

eSafety Forum

“Intelligent Infrastructure Working Group”

I - Elements for the definition of “Intelligent Infrastructure”

The terms “Intelligent infrastructures”, “Intelligent Highways”, “Intelligent Roads” are largely used, today, by road experts and managers, car manufacturers, equipment providers... Surprisingly, there are not so many explicit definitions of these terms. Surfing the Internet provides a large variety of visions of “Intelligent Roads” or equivalent, either via their constitutive technologies (wireless communications, sensors, video...) or their potential applications (to safety, to traffic management...), but rarely an attempt of direct and explicit definition.

The following approach was adopted to draft a first definition for starting discussions:

1. Find on Internet some available and representative information on intelligent road infrastructures (the technologies, the applications);
2. Get out of these pieces of information recurrent key sentences
3. Identify key words
4. Propose some basic statements
5. Attempt to draft a definition.

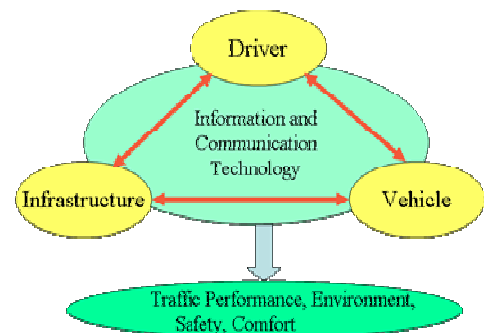
This approach resulted in a first draft definition placed in its context

The increasing demand for mobility (both people and goods), the environmental problems and road safety require a high performance road transport system where drivers, vehicles and infrastructure are integrated into one reliable, efficient and smart transport system. These objectives can be realised by services and systems supported by an integrated approach of intelligent vehicles and intelligent infrastructure supporting the driver. These intelligent systems and the interaction between vehicles and roadside are today enabled by advanced information and communication technologies.

These services/systems are dealing with:

- Up-to-date traffic information, traffic management, congestion reduction, improved mobility
- Increased road safety and security,
- Reduction of environmental problems,
- Development of sustainability.

The intelligent infrastructure is the key component in the support, management and interaction between the drivers/vehicles and the network operator.



The following definition is proposed for Intelligent Infrastructure:

The Intelligent Infrastructure is the organisation and technology of the roadside for ICT-based (cooperative) services beneficial for both road users and road network operators

In this definition:

- **organisation** means the cooperation between all stakeholders in the service value chain necessary to operate all roadside based services and systems;
- **technology** means all systems on the roadside to support the (cooperative) transport services. This includes all systems along the roadside, the communication between systems and service/traffic management/operator centres;
- **roadside** means the total infrastructure along and beyond the road not being the in-car technical infrastructure including the total back-office/end
- **ICT-based services** means those traffic/transport services provided from the road directly to the road users via roadside systems (e.g. VMS, ramp metering, warning and signalling) and to the vehicle via short/long range communication (as information to the driver or data for the in-vehicle systems). Also data (e.g. sensor data) back from the cars to the roadside is part of this. It also includes data to and from Nomadic devices.
- **Cooperative** means in this context cooperation or communication among systems. This communication is between vehicle(s) and Infrastructure (V2I), Infra to Vehicle (I2V), Nomads to Infrastructure (N2I), Infrastructure to Nomads (I2N) and infra-infra (I2I). The Intelligent Infrastructure focuses to all aspects related to "I" excluding V2V.
- **Communication** means both short and long range communication via all different media.

The definition must be read in the following context and is based on the following characteristics:

- Future intelligent/cooperative vehicle and infrastructure systems necessitate the co-operation of various stakeholders (e.g. public organisations, telecom and service providers, car manufacturers, etc).
- The concept of an 'intelligent infrastructure' will develop with the integration of in-vehicle technologies and systems that can interact with the already existing roadside infrastructure.
- Collect data from the standard vehicles (measured by on-board sensors), fixed traffic or meteo stations, monitoring devices, etc. via wireless or fixed communications; and/or
- Collect aggregated information from vehicles or fleets of vehicles, fixed traffic or meteo stations, monitoring devices via wireless or fixed communications; and /or
- Access services offered by vehicles or fleets of vehicles, fixed traffic or meteo stations, monitoring devices, etc. via wireless or fixed communications
- Store/compute/consume, in a centralised or distributed computing infrastructure, these data/information/services
- Process all these data/information/services to produce relevant aggregated information and value added services;

- Provide new and customized services to all users as well as to the road managing authorities.
- communicate with all “intelligent vehicles” (based on standardized wireless communication technologies)
- understand data coming from these vehicles, with their localization (thanks to standardized data format) and/or
- understand information coming from these vehicles (thanks to standardized information schemes) and/or
- consume services coming from these vehicles (thanks to standardized service description schemes)
- process these data together with data coming from other sources (fixed stations, monitoring devices, embedded sensors, etc)
- use information and services coming from vehicles, or other sources
- generate location-based (relevant for a specific position) aggregated information and services useable to improve traffic fluidity, safety, security and environmental impact
- offer to vehicles and other users the relevant services, at the right time and the right location

Reference information used for the definition

Based on the following analysis, the definition is derived and proposed for discussion.

