A Vision of Intelligent Roads (INTRO project)

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Abstract

The INTRO research experts feel that the existing technologies and applications used in an efficient way, as well as the coming developments in term of (remote) sensing, new communication means, data fusion, enhanced software tools and new algorithms represent real opportunities to manage the road system and its use in a better efficient, safe and greener way.

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.

Of course the degree to which these things will happen is still open to debate, and is subject to many social, political and economic factors. Considering different scenarios permit to highlight large-scale forces that might push the future in different directions.

The scenario proposed by INTRO depicts the most probable world in which we might travel in 30 years; it is based on the extensive analysis of existing visions and on the experience of INTRO partners. It paints a realistic future, for this reason it is strongly based on the current trends and research and counts on the progressive implementation of in-vehicle and in-road ITS.

Within the INTRO vision of future intelligent road, different vision facets are developed to fit with various road types and conditions encountered in Europe: Urban motorway - Urban radial road - Interurban motorway - Interurban road - rural road.

The visions developed are further clustered following some major functional concerns for which providing intelligence to roads presents a great added value - safety issues, user services, infrastructure sustainability, transport and traffic capacity, global issues including environment, economy and social aspects -. Various items emerge as being the most important for short- to medium-term full implementation.

1. Background

The INTRO (Intelligent Roads) project 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. Within this 3 years R&D activity (co-funded by the FP6) a

specific task was to develop a consolidated overview of the visions of the future with respect to use of the road transport systems with specific relevance to Intelligent Roads (INTRO, 2007).

Most transport commentators and experts, including partners within INTRO, generally accept that the expected overall trends for the road transport system will be (INTRO, 2006):

- **Increasing traffic, combined with higher costs for fuel and road operation on the other;**
- **More awareness of road users and higher necessity for improved safety, economy and environmental road use;**
- **Future mobility focused on the customer's needs, which are basically individual mobility and the availability of goods.**

More than others the INTRO research experts feel that the existing technologies and applications used in an efficient way, as well as the coming developments in term of (remote) sensing, new communication means, data fusion, enhanced software tools and new algorithms represent real opportunities to manage the road system and its use in a better efficient, safe and greener way. 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.

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2. Scenario

The role of intelligent road systems in the future could vary enormously according to the degree of control society is willing to accept, and thus whether societies and governments adopt more controls and regulation or prefer a more "liberal" road transport system. Usually technological innovations as well as market participation do not, in themselves, restrict new developments and applications.

The scenario proposed by INTRO depicts the most probable world in which we might travel in 30 years; it is based on the extensive analysis of existing visions and on the experience of INTRO partners. It paints a realistic future, for this reason it is strongly based on the current trends and research and counts on the progressive implementation of in-vehicle and in-road ITS.

In 30 years time the infrastructure will in many respects look like it does today. Various reasons incline us to say this: the first one is linked to the intrinsic long lifecycle of the infrastructure projects (a direct consequence is that implementation is more likely to happen during the maintenance operations). On the other hand, no revolution in vehicle design is envisaged within the next 20 years (cars and trucks will still have axles, wheels and an engine), even if due to the economic and environmental constraints, they may be lighter, have more rational dimensions (smaller cars, optimised truck length) and be driven by various clean technologies. The supply of transport will also undergo some major changes: promotion of co-modality, transferable freight modules, etc.

The INTRO partners trust in the advent of a more technological road. Due to constraints mentioned before, authorities (governments, standardisation bodies, network managers, etc) will be forced to plan, harmonise, assess and control some considerable changes. Mobility needs are still increasing but the opportunities to expand the road network remain quite weak; one of the

preferred ways to deal with this challenge today is to deploy more and more ITS (deployment rate is likely to increase though PPPs). Deciding which measures will be easier, as the majority of road users, who are now better informed about the technological opportunities, are more aware of the environmental constraints, of the possible lack of resources in the short term, and are directly concerned by the cost and problems related to mobility, appeal for some changes and are more willing to agree to moves to safe, clean, comfortable and reliable travel. The market (automotive industry, financial companies, service providers, etc) will make the best of these developments and will support innovation to ensure a quick profitability.

