driving and Traffic

Lowering your car insurance contribution by installing a new advanced driving support system – that is the slogan Erna recalls from the commercial, while she takes her seat right beside her husband Francis. Erna was 37 years old and normally not as enthusiastic about technical things as Francis. That is why she is not keenly interested in the benefits and the technical specifications of the “novel concept for surface safety monitoring”. For her this is only a black box with a standard connection to the normal, usual every car’s Heads up Display (HUD). The sole benefit for her is the lowered monthly insurance fee Erna and Francis have to pay…

It was a cold and misty day, and now the visibility is even getting worse due to the dusk. Erna and Francis are on their way to visit Erna’s brother. According to their adaptive travel information system they will still have to drive some 20 minutes more. But the good news is there is no additional travel congestion reported besides the regular one out of the town.

“What will Marcus and Jane look like?” she wonders. It must be about 6 or 7 months since she last saw them. Her nephew and her niece are getting into their “lively” age now, she thinks by herself…

Suddenly the HUD shows a surface warning. Due to the information the central surface condition server received from another car (which had already passed this area), the measured surface condition has changed from “normal driving” to “careful driving (long stopping distance)”. Francis nods

at the systems HUD and starts to explain the mode of operation. "…By using the micro slip data derived from the inbound car-sensors the systems is estimating a slip level for other passing cars at the same route…". "…Aha" Erna nods - she tries to sound interested, even if this was not the easiest task. While Francis orates about some additional technical background information, ABS and ESP systems, he lowers the car's speed until the HUD shows that the estimated stopping distance is at an accepted level again.

Some minutes later, the radio speaker is just announcing the news and the current time (20:01), all of the sudden a big wooden box appears on the right lane side of the road, in a right hand bend. Erna screams - Francis starts the emergency breaking just in time… After some moments of heavy breathing they realise the situation: …the car stopped a few metres in front of the box. It was about one metre high and one and a half metres wide. The oncoming lorry passed them while they wondered, why …

5.2.3 Road Operation

Self-protecting Road and Infrastructure : Road pavement is sensitive to applied loads generated by vehicles, axles and wheels (static and on top dynamics by accelerations). Deterioration depends on different parameters (e.g. temperature and life status of the road). The future active "Self protecting Road and Infrastructure"[30] will:

- Inform drivers of vehicles about maximum load parameters (gross weight, axles and wheel load and in addition max tyre pressure),
- Indications will be given by active road signs including V2I communication (RFID, DSRC) and be indicated o in the OBU on board unit ADAS (advanced driver assistance systems).
- HS WIM High speed weigh in motion systems will measure load parameters (gross weight, axles and wheel load and in addition max tire pressure).
- If required and established, the intelligent vehicle will reduce the tyre pressure and limit the driving speed of the HGV.
- Violations will be reported automatically and fined by "national fining centres".

[30] Developed by ROC – Rigobert Opitz Consult

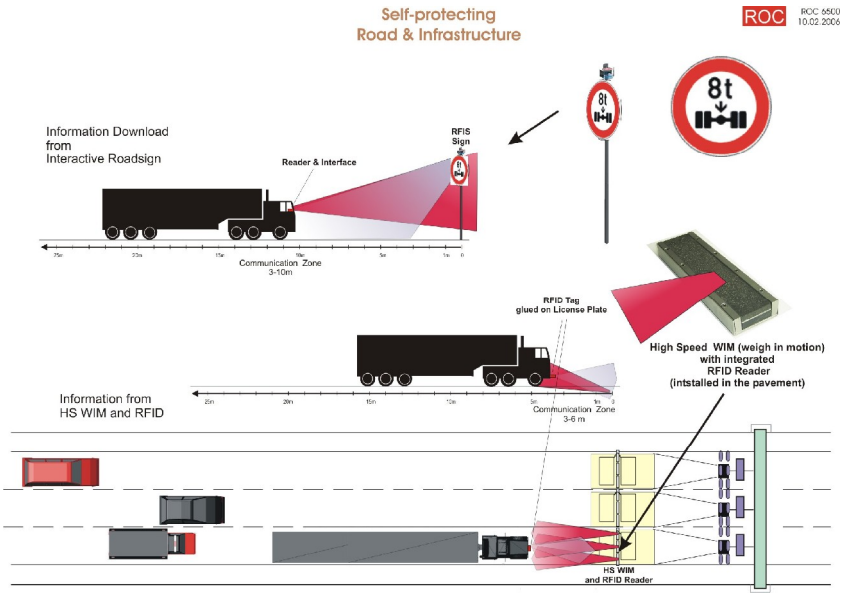


Figure 25. Self protection of road infrastructure



Figure 26. Tyres are monitored or deflated

Tyre pressure monitoring is an available technology already (see EU Project Apollo) and tire inflation monitoring can be used to assure safety and ensure drivers are operating the system in accordance with safety policy, best practices and legal permit limits. (Example above figure: IRD/Siemens VDO Automotive on board computers).

5.3 Final Comment

The important topic of “Intelligent road networks” is one which requires further analysis in future and in greater depth (including the risks of different trends, policies and developments), in order to support the EU and enabling it to create a future long-term vision (2030 or beyond) for road transport and the role of intelligent infrastructure and systems. The aim could be to avoid ongoing dislocated and divergent national or regional solutions at a general level and also to allow measures for regional optimisation at a secondary level.