1.1 Intelligent Infrastructure viewed through constitutive technologies

1. Constitutive technologies are pointed out in a number of references found in literature or on Internet (see appendix A).

2. These references provide key sentences for intelligent infrastructures:

- ... application of new technologies (data acquisition and processing, wired and wireless data exchange, general purpose information exchange, etc.) to road infrastructures and vehicles to improve road transport;
- ... attached or built-in components that are able to collect and transmit information about the state of the infrastructure to a central computer, and in some cases receive back instruction from the computer, which triggers controlling devices;
- refers to the currently evolving Intelligent Transportation System which ... encompasses the rapidly emerging intelligent transportation (sub) systems, products and services. Both technological and institutional integration are involved.
- ... a wireless network that is build up by communicative road markings with onboard sensors, the physical environment with its layout and surroundings, and the road users or clients. The clients have onboard sensors and a means to communicate with the road markings.
- ... a big improvement on the electronic highway signs that are often difficult to read or display outdated information...
- ... systems and services based on information and communication technology... Pricing measures and traffic management are components of ITS...
- The term *intelligent transportation system* (ITS) refers to efforts to add information and communications technology to transport infrastructure and vehicles

3. Therefore, key words for intelligent infrastructure nature seem to be: new technologies, on board sensors, data collection, central computer, data transmission, data exchange, wire/wireless, information and communications technologies but also products, services...

1.2 Intelligent Infrastructure viewed through potential applications

1. Potential applications which are mostly quoted are road safety and traffic management (see annex B for example).

2. References provide recurrent key sentences such as:

- ...vehicles on American roads and highways will be wirelessly connected to computerized systems that will boost safety and reduce congestion.

