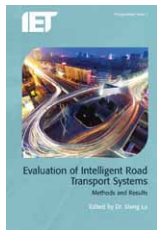


Evaluation of Intelligent Road Transport Systems: Methods and ResultsEditor: Meng Lu ¹[View affiliations](#)

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Publication Year: 2016

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p. 3 –23 (21)

Since motorised road transport started to develop, increasing comfort and safety have been important development goals in the transport domain. Over the last century, transport gradually gained more and more importance in a modernising society, with a growing need for individual mobility. The automobile is the embodiment of this need, providing the option of individual and distant transport to every citizen.

Part II: Needs and methods**• 2 ITS evaluation policy - Culture and needs**

p. 27 –46 (20)

Based on literature review as well as a questionnaire initiative and several face-to-face interviews, an analysis of the status quo for decision-making towards the implementation of ITS solutions was performed by the authors. The underlying thesis of this article can be formulated as follows: 'ITS evaluation contributes to better informed, evidence-based ITS decision-making'. In this context, it is important to understand first the general principles of ITS evaluation and the expected value by decision-makers. Followed by an analysis of the different decision-making and evaluation cultures around the globe finally the findings of a global survey among ITS practitioners and decision-makers are discussed. At the end recommendations for evaluators to make their work useful for decision-makers are formulated.

3 Frameworks and methods for ITS evaluation

p. 47 –65 (19)

In this chapter, an overview of the currently available evaluation methods and frameworks has been presented. It has been stressed that the level of detail of the utilized evaluation methodology is a function of the desired outcome of the evaluation. For example, in the case of the estimation of the actual economic impacts of an ITS project to the society, it is essential that a comprehensive and large-scale evaluation of the project is undertaken. On the contrary, the examination of the annual progress of

an ITS project towards its goals requires a more simplistic evaluation scheme. A critical factor for the determination of the level of detail of the evaluation framework is also the available budget for the implementation of the evaluation. The advantages and shortcomings of traditional evaluation methods (i.e. BCA, multi-criteria analysis) have been thoroughly analysed. BCA has been widely applied for the evaluation of investments in the transport sector, but several of the impacts induced by ITS projects can hardly be monetized (e.g. environmental improvements). Thus, several techniques have been developed within the context of multi-criteria analysis that facilitate the assessment of qualitative indicators based on experts' intuition. However, it is important to keep in mind that double counting of several impacts might occur during the application of multi-criteria analysis. The credibility of the evaluation results relies on the exclusion of the double effect of these impacts.

4 Evaluation of the impact of ITS

p. 67 –122 (56)

The evaluation of ITS begins and takes root within a European policy focused on the diffusion and enhancement of ITS. This section briefly introduces the history of the European policies and actions supporting these technologies to describe their scope in Europe. ITS apply information and communication technologies to make the transport of people and goods easy and flowing. The potential of ITS was expressly mentioned in several White Papers of the European Commission (EC), which considers them as a way to reduce congestion and bottlenecks. The implementation of traffic management plans, information services before and during the journey, goods management services, assistance and emergency services in case of emergency as well as electronic fee systems is therefore a priority and shall contribute to reduce the saturation of the road network. To support the extension of services in Europe, the European Community supports ITS in the road sector by co-financing several projects. Community policies for the development of the Trans-European Road Network (TERN) aim at establishing the interconnection, the interoperability and the continuity of services, above all on long-distance corridors and at borders. Traffic management advanced systems were implemented before 2001 in many European areas. National and regional ITS services were never coordinated, thus resulting in a fragmented mosaic. Aiming at a wide diffusion of ITS services all over Europe, the EC launched the programme Trans-European intelligent transport systems Projects (TEMPO) in 2001-2006. The key objective of the programme TEMPO on ITS in the road sector was to promote a harmonious and coordinated development of ITS in the member states of the Union, as well as the cooperation among the several countries, and the safety and quality of the service on the TERN network thanks to the cooperation between bordering regions by means of the so-called Euroregional projects. The programme TEMPO 2001-2006 includes six projects: ARTS, CENTRICO, CORVETTE, SERTI, VIKING and STREETWISE. The project CONNECT and the project ITHACA were added to the six projects, thus covering the whole Europe.