6 GLOSSARY

The following is a glossary of main acronyms and abbreviations used in this report.

ABS	Automatic Braking System
ADAS	Advanced Driving Assistance Systems
CALM	Communication on Air Interface , Long and Medium range
DSRC	Dedicated Short-Range Communications
EC	European Commission
ETC	Electronic Toll Collection
EU	European Union
FCD	Floating Car Data
FEHRL	Forum of European National Highway Research Laboratories
FP4 (5, 6)	4^{th} (5^{th}, 6^{th}) Framework Programme for Research and Development of the European Union
GNSS	Global Navigation Satellite System
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global System for Mobile telecommunications
HGV	Heavy Goods Vehicle
HMI	Human-Machine Interface
HOV	High Occupancy Vehicle
ISA	Intelligent Speed Adaptation
ITS	Intelligent Transport Systems
OBU	On-Board Unit
PMS	Pavement Management System

R&D	Research and Development
UMTS	Universal Mobile Telecommunication System
VMS	Variable Message Sign
VTI	Statens väg- och transportforskningsinstitut (Swedish National Road and Transport Research Institute)
V2I	Vehicle to Infrastructure Communication
V2V	Vehicle to Vehicle Communication
WIM	Weigh-in-Motion
HS WIM	High Speed Weigh in Motion
WLAN	Wireless Local Area Network

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APPENDIX 1: EUROPEAN TRAFFIC PREDICTIONS TO 2030

Comment: certain countries are presented specifically due to availability and as examples of trends.

Source: Eurostat & local transport statistics from the Transport Ministries of Poland, Slovakia, Hungary, Latvia and Denmark.

Czech Republic

	1990	***1995***	***2000***	***2005***	***2010***	***2015***	***2020***	***2025***	***2030***	***% change 90-05***	***% change 05-30***
Passenger transport activity (Gpkm)	**92**	**84**	**88.0**	**96**	**106**	**117**	**128**	**139.0**	**149**	**+ 4%**	**+ 55%**
Public Road transport	12	11	9	8	8.5	8.7	9	9.6	10	- 33%	+ 25%
Cars and motorcycles transport	62	62	68	76	84	93	102	110	117	+ 22%	+ 53 %
Travel per person (km per capita)	**8800**	**8100**	**8500**	**9400**	**10400**	**11600**	**12900**	**14200**	**15600**	**+ 7%**	**+ 65%**
Freight transport activity (Gtkm)	**70**	**54**	**55**	**58**	**63**	**69**	**75**	**82**	**86**	**- 18%**	**+ 45%**

Estonia

	1990	***1995***	***2000***	***2005***	***2010***	***2015***	***2020***	***2025***	***2030***	***% change 90-05***	***% change 05-30***
Passenger transport activity (Gpkm)	**12**	**8.5**	**9.4**	**10**	**11**	**12**	**13**	**14**	**15**	**- 17%**	**+ 50%**
Public Road transport	5	2.5	2.6	2.7	2.8	2.8	2.8	3	3	- 43%	+ 11%
Cars and motorcycles transport	5	5.5	6	6.6	7.5	8.5	9	9.7	10	+ 32%	+ 51%
Travel per person (km per capita)	**7400**	**5900**	**6800**	**7900**	**9100**	**10700**	**12200**	**13600**	**14800**	**+ 6%**	**+ 87 %**
Freight transport activity (Gtkm)	**11**	**5**	**11**	**12**	**13**	**14**	**14**	**15**	**15**	**+ 9%**	**+ 36%**

Hungary

	1990	*1995*	*2000*	*2005*	*2010*	*2015*	*2020*	*2025*	*2030*	*% change 90-05*	*% change 05-30*
Passenger transport activity (Gpkm)	**72**	**61**	**70**	**80**	**93**	**105**	**115**	**122**	**128**	**+ 11%**	**+ 60%**
Public Road transport	11	10	11	12	12.5	12.7	13	13	13	+ 9%	+ 8%
Cars and motorcycles transport	48	41	46	54	64	73	80	85	90	+ 12%	+ 66%
Travel per person (km per capita)	**6900**	**6000**	**7000**	**8200**	**9700**	**11300**	**12600**	**13800**	**15000**	**+ 18%**	**+ 82%**
Freight transport activity (Gtkm)	**34**	**22**	**27**	**32**	**38**	**44**	**47**	**53**	**57**		

Latvia

	1990	*1995*	*2000*	*2005*	*2010*	*2015*	*2020*	*2025*	*2030*	*% change 90-05*	*% change 05-30*
Passenger transport activity (Gpkm)	**20**	**16**	**17**	**19**	**21**	**24**	**27**	**29**	**30**	**- 5%**	**+ 57%**
Public Road transport	6	2	2.4	2.5	2.6	2.6	2.6	2.6	2.6	- 40%	0%
Cars and motorcycles transport	7.6	13	14	15	17	20	22	24	25	+ 90%	+ 66%
Travel per person (km per capita)	**7400**	**6600**	**7300**	**8000**	**9200**	**11000**	**12700**	**14000**	**15300**	**+ 8%**	**+ 91 %**
Freight transport activity (Gtkm)	**25**	**12**	**16**	**20**	**23**	**25**	**27**	**29**	**30**	**- 20%**	**+ 50%**