Technologies already existing or in development allow an outline to be drafted of how the infrastructure will look during the next 30 years. Many other technologies, unknown today, will have the potential to improve the infrastructure's ability to measure, analyse, communicate, interact or furthermore to drive.

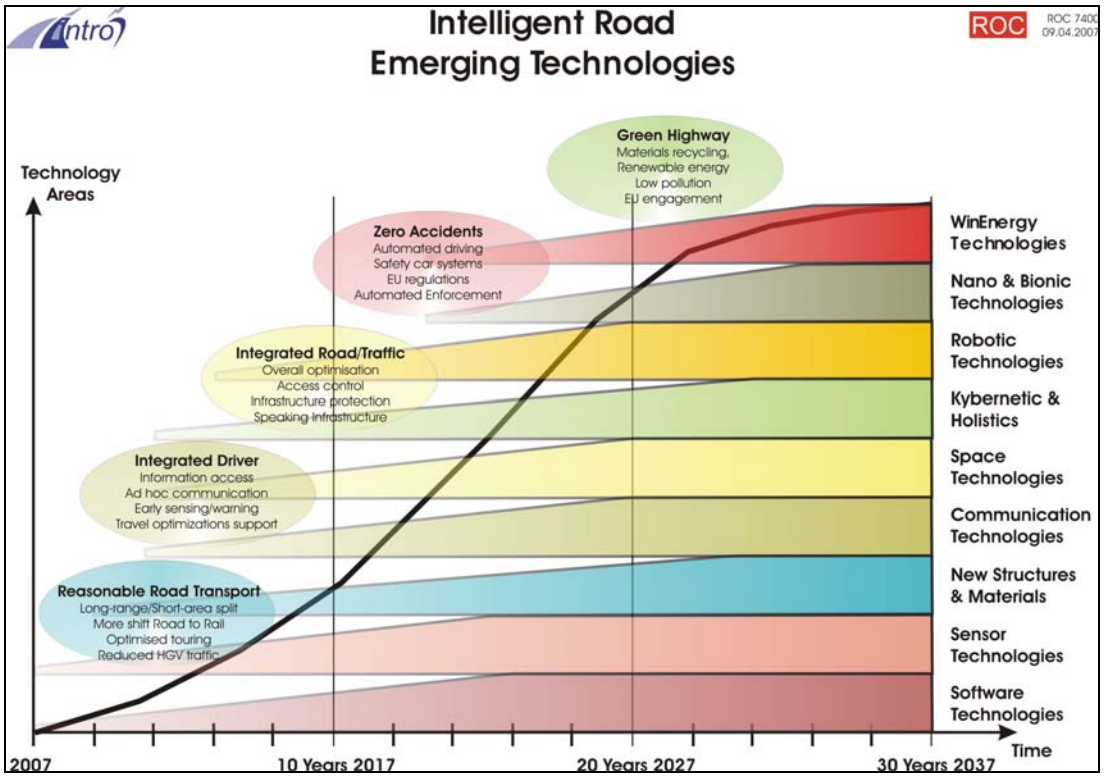

Figure 1. Scheduled benefits from some main emerging technologies areas (great potential for "intelligent road applications") (INTRO, 2007)

Despite a more or less unchanged aspect, some visible modifications having a direct impact on our everyday life will happen, like the optimised use of more dynamic, more interactive and more informative signs, etc. In parallel, more intelligent vehicles will be supported by more intelligent roads and infrastructure; existing and further new communication means will lead to an explosion of wireless sensing and multidirectional interactions between vehicles and with the infrastructure; huge amount of data collected from various sources (including innovative embedded instrumentation and in-vehicle standard sensors) will provide more available information for service providers and road and traffic managers (road condition surveying, capacity optimisation, hazard warnings, environment management measures, etc), this through developments in data fusion and more complex algorithms.

