



Smart Roads: A Vision

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1. Introduction

Over the last few years, the use of the term “smart” has become a widespread practice at all levels: now we use smartphones, there is hardly a city that does not aspire to be a Smart City, technology tends to become smart in numerous areas, new buildings are smart buildings and even energy is smart.

Roads must transform themselves in order to play a relevant role in this “revolution”: there cannot be a smart city without a smart road and together a smart city with smart roads can provide citizens with smart mobility.

The road sector faces a major challenge for this century: the definition of a new paradigm that makes **Smart Roads** a reality.

2. Background

Public perception of roads has been subject to a “degenerative” process, in the form of decreased international social, media and political presence. In short, there is an increased association of highways with exclusively negative attributes such as noise, pollution, acceleration of climate change, accident rates and external costs.

The efforts deployed by the road infrastructure sector are largely ineffective; at the same time, the quality of service provided by these transport infrastructures in developed countries is currently decreasing as it suffers from massive spending cuts. Meanwhile, alternative transport modes (whether aeronautic, rail or other) have been subject to systematic improvements and heavy public investments.

These other transport modes have successfully incorporated both structural improvements and emotional attributes into their efforts. They have also come to be dissociated from the cost-benefit analysis concerning the public spending allocated to their benefit, as political decisions have often taken precedence over economic rationality.

Whilst the other transport modes have continued to propose a range of solutions (high-speed and commuter trains, light rail transit, short sea shipping, low-cost flights, etc.), no major improvements have been made to the road networks available to users, likely as a result of overestimating the central role of roads in the movement of people and goods in countries around the world. Over time, political decision-makers have consequently turned their interest away from roads, acknowledging only the negative aspects of these transport infrastructures.

The time has come, however, for the road infrastructure sector to identify all positive aspects inherent to its use and bring them to the attention of society, the media and the

political authorities, by show-casing the high profitability of spending on road infrastructures as an economic driver providing the general population guaranteed access to other infrastructures, services, health facilities, cultural and leisure attractions, administrative centres, etc.

3. A new working approach

The approach proposed is based on the definition of a **broader, all-inclusive concept** incorporating all parameters contributing to the amelioration of road infrastructures: mobility efficiency, environmental performance, advanced traffic control technology, life-cycle analysis of construction and maintenance costs and energy inputs, user-oriented designs, safety and security performance, and long-term financing solutions. At the end of the day, Smart Roads must address the people's highest expectations in relation to road transport and, in so doing, define a model for a highway of tomorrow that adapts to societal demands.

The challenge lies in identifying the various positive attributes of smart roads from an infrastructural, technological and social perspective with a view to then redefining the concept of a "road" itself. This approach supports the advancement of road-based solutions for transporting people and goods which are more attractive, safer, more interesting, more reliable, more comfortable, etc., whilst also providing for a better sustainable, environmental and economic performance, both in the urban and the interurban contexts.

Furthermore, this concept must not only encompass the design, construction and operation of new infrastructures, but also contribute to the improvement and adequate maintenance of existing road networks, with the objective of ensuring that all highway upgrade and modernisation efforts take into account the attributes of the Smart Roads concept.

4. The key attributes of Smart Roads

We must distinguish the attributes with a direct influence on road design, construction and maintenance – we will name them **structural** aspects – from those aspects related to the **subjective** perceptions of users driving through our roads, to then reconcile those structural aspects with the users' expectations.

4.1. Structural attributes

Smart Roads are associated with structural aspects such as, although not limited to, the following:

- i. **Optimal environmental integration and energy efficiency:** This refers to the capacity of our road systems to respect high environmental protection levels, minimising the associated environmental impacts whilst also allowing all users to enjoy the surrounding region through careful landscape integration. At the same time, this approach involves developing optimised models for the lowest possible energy consumption and emission levels, maximizing the use of recycled and waste materials. To this end, it is important to take into account the entire life cycle of a road infrastructure.
- ii. **Optimal service quality:** Through advanced traffic management it is possible to optimise the use of existing road networks, limiting congestion during hours of peak demand, and at the same time distributing traffic as evenly as possible to maximise the service levels offered at all times. This approach relies on the streamlined transmission of real-time information to road users and on fostering the interaction between users and the information presented to them.
- iii. **Economic sustainability:** Highways designed for the mass transport of people and goods are economically justified in most of the cases. This principle is all the more important when it comes to evaluating the cost of operating and maintaining this type of infrastructures. It is therefore highly advised to proceed with detailed cost-benefit analyses with a view to justifying the usefulness of every road project. Full debate must also be undertaken when seeking public-private partnerships financing the construction of new infrastructures and the maintenance and upgrading of existing networks.
- iv. **Improved safety:** This means following internationally-recognised best practices in the design of new road infrastructures and in the implementation of the best possible safety solutions - for all users - in the maintenance, upgrading and modernisation of existing infrastructures. Collaborative efforts in this regard should contribute to reducing road mortality and injury rates through more effective design, construction and maintenance of road infrastructures.
- v. **Coverage of externalities:** The external costs arising from the movement of people and goods on roads must be kept to a minimum through the development of technologies to absorb emissions and noise, minimise the probability of and mitigate the impacts of accidents, and in addition provide maximum travel time in free-flowing traffic.
- vi. **Assurance of regional cohesion:** Conventional roads are a paradigm for effective regional development, as they offer all users an ideal door-to-door transport alternative providing access to all social services (e.g., leisure, culture, health,

education and other infrastructures). At the same time, it is necessary not to overlook the importance of roads in urban and suburban areas, which are fundamental for those living both in and outside cities.

- vii. **Focus on co-modality:** It is also important to acknowledge the key role roads play in a realistic scenario for the effective use of different transport modes in combination, with a view to realising a sustainable utilization of transportation resources. Roads are inevitably an essential link in the modal chain as they are the sole mode providing access to ports, airports, commuter stations, bus connection points and so on. This unique attribute of road infrastructures consequently needs to be highlighted as a complementary factor in relation to other transport modes.
- viii. **Adaptability of services offered:** Over time, all transport modes have successfully adapted their offer to the expectations of the various types of users (commuter and high-speed trains, rail transport of goods, light rail and underground transit, international flights, private jets, mid-haul flights, etc.) and, in so doing, the related infrastructures have been adapted to each type of mobility demand. On the other hand, roads have provided a solution to all users and for all types of travel around the clock, 365 days a year, based on two main offerings: conventional roads and divided highways. The time has come for road infrastructures also to modify their type and characteristics through an optimised design and differentiation amongst uses and users per itinerary (e.g., toll highways reserved for light-duty vehicles during predetermined time periods).
- ix. **Social commitment:** Given their attributes, roads are the only transport mode that guarantees practically universal access for the movement of all users under more or less the same conditions, regardless of their economic or social status. The universal nature of this access, which dramatically affects the quality of the services offered, is what positions this transport mode as the primary and conceptual cornerstone of the economic and social development of an advanced country. A fact that also cannot be overlooked is that roads are used not only by personal vehicles and heavy equipment but also by mass transit vehicles that provide social service and economic accessibility, not to mention motorcycles and bicycles, amongst other vehicles.
- x. **Economic contribution:** This has always been and will always be one of the main advantages of highway networks and road transport. Roads bring an enormous positive impact to national economies via their contribution to the gross domestic product, government tax revenues and the creation of direct and indirect jobs.

- xi. **User-oriented roads:** It is time to move on from the traditional concept that implies that the main “clients” of road infrastructures are always national or regional governments. The true clients are the citizens using these roads. With this in mind, Smart Roads are to be defined and re-defined on an on-going basis taking into account the requirements and expectations of users.
- xii. **Technology and innovation:** All the parameters above require a decided action from those public and private stakeholders active in the road-related scientific and technological arena. Innovation plays a key role on all levels, from the provision of more effective services to the development of new materials, road equipment, sustainable road maintenance methods and much more.

4.2. Emotional Attributes

It is also possible to identify a series of emotional attributes associated with the Smart Roads concept, insofar as they are linked closely to the structural aspects set out above, notably:

- i. **Reliability:** Roads should provide assurance in terms of predictable travel time and, by extension, free traffic flow for as much of the day as possible. This calls consequently for the systematic use of advanced technologies for managing actual demand from one moment to the next.
- ii. **Safety:** Roads should offer the highest safety levels that technical and technological progress to date allows, with a view to securing mobility with the lowest possible risk and minimising the probability of and mitigating the potential effects of accidents. These characteristics are to be taken into account for all users that may happen to use any given route.
- iii. **Security:** Roads should be the most important part of an integrated system managing the risks associated to natural and man-made disasters, and in addition providing an adequate response and recovery time to all kinds of incidents.
- iv. **Comfort:** Good driving conditions are an essential parameter for ensuring user satisfaction and must take into account adequate road visibility and signalling, even pavements and proper services alongside roads.
- v. **Modernity:** Insofar as no specific model has been defined for every possible typology for road travel, users do not generally classify roads as an “advanced” transport mode. Making a distinction between passenger and goods transport,

between short, frequent trips and long-haul travel, etc., are key challenges to design a system perceived as modern and attractive by the public opinion.