5 ITS evaluation - A network perspective

p. 123 –139 (17)

The benefits of Intelligent Transport Systems (ITS) projects are not as well understood as benefits from more traditional transportation projects. While ITS professionals are well aware of the significant impacts that ITS can have on a transportation network, others, including many decision-makers and the general public, may find it more difficult to understand why, how, or when ITS investments can provide significant benefits. ITS evaluation frameworks have been in place in the United States and several European countries for more than a decade; however, only one or two efforts have been made to evaluate ITS programs or groups of projects. This focus on individual projects rather than programs of investment is a shortcoming in transportation planning and evaluation in general.

6 Field Operational Tests (FOTs) - The ultimate answer to impact evaluation?

p. 141 –160 (20)

During the last 10-15 years, several new functions have been introduced into vehicles, in passenger cars, as well as in trucks and buses. There are functions like collisions warning, lane departure warning (LDW), blind spot warning, adaptive cruise control (ACC), stop-and-go support. Also, functions to help the drivers and other users to manage the traffic situation have been developed. Examples include navigation support, traffic information (TI), and functions that are linked to efficiency and mobility aspects, as well as to eco-driving support. These new functions are often referred to Intelligent Transport Systems (ITS).

7 Assessing transport measures using cost-benefit and multi-criteria analysis

p. 161 –188 (28)

To assess transport policy measures and putting together packages of measures for implementation, various methods and tools are available in the Netherlands. These methods comprise approaches to achieve packages of transport policy measures at a regional level and which are supported by the stakeholders. The best-known methods in the Netherlands are: 1.) The Sustainable Traffic Management method (GGB). This nine-step method can be used to compose packages of traffic management measures at a regional level, involving all relevant stakeholders. 2.) The Accessibility Solutions method. This is a quick scan method, to reach a consensus on a package of solutions for regional accessibility that contains both demand and supply-oriented measures. 3.) The Assistance for Cost-Effectiveness Analysis (KEA). This is a guide which shows how regional projects can be developed, balanced and optimised. Cost-effectiveness is an important criterion for deciding on the package of measures. 4.) The Toekan methodology. This methodology is meant to plan accessibility measures for temporary projects, such as (major) roadworks. In line with these methods, there are several other studies available that focus on optimising packages of transport policy measures. They are mostly related to one specific policy topic (traffic flow, safety or sustainability) or one specific type of measure (demand management, capacity management). There are also several studies on effects, ratios and cost-effectiveness of measures implemented and available. An overview of the effects of Dutch implementations of traffic management measures is given by Taale and Schuurman [2015]. The existing methods all have their own purpose and function to assess policy packages of measures or individual measures. However, there is a lack of a unified, integrated and comprehensive method to determine the cost-efficiency or to make a (social) cost-benefit analysis for such packages or measures. Currently, on one hand the integration of the different policy objectives and the different types of measures is missing, while on the other hand the uniformity of definitions, data (key figures and costs) and calculation methods is lacking. This chapter tries to fill this gap and describes an integrated and uniform approach, called the Assessment method for demand and traffic management (AMDTM).

8 Technical assessment of the performance of in-vehicle systems

p. 189 –214 (26)

In this chapter, a methodological framework and procedures to be used for the validation of in-vehicle complex systems has been presented. This one is based on the V-shaped approach and has been progressively improved through the experiences gained in various European projects. However, this methodology should not be seen as a rigid framework but more as a source of inspiration for future works. To illustrate this one, an original driver assistance system has been designed. The so-called ISA++ system aims at determining the speed limit a driver has to follow based on the speed signs detection, the map-matching of the vehicle and the detection of low visibility distances caused by fog presence.

9 Evaluation of ITS: opportunities and challenges in the era of new pervasive technology

p. 215 –231 (17)

The advent of new pervasive technology has enabled a new tranche of ITS schemes to develop, based on personal devices and often employing social functionality alongside functions that are more clearly transport focused. As with established, fixed-based ITS, the possible permutations of technology configurations and functionality is vast. In this chapter, we have focused on two particular types to illustrate how evaluation methodology should now evolve - new mobility scheme (NMS) and social innovation (SI) schemes.