Progressively technologies and developments clustered in the INTRO Vision will enter our everyday life and most of them will, within 30 years, reach the critical mass necessary for an optimal road use (transport and travel) management, this in close and intelligent liaison with the other transport modes.

3. A 30 years Vision

One vision cannot fit all types of networks (trans-European networks, urban highways, secondary strategic state roads, rural roads, mountainous roads, etc) and can also not fit all type of road system functions. We should also remember that visions are a concrete description of how the road will look like in the next decades; they base on the previous scenario and include therefore a certain degree of uncertainty. A vision should be pragmatic, based on prioritising applications and services for different road types, and not an unattainable nirvana which would be prohibitively costly, however funded, or politically unacceptable in a democratic society

Table 1. Clustering of Visions per road conditions for Safety Issues (example) – Req.: Required; Rec.: Recommended (INTRO, 2007)

Road type code	**UM**	**UR**	**IM**	**IR**	**RR**
Location	Urban ring road	Urban radial road	Interurban – part of TERN in mountainous area	Interurban – part of TERN	Rural – regional road e.g. in mountainous area
Dynamic and Interactive road infrastructure					
Optimised & Dynamic road geometry	Rec.	Rec.	Req.	Rec.	
Forgiving road (barriers, energy absorbers, electronic rumble strips)	Rec.		Req.	Rec.	Rec.
Dynamic & interactive signing	Req.	Req.	Req.	Req.	Req.
Traffic monitoring	Req.	Req.	Req.	Req.	Rec.
Surface and road condition monitoring	Req.	Rec.	Req.	Req.	Rec.
Incident management (including rescue management)	Req.	Rec.	Req.	Rec.	Rec.
Infrastructure/vehicle interaction to support:					
Hot spots and Pre-crash warning & prevention	Req.	Req.	Req.	Req.	Rec.
Advanced Driver Assistance Systems	Req.	Req.	Req.	Rec.	Rec.
In-vehicle control	Req.	Req.	Req.	Rec.	
Violation control & prevention measures					
Enforcement measures on single spots	Req.	Req.	Req.	Req.	
Dynamic automated enforcement, in vehicle control, section & network control systems	Req.	Rec.	Req.	Req.	
Long range tracking and tracing of traffic and driving behaviour	Req.	Rec.	Req.	Rec.	

Within the INTRO vision of future intelligent road, different vision facets are developed (Table 1) to fit with various road types and conditions encountered in Europe: Urban motorway - Urban radial road - Interurban motorway - Interurban road - rural road. The visions developed are

further clustered following some major functional concerns for which providing intelligence to roads presents a great added value - safety issues, user services, infrastructure sustainability, transport and traffic capacity, global issues including environment, economy and social aspects -.

For each road type a range of ITS services is considered and each one was rated as “required” (an essential part of the vision), or “recommended” (desirable but of secondary importance and according to local circumstances, cost, business case, etc). These choices were made by the INTRO experts responsible for this report and then discussed, modified and validated among a wider group within the INTRO consortium.

The following items emerge as being the most important for short- to medium-term full implementation:

- On the **European urban motorways (UM)** safety issues will be addressed by further developments in dynamic and interactive signing, by advanced methods for surface and road condition monitoring, for traffic monitoring and incident management as well as through infrastructure/vehicle interactions (ADAS, hazards warning) and additional measures to prevent and control violations (dynamic automated enforcement, in vehicle control, long range tracking and tracing). Additional services will be available for users travelling on these roads, this includes pre-trip and real time information as well as other infrastructure based services like multimodal interfaces, dedicated freight services, payment services and tolling support.

  These roads will be maintained and managed in a more sustainable way; optimised pavement monitoring, enhanced modelling systems will allow an optimised lifecycle management; roads and bridges will be self controlling and protecting (automated load control, enforcement, dynamic lane marking) and finally a reliable environmental monitoring will dynamically support access and traffic flow control.