Poland

	1990	***1995***	***2000***	***2005***	***2010***	***2015***	***2020***	***2025***	***2030***	***% change 90-05***	***% change 05-30***
Passenger transport activity (Gpkm)	**213**	**200**	**226**	**240**	**274**	**323**	**386**	**450**	**515**	**+ 12%**	**+ 114%**
Public Road transport	56	44	43	43	44	45	47	50	50	- 22%	+ 13%
Cars and motorcycles transport	104	140	153	168	198	242	295	345	394	+ 61%	+ 134%
Travel per person (km per capita)	**5500**	**5500**	**5800**	**6200**	**7100**	**8400**	**10200**	**12000**	**14000**	**+ 12%**	**+ 125%**
Freight transport activity (Gtkm)	**122**	**120**	**125**	**131**	**147**	**174**	**206**	**240**	**270**	**+ 7%**	**+ 83%**

Slovakia

	1990	***1995***	***2000***	***2005***	***2010***	***2015***	***2020***	***2025***	***2030***	***% change 90-05***	***% change 05-30***
Passenger transport activity (Gpkm)	**30**	**25**	**34**	**37**	**43**	**51**	**59**	**67**	**75**	**+ 23%**	**+ 102%**
Public Road transport	12	9	8	7	6	7	8	8	8	- 40%	+ 14%
Cars and motorcycles	13	17	23	28	34	40	47	54	60	+ 115%	+ 114%
Travel per person (km per capita)	**5600**	**6100**	**6300**	**7000**	**8000**	**9400**	**11000**	**12600**	**14400**	**+ 25 %**	**+ 105 %**
Freight transport activity (Gtkm)	**23**	**19**	**15**	**16**	**18**	**22**	**26**	**30**	**35**	**- 30%**	**+ 118%**

Germany

	1990	*1995*	*2000*	*2005*	*2010*	*2015*	*2020*	*2025*	*2030*	*% change 90-05*	*% change 05-30*
Passenger transport activity (Gpkm)	**870**	**930**	**939**	**995**	**1099**	**1200**	**1315**	**1421**	**1225**	**+ 14%**	**+ 23%**
Public Road transport	73	68	69	67	70	75	78	81	84	- 9%	+ 25%
Cars and motorcycles transport	698	743	740	790	870	960	1040	1120	1190	+ 12%	+ 40%
Travel per person (km per capita)	**10900**	**11400**	**11400**	**12000**	**13200**	**14500**	**15800**	**17000**	**18600**	**+ 10%**	**+ 55%**
Freight transport activity (Gtkm)	**357**	**413**	**491**	**547**	**612**	**681**	**750**	**819**	**892**	**+ 53%**	**+ 63%**

Denmark

	1990	*1995*	*2000*	*2005*	*2010*	*2015*	*2020*	*2025*	*2030*	*% change 90-05*	*% change 05-30*
Passenger transport activity (Gpkm)	**68**	**77**	**92**	**98**	**103**	**106**	**108**	**110**	**111**	**+ 44%**	**+ 13%**
Public Road transport	9	10	11	11.2	11	11	11	11	11	+ 22%	0%
Cars and motorcycles transport	48	54	67	71	74	76	77	78	79	+ 41%	+ 3%
Travel per person (km per capita)	**13300**	**14800**	**17300**	**18100**	**18800**	**19200**	**19500**	**19600**	**19700**	**+ 36%**	**+ 8%**
Freight transport activity (Gtkm)	**17**	**19**	**21**	**22**	**23**	**25**	**28**	**30**	**32**	**+ 29%**	**+ 45%**

France

	1990	*1995*	*2000*	*2005*	*2010*	*2015*	*2020*	*2025*	*2030*	*% change 90-05*	*% change 05-30*
Passenger transport activity (Gpkm)	**735**	**781**	**869**	**937**	**998**	**1060**	**1127**	**1194**	**1263**	**+ 27%**	**+ 34%**
Public Road transport	41	42	45	41	43	44	46	48	50	0%	+ 20%
Cars and motorcycles transport	600	650	711	779	830	870	935	970	1020	+ 29%	+ 30%
Travel per person (km per capita)	**12600**	**13100**	**14300**	**15100**	**15800**	**16600**	**17400**	**18300**	**19300**	**+ 19%**	**+ 27%**
Freight transport activity (Gtkm)	**258**	**287**	**336**	**372**	**410**	**452**	**500**	**550**	**603**	**+ 44%**	**+ 63%**

EU-25 Total

	1990	*1995*	*2000*	*2005*	*2010*	*2015*	*2020*	*2025*	*2030*	*% change 90-05*	*% change 05-30*
Passenger transport activity (Gpkm)	**4685**	**5038**	**5519**	**5943**	**6432**	**6964**	**7510**	**8045**	**8540**	**+ 26%**	**+ 43%**
Public Road transport	484	469	493	498	503	518	533	546	556	+ 2%	+ 11%
Cars and motorcycles	3593	3950	4290	4646	5024	5410	5780	6140	6475	+ 29%	+ 39%
Travel per person (km per capita)	**10600**	**11200**	**12200**	**12900**	**13900**	**1500**	**16200**	**17433**	**18653**	**+ 21%**	**+ 39%**
Freight transport activity (Gtkm)	**1765**	**1859**	**2148**	**2398**	**2690**	**3000**	**3340**	**3686**	**4046**	**+ 35%**	**+ 69%**

Remarks and Conclusions:

New EU countries:

- In the new EU eastern countries after a big decrease in the beginning of 90s caused by a economic crisis during the transformation from communism to capitalism and decreasing of inter-country trade in the RWPG system all the indicators of transport are growing very fast.