- vi. **Freedom:** Far from an association with fixed departure times or limited service offers that do not necessarily fulfil the needs of users, roads are synonymous with freedom.

5. Visualising the Smart Roads

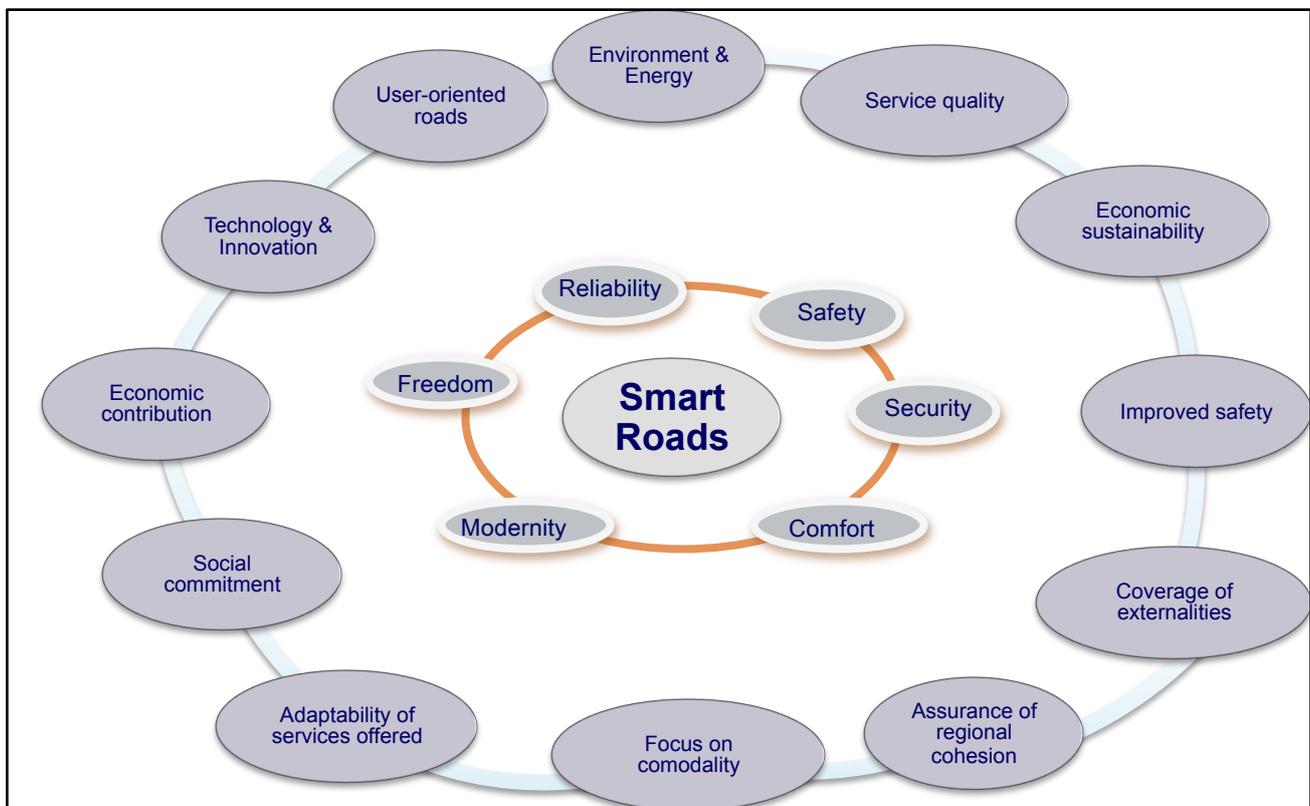


Figure 1 – The Key Attributes of Smart Roads

Source: Author's own elaboration