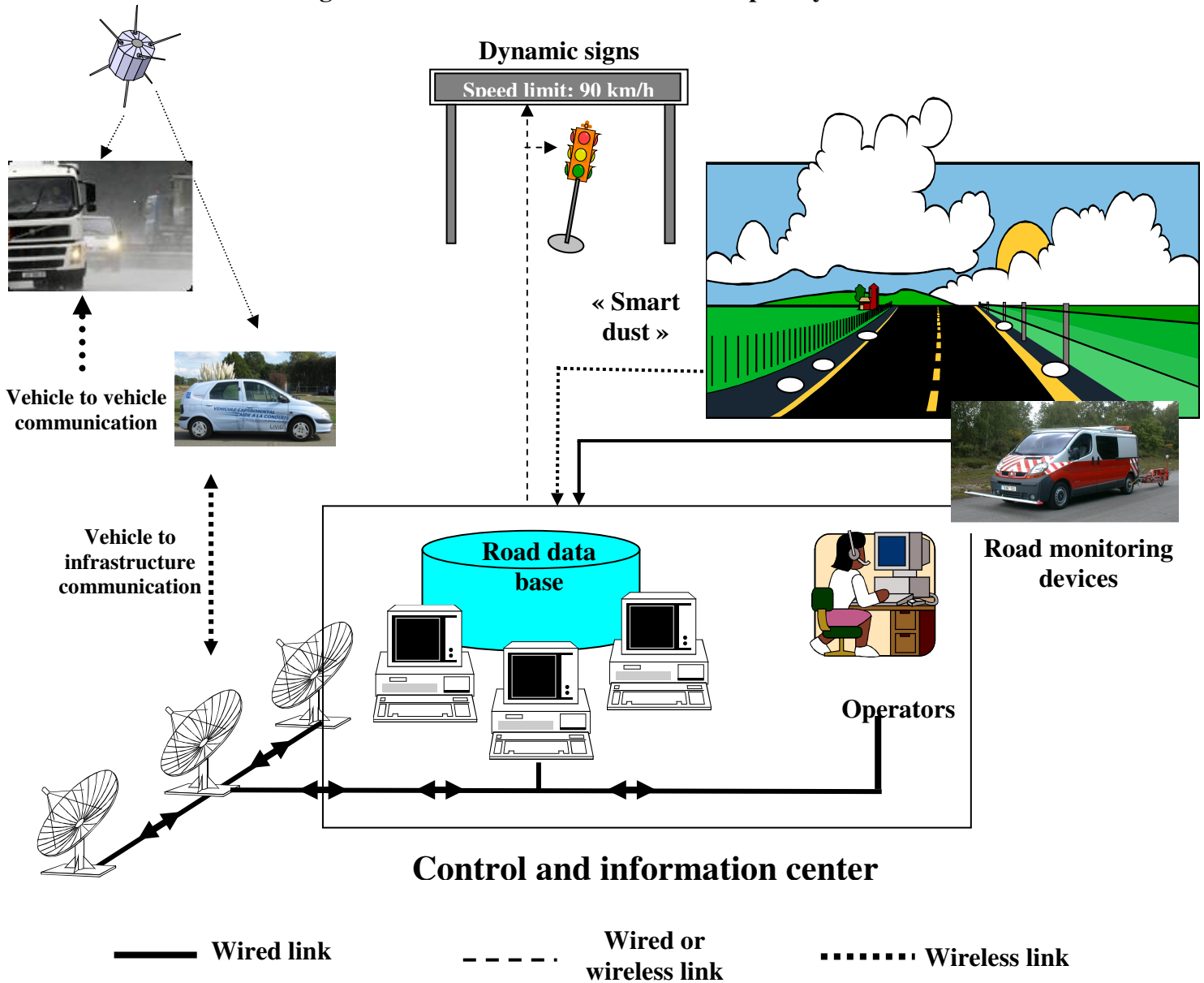
- ... will provide an opportunity to manage the road and traffic network better
- ... can help make transport more secure
- ... enhancement of road safety by direct and up to date traffic information communication between infrastructure and motorized vehicles
- ...provides for impact assessments on safety... This would include ... the use of intelligent road signs and intelligent transport systems and telematics services for emergency and signage purposes.
- Intelligent Transport Systems will enable all road users... to be “truly mobile”. Motorists will start their journey already aware of real time traffic situations, available parking places... if they have car breaks down or accident en-route, assistance and emergency services will be automatically alerted through a synergy between user and infrastructure.
- Vehicle technologies and intelligent transport systems can play an important role in addressing environmental problems in urban areas and in developing long-term sustainability of towns and cities.
- The term *intelligent transportation system* (ITS) refers to [...] an effort to manage factors that typically are at odds with each other, such as vehicles, loads, and routes to improve safety and reduce vehicle wear, transportation times, and fuel consumption.

3. Therefore, key words for intelligent infrastructure application seem to be: boost safety, reduce congestion, manage traffic, more secure, improved mobility, reduce environmental problems, and develop sustainability.

II - Intelligent highways system: illustration

This vision of the intelligent road transportation system may be illustrated, with unavoidable simplifications, such as in figure n° 1.

Figure n° 1: Futurist vision of road transport system



The main components of this system are: the vehicles, their positioning and guiding (GPS-map) system, the infrastructure and its equipments, the road data base, the road monitoring devices, the vehicle to vehicle communications, the vehicle to infrastructure communications, and the so-called “smart dust” (sensors dispersed in the infrastructure).

Appendix A - Some definitions from literature and internet

A.1 Intelligent road transport

(From “A smarter future - Foresight Project on Intelligent Infrastructure Systems”, Thinking Highways, Vol. 2, n° 2, UK Office of Sciences and Technology)

What does “Intelligent road transport” mean? It refers to the application of new technologies to road infrastructures and vehicles to improve road transport. In that context, new technologies includes: data acquisition and processing, wired and wireless data exchange, general purpose information exchange, etc. Improve road transport means developing more effective, more sustainable, safer and less polluting transport.

A.2 Intelligent Infrastructure (II)

(From “Research in the department of civil engineering of University of Toronto”)

"Intelligent infrastructure has attached or built-in components that are able to collect and transmit information about the state of the infrastructure to a central computer, and in some cases receive back instruction from the computer, which triggers controlling devices."

A.3 Intelligent Transportation Systems (ITS)

(From the Ontario Ministry of Transportation Web Page)

The term “ITS” is used in two contexts. When used in the plural - ITS refers to the rapidly emerging transportation products, services and systems which are based on advanced technologies such as computers, communications and electronics; and which are called "intelligent" because their essential functions are based on attributes normally associated with intelligence - sensory capabilities, memory, communications, information processing and adaptive behaviour. When used in the singular, ITS refers to the currently evolving Intelligent Transportation System which integrates all modes of the existing transportation systems that move people and goods; and encompasses the rapidly emerging intelligent transportation (sub)systems, products and services. Both technological and institutional integration are involved.