  Capacity management is a quite important issue on these busy motorways; new sources of traffic data including area tracking and tracing of traffic will be developed on such networks to achieve an active traffic and dynamic capacity management, including dynamic access management, variable lane configuration and dynamic lane allocation; ITS and VMS equipments will be used all along these roads. Mobility will also be managed through differential road pricing measures.

- During the next 30 years, **urban roads (UR)** will also face safety problems (due to the mix of different types of road user and the presence of at-grade junctions); developments mentioned here above for urban motorways will therefore also find their place on such roads, however the environment is here less adapted to systems that allow real-time monitoring of the surface and road condition, to control sections and network, or track the traffic on long distances. Pre-trip and “along the road” information will be part of the services panel available for users travelling on these urban radial roads; multimodal travel for people and freight delivering will be supported by specific and reliable systems.

  Life cycle schemes and strategies will be optimised on these roads, loads control and access will be automatically managed and enforced. In this sensitive environment (high density of people) an environmentally driven management is primordial, this will lead to adapted consumption reduction schemes, including traffic measures like the dedication of lanes to public transport and possibly also high occupancy private vehicles.

  The maximum road capacity will be ensured by a dynamic access management (shift in time scheme, access regulation), an active traffic management and different systems allowing a I2V and V2V cooperative driving (anti-collision, emergency warning at junctions, etc).

- **European Interurban motorways (IM)**, part of the TERN, were characterised by low accident rates as well by some potential for serious accidents involving heavy vehicles in tunnels or in bad weather; this network is therefore the ideal candidate for a very large set of safety measures, including the one already implanted on the urban motorways, plus an optimised and dynamic road geometry and active safety systems along the road.

  Due to the long distances travelled, quite often by international people and transport, the provision of relevant and reliable services to users is fundamental on the interurban motorways, it includes pre-trip and real time information via the on-board navigation systems or other nomadic devices and through roadside information, dedicated freight services, payment services and tolling support.

  This IM network plays a vital role for the European mobility and, considering its intrinsic value (asset), it must be managed in the most sustainable and efficient way, this means an intelligent lifecycle management: optimised (real time) pavement monitoring, enhanced roads and bridges modelling, lifecycle optimisation strategies, optimised targeted repairs. These roads will also be self sufficient and self controlling (self protecting roads and bridges, self repairing pavements, automated winter services but also dynamic light lane marking, self supplying and intelligent road lighting). Finally, approximately the same level of intelligence as on the urban motorways will support the capacity management (maybe with some specific traffic monitoring methods).

- On **Interurban roads,** safety issues will be mainly addressed by developments in dynamic and interactive signing, by advanced methods for surface and road condition monitoring, for traffic monitoring; hot spots and pre-crash warning, prevention and dynamic enforcement measures will help improve safety. User services will be oriented to pre-trip information and on-trip information delivered via mobile, nomadic devices, roadside infrastructure and interactive systems. This network requires the same level of intelligence as interurban motorways insofar as lifecycle management is concerned.

  As congestion problems are rare, active traffic management and ITS/VMS systems will be in use only on critical sections. However the dynamic access and flow control remains also an important measure on these roads that will be driven by the environmental constraints.

- **RR – Rural road:** It is generally uneconomic (from a cost-benefit point of view) to put intelligence into such a lightly used rural road; on secondary roads or roads supporting less traffic, different more cost effective solutions will be largely used, like floating car data, and sensing vehicles, etc.

  Dynamic and interactive signing will support the road user safety, mobile and nomadic devices will be the principal dissemination way for pre- and on-trip information, advanced developments like the automated self winter service will mitigate winter hazards.

These scenario and vision are being consolidated through a stakeholder consultation that address, on one hand the relevance of the different vision facets presented by the INTRO partners and on another hand the question on how to scale these developments in time. Results of this consultation will be available for presentation during the conference.

4. References

1. INTRO project (2007). A Vision of Intelligent Roads, *INTRO, Deliverable D5.3*. FP6.
2. INTRO project (2006). Report on Scenarios, Structure, and potential Short-Term trends, *INTRO, Deliverable D1.2*. FP6.