- In the post-Soviet countries like Estonia and Latvia the decrease was much stronger (caused by a big reduction of trade contacts after the Soviet Union collapsing. Now the increasing is connected with EU accession and free trade possibilities.
- In all these countries there is a tendency to hold the public transport on non change level after 2010-2015. The number of inhabitants is not going to grow very fast (rather to decrease) so there will be no needs to increase the public transport fleet.
- On the other hand the number of cars will grow higher then in the whole EU (earnings grow).

The INTRO systems should be much more focused on the private users than on the public transport. The traffic management systems will become very important in these countries due to the big increasing of the private cars number.

Old EU countries:

- The trends in old EU countries are much more different than in the new one. All indicators are growing much more slower due to the fact that these countries have much bigger earnings than a new one. Only the goods transport is increasing so fast as in the new EU countries. So the INTRO systems should be focused on increasing the driving comfort and safety.
- The number of drivers will not increase but rather decrease due to the population decreasing so the traffic problems will keep on the same level as now. The systems should so try to solve it and there will be no need to develop them more.
- Germany may be an example of old and new trends as the mixture of “capitalism” and “socialism” parts so the trends are mixture of old and new EU countries trends.

The whole EU:

- Globally in the whole EU the number of travels will increase (holiday travels, better infrastructure) so the INTRO systems should be focused on the information for drivers
- The goods freight will also increase (people from the western countries will have more money) so a heavy trucks control and guiding systems should be developed.
- Also as always the safety systems should be developed.

APPENDIX 2: VISION 2030 PROJECT SUMMARY

A number of visionary ideas about the possible future of inter-urban transport were distilled from the three Vision 2030 scenarios in this project commissioned by the Highways Agency in the UK. The focus was future transport concepts and issues which offer new starting points for activity and business development for the Highway Authorities.

DRIVERS FOR CHANGE

The major driving forces affecting transport supply and demand are covered in the Vision 2030 project report "Overview of provide a more integrated transport system to tackle the problems of Future Trends", which is the main deliverable from the information gathering phase of the project. Demographic factors are important in shaping travel patterns.

The **number of households** in England is forecast to grow faster than the population with a projected 19% increase by 2021(1996 base). Due to increasing life expectancy, almost one third of the population will be over 60 by 2031.

Our **lifestyles** are also expected to change as more land comes under pressure for house building and people have more leisure time.

Environmental issues have risen to the fore in recent years signified by the Kyoto agreement and a growing recognition that we have to find a more sustainable development path. Transport produces 25% of CO 2 emissions and this share is growing. Congestion also raises other issues such as air quality and resource utilisation.

Major Challenges Ahead

In terms of **energy**, the transport sector is heavily dependent on crude oil, which is a finite and ultimately exhaustible resource. Energy consumption in transport is growing at a faster rate than for other sectors.

Alternative and renewable fuels and **new vehicle technologies** offer some promising opportunities, although the migration process could take decades to complete. **Automating vehicles and/or the infrastructure** would also lead to a better utilisation of resources, for example, highway capacity.

Tackling the **growing demand for transport –** both passenger and freight - is a common theme identified in the scenarios.

Between 1996 and 2031 **car traffic** could grow by more than half, according to the central estimate of the National Road Traffic Forecasts.
Van and lorry traffic is forecast to grow even faster. Although it is difficult to predict how drivers will react to increasing congestion, DfT estimates that journey times will increase substantially especially on urban motorways and during the peaks.

Air travel is forecast to double both globally and in the UK in 15 years. Providing efficient surface access to airports will be a critical success factor.

Demand for **rail travel** has been steadily increasing over the past five years, and growth is forecast to continue as long as capacity can be provided and service quality improved.
Increasing congestion and **growing environmental concerns** are imposing **rising costs** on the freight industry and society.

In the longer term, an essential task is to **transfer some road freight to other modes** but logistics operators are unlikely to use costly and inflexible rail and waterway networks unless they are integrated intelligently and efficiently.

In the Vision 2030 project **three alternative socio-economic scenarios** were developed each associated with a vision for the future of the transport network. They are:

- • **"Global Economy"** - a market-driven approach;
- • **"Sustainable Lifestyle"** - a community based way of living; and
- • **"Control and Plan"** based on greater regulation of movement.

Each of the three scenarios was elaborated with reference to the following categories:

Policy, Economic, Societal, Technological, Legal and Environmental.

The PESTLE tool is commonly used in strategic planning, as it seeks to identify those external factors in commerce that there is little or no control over, such as government policy.

By identifying these factors, at least the organisation can construct a narrative based on an

optimistic or pessimistic assumption for that factor.

Scenario 1: "Global Economy" - a market-driven Laisssez-Faire approach

There is a vibrant global economy built in response to businesses taking full advantage of the open market. National government has seen many of its legislative and economic controls disappear, either to regional and local government in a process of devolution to the marketplace, or to corporations and to international organisations.

In this increasingly consumer-based and hedonistic society, there is a great diversity in lifestyles; thus the boundaries of social exclusion have widened.