(From “Cooperative vehicle-infrastructure systems: an intelligent way forward? », by Prof.Dr.ir. B. van Arem, TNO, 2007

A development in the traffic and transport system that is of growing importance is the application of systems and services based on information and communication technology, leading to ‘Intelligent Transport Systems (ITS)’... Pricing measures and traffic management are components of ITS...

A.4 Intelligent Road

(From the Lulea University of Technologies Web Page)

An “intelligent road” consists of a wireless network that is build up by communicative road markings with onboard sensors, the physical environment with its layout and surroundings,

and the road users or clients. The clients have onboard sensors and a means to communicate with the road markings.

Altogether this setup constitutes a so called intelligent transport system which aims at improved mobility, increased safety and security of the clients. At the same time, energy consumption of transports on the road can be optimized. It is also expected that such an ITS can be used for test and verification of onboard sensor of vehicles and functions that are build upon this information, namely preventive safety functions.

A.5 Intelligent Highways

(From the TechFAQ Web Page)

Intelligent highways are the new highway traffic analysis and response technology that will be implemented in major cities in the near future in order to decrease traffic congestions and accidents.

A.6 Intelligent Transport Systems

(from Wikipedia)

The term *intelligent transportation system* (ITS) refers to efforts to add information and communications technology to transport infrastructure and vehicles in an effort to manage factors that typically are at odds with each other, such as vehicles, loads, and routes to improve safety and reduce vehicle wear, transportation times, and fuel consumption.

Appendix B – Intelligent Road Infrastructure application, from internet

B.1 Application to traffic enhancement

(From “The Intelligent Highway: A Smart Idea?”, by Joyce Wenger, Jack Opiola, and Tony Ioannidis, on “Strategies + business Web Page”)

It’s a persistent dream of transportation professionals that vehicles on American roads and highways will be wirelessly connected to computerized systems that will boost safety and reduce congestion. The advanced communications networks that form such a system might, for example, inform drivers about to make a left turn that oncoming traffic is moving too fast to proceed safely, or perhaps send drivers a warning of an accident or of congestion ahead — a big improvement on the electronic highway signs that are often difficult to read or display outdated information. These systems could also help drivers sidestep gridlock by suggesting an alternate route; help locate and reserve a parking space; provide information that warns drivers of changing traffic patterns; automatically adjust the timing on traffic signals along the route; and reduce traffic during busy periods by dynamically assessing fees for driving on the most congested routes.

(From “Intelligent transport infrastructure”, BCS Thought Leadership Debate, 11 July 2005, British Computer Society Web Page)

An intelligent infrastructure will provide an opportunity to manage the road and traffic network better, easing congestion and improving quality of life. In addition an intelligent infrastructure can help make transport more secure. The debate was held in central London four days after bombs murdered more than 50 people on the capital’s public transport system. An intelligent infrastructure that monitored vehicles and people could probably improve security.

B.2 Application to road safety

(From Wikipedia)

The goal of the [COOPER] project is the enhancement of road safety by direct and up to date traffic information communication between infrastructure and motorized vehicles on a motorway section.

(From European Parliament Web Page)

Parliament will vote at first reading on a draft directive to upgrade road safety management standards. The aim is to establish EU-wide standards on road infrastructure management, notably for Trans-European Networks. Safety standards for roads, in particular in road design and road maintenance, differ greatly between the EU Member States. To raise standards, the draft directive provides for impact assessments of the effect of road building on safety, safety audits and inspections, and improved safety in the existing road network. This would include the identification of high-risk road sections as well as the use of intelligent road signs and intelligent transport systems and telematics services for emergency and signage purposes.

(From 2nd European Road Congress, “Findings and Future Perspectives”, 6 November 2006, Brussels)

In the future all modes of transportation will become more “intelligent” due to the application of newer and newer technologies. This is particularly true for road transport, because of its great flexibility. Road transport will reap great benefits from the development and implementation of initiatives aimed at increasing safety, decreasing congestion and ameliorating logistics. Intelligent Transport Systems will enable all road users, both private and commercial, to be “truly mobile”. Tomorrow motorists will start their journey already aware of real time traffic situations, they will know where and when parking places are available (with the possibility to book them in advance) and if their car breaks down or has an accident en-route, assistance and emergency services will be automatically alerted through a synergy between user and infrastructure.

B.3 Applications to greener road transport

(From Intelligent Infrastructure Futures - Environmental factors in transport, foresight.gov.uk)

Increased road use highlights the problem of congestion, not only because it threatens economic growth but also as a contributor to poor air quality, noise and global warming. Vehicle technologies and intelligent transport systems can play an important role in addressing environmental problems in urban areas and in developing long-term sustainability of towns and cities.