Despite this, society has continued to demand a transport system that is comfortable and reliable. Transport services are provided as an integral part of the value chain through which the market organises and provides services to the consumer.

Affordability is key – personalised transport services are provided through new business organisations – travel brokers or lifestyle providers – which buy space on transport networks from the network operators. Large multinational organisations run and manage these integrated transport networks.

Freight transport and deliveries are organised in much the same way through bespoke travel, serving niche markets. Freight is shipped by forwarding companies which provide door-to-door, multi-modal transport and delivery services.

Urban and inter-urban mobility services are fully integrated. There is high intensity use of existing corridors with increasing levels of automated control to meet the demand capacity, reliability and service level targets – "Sweating the corridor".

Scenario 2: "Sustainable Lifestyle" - a community based way of living

Local communities have emerged to pursue the goal of sustainable living in order to achieve an improved quality of life. Those who hold these new values embrace advancing technologies and adopt day to day lifestyles that reduce their use of energy and dependency on the car.

Land use planning takes account of transport needs whilst encouraging people to live and work in sustainable locations.

Improved collective transport, greater use of non-motorised modes, less dependency on the car and increased distribution services are implicit in this scenario. High quality public transport networks service radial routes from city centres to the suburbs.

Other mobility needs are satisfied through a combination of walking, cycling, vehicles for the elderly/disabled, hybrid power taxis, minibuses and home delivery. Parking and interchange at the edge of conurbations encourages those living beyond city limits to use collective transport to access the city centre.

Commercial distribution in 2030 is highly competitive, efficient and well organised. Integrated services for both suppliers and consumers minimise the volume of delivery vehicles on the network.

On the inter-urban network, more trips are now for leisure purposes. Business travel mostly uses the smart corridors between city centres, often on the extended national rail network.

Motorways are gradually upgraded to provide a fully automated system.

Access to this network is provided at integrated transport hubs and at the boundaries of the conurbations. Freight transport also benefits from the improved transit times and reliability afforded by automation.

Scenario 3: "Control and Plan" Scenario

A "top-down" approach of governmental control and regulation, has become a political necessity following repeated episodes of gridlock on the country's roads, increasing public concern over road safety, and a rapid escalation of international concern about climate change.

Over the past 30 years there have been major changes to the transport system, through investment in the infrastructure and supporting systems, which maintain high quality access in a safe and sustainable manner.

Through controlled management of the transport network, an optimised, and in some cases reduced, use of the existing infrastructure is now possible, with increased emphasis on safety.

Government-led initiatives are encouraging the development of integrated multi modal transport and information systems at local, regional and national levels. Road traffic growth continues at a lower rate to that observed at the turn of the Century due to strong regulation and pricing.

Supported by national and local government, many towns and cities now have road pricing and zero emission zones which have significantly improved the quality of urban life.

Central investment in infrastructure focuses on systems which reduce speeds and improve driver and vehicle control (e.g. dedicated lanes, speed control devices). Available space on the transport network is rationed through restricted choices of mode, journey time and travel time. Road pricing applies to all inter-urban routes – the system gives freight priority over other traffic recognising its economic importance.

The booking, enforcement, access and vehicle control systems all use state of the art technology.

Interestingly, although there are big differences between the three scenarios, there was also a degree of convergence for some aspects.

For example, all three envisioned a transport system with a greater degree of automation and control than at present, but for different reasons.

Finding the “right” strategy is not easy when the changes we are and will experience are so fundamental and profound. However, we will soon be beyond fine tuning our existing systems and there is increasing evidence that we need new ways to think and act.

Twelve transport visions emerged from the process. They all have important implications for the Highways Agency in the UK. Each represents a particular vision for the future of interurban travel, whether by road or other modes, and can be mapped on to the Agency’s current business.

Twelve Transport Visions

1	The Green Highway	"The highway of the future will be completely sustainable. Materials recycling, emissions control, renewable energy sources, community engagement and preservation of bio-diversity will be standard practice."
2	Zero Accidents	"On the highway of the future crashes and multiple collisions will be virtually eliminated."
3	The Connected Customer	"Road Users of the future will have access to all necessary information at all times, irrespective of mode, in order to provide informed travel choice and options as the journey unfolds."
4	Freight Foremost	"The highway of the future will prioritise freight on the network and guarantee safe, secure, speedy, cost-effective and reliable distribution of goods in the interests of sustaining Britain's competitive economic position."
5	Favouring Public Transport	"Reliable, integrated transit services that can compete with the comfort and convenience of the car will be integral to the most heavily-loaded transport corridors."
6	Understanding the Customer	"Highways will serve an increasingly diverse and dynamic customer base. Everyone, young or old, on leisure and work journeys, will experience a responsive and positive travel experience."
7	Easy Interchange	"An efficient and attractive network of strategic interchanges for people and goods will optimise links to congested centres and provide safe, secure efficient transfer."
8	Institutional change	"Pressure will grow to get best value from highways as a national asset and to operate the network in response to society's mobility needs. Innovation and flexibility over financial, contractual and organisational arrangements will follow."
9	Managing Supply	"Traffic Growth and personal travel will continue unabated leading to greater congestion and more extensive and frequent standstills. Active and dynamic traffic management will be vital to counter long-term regular gridlock."
10	Managing Demand	"Space on the highway will be at a premium. Managing demand and the allocation of road space will be essential for efficient and reliable operation of the network."
11	Co-operative Driving on the Automated Highway	"The highway of the future will utilise intelligent infrastructure which interacts with the vehicles and people using it."
12	Land Use Planning	"An active involvement in planning and development control is essential to achieving the vision of integrated transport and sustainable use of the Highway network."

APPENDIX 3: ROAD POLICY DEVELOPMENTS IN EASTERN EUROPE

This appendix provides an overview of road policy developments in four example New EU Member States: Latvia, Poland, Slovakia and Slovenia. It provides an expansion to Chapter 3.2.2 on national ITS policies, but given that ITS so far plays only a small role in policies in these countries, has not been included in this chapter. The following demonstrates the main overall policy goals, which are now generally consistent with those in Western Europe, except that there is a major emphasis on building and updating infrastructure.

Latvia

The National Transport Development Programme (2000-2015) is a document of plan character that constitutes the activities (actions, tasks, types of activities) of economic, organizational, institutional nature and other-type of programmes falling within one system. It is worked out for 15 years period.

The National Transport Development Programme consists of nine sub-programmes:

- Maintenance and development of transport infrastructure;
- Improvement of transport services;
- International (export, import, transit) transport operations. (Transport corridors, cooperation with neighbouring countries and integration into the European transport network);
- Integration of transport systems;
- Traffic safety;
- Establishment of the environmentally friendly transport system;
- Transport statistics and information infrastructure;
- Transport legislation and institutional regulations;
- Education and science.

The main institution implementing the programme is the Ministry of Transport.

The Ministry of Transport has not carried out a special research in the transport telematics. For co-ordination of research and education in transport area the Latvian Transport Development and Education Association (LaTDEA) was established. It is non-governmental, non-profit organisation. LaTDEA operates as Thematic Network and co-ordinates research and educational programs in Latvian transport area in accordance with the agreement between Association, Latvian Ministry of Transport and Latvian Ministry of Science and Education.

The goals of Thematic Network are:

- to define results and recommendations from research projects as well as demonstration and pilot activities which will further the process of revitalising transport business;
- to recommend activities, including new proposals for implementation.

On the field of intelligent roads there are proposed two big initiatives:

Transport Telematics and Logistics

This direction encloses the Latvian transport, including the elaboration of the multimodal, telecommunication and information supply by the methodological base for the creation of the transport information and telecommunication supply integrated system on its base, for the development of transport multimodal system integrated model and its utilization to analyse the sources of data obtaining with the aim to update the information to develop data reception and constant actualisation methodology.

Transport Quality Management Systems

This direction contains process of management, reliability, safety and environment harmonization supply united methodological elaborations, agreed and optimised separate transport areas full value systems, efficient methods and rational principles, realizing the performance of the research in the direction of the education and qualification training integration and implementation of the multimodal and interregional transport corridor highly efficient harmonized management and quality system.

Poland

In the National Programme of Development for 2005-2020 years there are some information about implementation of intelligent transport functions. But it is only some small vision, without any characteristic and demands for the road administrators and builders. Below is an extract from that programme:

Goals and tasks for transport system in Poland (long- and medium-term)

The general goal of the State's transport policy is achievement of transport system sustainable from the technical, spatial, economic, social and ecological points of view, in the conditions of intensively developing market economy and improvement of living standard, taking into account international competition and the country's place in the international turnover of transport services.

Implementation of the above mentioned goal is possible through a gradual change of the existing ways of conducting economic activity in the transport sector, adoption of new technical, organizational and legal norms, while taking into account the internal conditions (accessible financial means, social and economic matters, spatial planning and environmental protection) and the external environment

(membership in the European Union and NATO, other international agreements concerning transport sector and its individual parts).

Specific goals of the transport policy are the following:

- influencing the transport service demand in order to decrease transport intensity of the

economy and to rationalise mobility of the society, to improve the spatial structure of the country and decrease the negative impact of transport on the whole environment, including reduction of environmental pollution generated by transport;

- influencing the modal split between different means of transport in order to achieve a more balanced transport system taking into account the external costs through realization of the rule “polluter pays”, with the “door-to-door” delivery, etc.;
- efficient realization of the development activities in transport, especially in the framework of realization of tasks connected with Poland’s integration with the European Union;
- improvement of functioning and level of modernity of the country-wide accessible transport infrastructure together with introducing charges for its users (in compliance with regulations and requirements contained in *acquis communautaire*);
- improvement of efficiency and accessibility of transport infrastructure network on different areas of the country, connected with realized regional development strategies.

For passenger transport the most important challenge of today is rationalisation of relations between level of motorization and transport market offer. It means:

- the necessity of introducing new management mechanisms for urban transport, where the priority must be given to public transport rationalize occupation of land, lessen the burden on the environment, rationalize the amount of the necessary public resources as well as allowing engagement of private capital; in the time of reform the use of railway systems has special importance in this context – the existing railway systems possessing surpluses in transportation capacity over the existing demand;
- in inter-urban transport the offer of the road network will certainly not follow the demands of potential users, however realistically balanced resources of the State, EU support and private capital indicate the possibility of limited but still relatively considerable progress in realization of improvement programme in the road sector; in particular:
- the East-West direction (motorway A-2 and A-4) would be realised between the Western border and the line of the Vistula river: A-2 in BOT system and A-4 in budgetary system with commercial operation of a tolled road;

- the North – South motorway (A-1) requires a considerable support of the State and thus it would be realized in partnership between the State and private concessionaires on the section between Gdansk and the Silesia area;
- realisation of other main road would be waived and exchanged with progressive modernization of roads in the standard of bearing capacity, traffic conditions, starting with cities' by-passes and modernization of bottleneck sections with highest congestion and safety hazard;

It shows that the main effort is directed to an infrastructure investments, telematic is being the minor problem. A lot of big cities are implementing their local intelligent road strategies, due to the big congestions but they rather introduce well known strategies, software and hardware then research on the new development.

One of the points where a ITS strategy for Poland is prepared and very well researched is the platform of the CONNECT project.

Polish ITS Architecture is needed to harmonise the national user needs and to investigate the possibility of common System Architecture for the CONNECT region.

The National ITS Architecture will create the bases for the development of future ITS applications in the field of:

- Improving safety of road users
- Improving efficiency of traffic flows and tackling congestion
- Reducing the travel time of road users
- Promoting the safe and economically efficient road improvements
- Improving interoperability between national ITS applications

The strategy of implementation the National ITS Architecture will cover the indispensable actions of all CONNECT Domains.

Slovakia

The basic fundamentals for formulating the Transport Policy of the Slovak Republic until 2015 (Transport Policy) are as follows:

- Conceptual and development documents approved on national and European level,
- SWOT analysis of strengths, weaknesses, opportunities and threats.

Conceptual and development documents approved on national and European level:

1. Principles of State Transport Policy of the Slovak Republic,
2. Development concepts in transport sector, in relation to other development concepts of
3. national and regional scale,
4. White Paper – European Transport Policy for 2010 – Time To Decide,
5. Lisbon Strategy of EU.

The main principle of transport policy is sustainable development arising from the support of sectoral balance, transport user orientation, support of equality of opportunity, effective use of land and resources, open approach and gradual transition of cost reimbursement onto its originators. According to the White Paper, this approach is reflected in the core principles leading to proportional and structurally balanced sustainable development of transport and to the establishment of new mutual bonds inland as well as with foreign countries.

Core principles:

Transport and political principles

- Understanding of transport as a complex transport system with integration of individual means of transport,
- Sustainable development of transport,
- Optimal balance in the potential utilization of individual means of transport,
- Customer oriented transport,
- Decreasing dependency of transport demand increase on gross domestic product increase.

Economic principles

- Equal opportunity and harmonisation of conditions,
- Efficient use of financial resources,
- Transition of total cost including externalities onto its originators.

Environmental principles

- Transport requirements optimisation,
- Effective use of land and resources (both renewable and non renewable resources)
- Individual responsibility for environmental damage – “Polluter pays!“

- Reduction of environmental pollution.

Social principles

- Solidarity,
- Equality of access conditions to public services,
- Preference for social interests over individual/local interests,
- Health protection, improvement of transport safety, improvement in quality of life and price affordability of public transport.

Objectives of transport policy until 2015

Transport policy presents a set of defined objectives, interlinked accesses, and methods for their implementation in individual means of transport and consequent, cooperating and respective activities. Conformity between the objectives and the means for their achievement is essential to make the implementation of transport policy a dynamic element of economic development and at the same time the necessity to incorporate the transport system of SR into the European transport system. The core aspect of intelligent roads in transport policy for Slovakia is in the specific objective "Improve quality and development of transport services"

The main task of transport is to satisfy transportation needs of citizens, enterprises and society with minimal economic demands (mainly external, which are not paid for by users) and environmental impact. A primary contribution is the impact on the whole society due to transportation of goods and people, which leads to proportional social development with minimal negative impact on the environment. Ensuring this relationship has become the main task of transport policy where quality is concerned.

Priority Development of transport services

It is necessary to implement another body of measures including public support in order to create such an environment, where operators' services are more attractive even for socially stronger groups, focused on the transport user, i.e. customer. One of the factors of transport service quality improvement is observing the timetable in passenger transport and the transportation guaranteed time in freight transport. Within the development programme of travelling culture it is necessary to create conditions for a simplified access to transport services, to transport means utilisation and to respective services. Priority support will be granted to programs and projects focused on improvement of transport quality and safety, and on simplified accessibility to transport for people with limited mobility and orientation.

Level of state administration central bodies:

- Enforce an intermodal approach to freight transport and integrated approach to passenger transport by interlinking all means of transport with logistic processes,
- Utilise information and telematic systems in supporting transport and carriage processes with focus on quality improvement,
- Support establishment and expansion of integrated transport systems,
- On a state interest level, ensure programmes for link search in public transport by a transport timetable system that would enable access to information on transport connections for visually-impaired people and other seriously disabled persons,
- Develop interoperable mechanisms among EU countries and thus create a single European system of safety in transport,
- Support introduction of low-platform vehicles or vehicles equipped with lift platform enabling access for disabled persons,
- Following the European quality standard in public transport (EN 13816/2002), ensure application of quality standards of public transport.

Level of Regional Administration / municipalities:

- Make all means of public transport accessible to persons with limited mobility and orientation,
- Provide higher quality transport to persons with lowered mobility or orientation via gradual removal of architectonic barriers that disable access of such persons to transport terminals, or restrict their ability to get on and off the vehicle of public passenger transport, provide higher quality transport by implementation of modern technologies, such as voice information and guidance systems for the visually-impaired in public passenger transport.

Priority Application of modern information and communication technologies and telematics in transport

The creation of intelligent transport systems requires application of information and communication technologies with transport engineering in the systems and means of transport in order to improve their quality, reliability and safety. Transport telematics and its establishment is a complex process, in which a European view must be applied. Transport systems in individual member states must be compatible with EU 34 standards but, at the same time, national interests and member states' specifics must be included and reflected in concepts.

Due to inevitable globalisation in transport processes, increasing requirements on growth and quality improvement of transport services, and reduction of negative environmental impacts, it is necessary to pay special attention to global navigation satellite systems (GNSS) in the implementation of modern

information and communication technologies in the transport sector. These systems provide services for public use based on the need for positioning static and moving objects in real time. The systems feature a huge potential for the transport sector in electronic collection of fees for transport infrastructure use, in optimisation of transport management, in improvement of safety and reliability, in search and rescue services, etc.

The Slovak Republic, as a EU member state, should be fully involved in the Galileo project –

European global navigation satellite system. The huge potential of the highly efficient Galileo system applications for all means of transport is based on the complexity of its services, its global accessibility and availability, and its guaranteed reliability and integrity.

Due to extensive investment and operational costs for intelligent transport systems it is also necessary to look for alternative ways of financing in the private sector, and pilot projects and grants provided by EU to ensure that implementation of intelligent transport systems brings benefits to passengers and the private sector as well as to sectors providing functionality of transport and services to their respective users (police, emergency, etc.).

Level of state administration central bodies:

- Create conditions to enlarge the local operation of intelligent transport systems,
- Improve safety and fluency of road transport by implementation of integrated transport operation management and by introduction of dynamic transport systems within and outside municipalities,
- Support utilisation of global navigation satellite systems (Galileo system),
- Analyse possibilities for utilisation of global navigation satellite systems in Slovak conditions,
- Involvement in relevant international, European scientific, research and standardisation unions,
- Provide interoperability of intelligent transport systems within EU.

Slovenia

Also in Slovenian Transport Policy, the main emphasis is put on the road construction and the road accidents reduction (but mostly by infrastructure investments). The existing telematic systems are planed to be developed but there is not much data about its future. The documents define needs of investments in systems preventing congestions, accidents, etc., but are not much precise in it.

Here is a short view of Slovenian Transport Policy for the next 15 years.

Road construction and technical improvements to vehicles in the last few years have been important factors behind a gradual improvement in road safety. Nevertheless, traffic safety in Slovenia compared with other countries is poor.

Each year some 38,000 traffic accidents occur on the roads, of which 41% are on national roads (motorways, trunk and regional roads). But an analysis reveals that the proportion of fatalities and injuries which occur on national roads is much higher; they account for around 70% of fatalities. A breakdown into road type shows that around 8% of fatalities result from accidents on motorways, over 40% on major (trunk) roads, 20% on regional roads, approximately 10% on local roads, 11% on urban roads and the remaining 7% on unclassified roads.

Transport policy goals

The experience gained by other countries shows that the perfect or ideal transport policy simply does not exist - but it is possible to recognize that certain individual projects have been successful. A transport policy cannot guarantee perfection or excellence in advance; attention needs to be focused on the establishment of mechanisms for responding to changes in the external environment.

The defining of priority goals in transport policy, which are to ensure cost-effectiveness of transport, protection of the environment and traffic safety, is based on the undesirable trends that have been identified in the transport system. The economic viability of the measures taken to achieve the goals that have been set is established through an assessment of the external costs of transport, which amount on average in the EU to 4.1% of GDP (2% due to traffic jams, 1.5% due to accidents, air pollution 0.4% and noise 0.2%), while in Slovenia the external costs of transport are estimated at 4% to 6% of GDP, and the great majority of these costs, around 90%, are a result of road traffic.

The basic goals of transport policy are:

- Control of traffic flows
  - Ensuring at least a minimum level of mobility
  - Reducing the burden of transit traffic
  - Preventing unnecessary traffic
  - Promoting non-motorised transport (walking, cycling)
  - Redirecting passenger traffic to public transport
  - Redirecting freight to public transport companies
  - Encouraging cooperation between companies providing public transport
- Protection of the environment
  - Rational use of the physical environment
  - Preserving the identity and biodiversity of the environment
  - Reducing air pollution from vehicle emissions

  - Safe transport of hazardous substances
  - Reducing the noise level of road and rail traffic
  - Reducing the harmful effects of air traffic on the environment
  - Preventing pollution of the sea and the environment from maritime traffic
  - Dealing with the problem of recycling old cars and car parts
  - Providing public information on protection of the environment
- Reducing the number of accidents
  - Introducing measures to increase road safety
  - Retaining the existing levels of safety in rail and air traffic
  - Preserving the high level of safety in maritime transport
- Neutralising and tackling the consequences of transport deregulation and liberalisation
  - Gradual equalisation of the quality and level of transport infrastructure services with the EU countries
  - Retaining the social security of transport workers
  - Integrating urban and rural areas using environmentally friendly means of transport
  - Integrating demographically threatened regions, special groups and the socially deprived