Part III: Intelligent road transport systems evaluation results

10 Evaluating cooperative ITS

p. 235 –256 (22)

Cooperative Intelligent Transport Systems (C-ITS) is a subset of ITS which involves communicating and sharing information between ITS-stations. These ITS-stations comprise personal devices, vehicles, the roadside infrastructure and the back-office. The objective of C-ITS is '... to give advice or facilitate actions to improving safety, sustainability, efficiency and comfort beyond the scope of stand-alone systems'. C-ITS is also known as 'connected vehicles' and require a substantial value chain to deliver the services and include vehicle manufacturers, in-vehicle product developers, electronics companies, app developers and mobile network operators.

11 The evolution towards automated driving - Classification of impacts, review of assessments of automated driving functions, challenges for evaluation

p. 257 –285 (29)

Automated driving will provide many kinds of benefits - some direct and some indirect. The benefits originate at the individual level, from changes in the behaviour of drivers and travellers with regard to driving and mobility, ending up with benefits at the social level via changes in the whole transport system and society, where many of the current planning and operations paradigms are likely to be transformed by automated driving. There may also be disbenefits, particularly at a social level, for example in intensity of travel which could result in additional congestion and increased use of natural resources. There may also be unintended consequences. For example, we do not know the impacts on public transport: driverless vehicles could provide a means to a lower cost service provision, but the availability of automated cars could lead to more car travel at the expense of collective transport.

12 User-related evaluation of ADAS and automated driving

p. 287 –307 (21)

Newly developed Advanced Driver Assistance Systems (ADAS) and automated driving offer support to the driver in his/her driving task. Besides driver comfort, these systems are expected to give significant safety improvements. However, the expected positive safety effects only will be achieved if the driver uses the system in the way it was intended to be used, he/she follows its recommendations and does not compensate for perceived safety improvements by driving faster or less attentively. The financiers of technology development programmes (e.g. the European Commission) are becoming increasingly conscious of this possible phenomenon of behavioural adaptation, when the driver perceives safety improvements, and hence give growing importance to user-related assessment of new technology, since it is through the user the expected advantages of a new system may (or may not) materialize. User-related evaluation of ADAS and automated driving applications involves a great variety of issues (such as locus of control, trust, mental representation of the system, situational awareness (SA), mental and physical workload, feedback, stress and acceptance), hence it is of importance to identify and define these issues as focus of user-related evaluation. As a first step of the user-related evaluation process, research questions concerning these issues are to be outlined, and based on them working hypotheses to be formulated and evaluation indicators to be identified. For testing the hypotheses, there is a great

variety of evaluation methods and tools that can be employed. The aim of this chapter is to list and describe relevant issues of user-related evaluation of ADAS and automated driving applications, to give examples of hypotheses and evaluation indicators, as well as describe available evaluation methods and tools and discuss relevant study design issues.

13 Towards a coherent cost-benefit analysis of ITS - A review of effects and assessments of ITS applications for traffic management in Sweden

p. 309 –325 (17)

There is a need to compare the costs and benefits of investments in Intelligent Transport Systems (ITS) and Services with those of investments in traditional infrastructure. Such comparisons need quantified data. However, some impacts of introducing ITS measures are difficult to quantify. For the Swedish Transport Administration (STA), which is nationally responsible for long-term planning of the transport system, as well as for building, operating and maintaining public infrastructure in accordance with the national transport policy in Sweden, the impact on society of building ITS installations is in need of clarification. The STA has made substantial efforts over the years to develop methods to evaluate road infrastructure investments. This work has resulted in a series of publications with quantified impact assessments, which aim to define the relationships between investments and their consequences on society. The purpose has been to enable cost-benefit analysis (CBA) for all types of road investments, including investments in ITS. Despite several attempts to create a foundation for the estimation of effects of ITS, few of these efforts has resulted in full CBA models. A long-term goal for the STA is to promote better ITS evaluations and follow-ups so that such input can be aggregated to create good knowledge and understanding of ITS effects. The goal is to enable the impacts of ITS measures to be described at a level of detail equal to that of traditional infrastructure measures. The aim has been to enable effect comparisons of ITS against other infrastructure measures.

14 Effectiveness of Intelligent Transport Systems: Wet Weather Pilot

p. 327 –344 (18)

The M1 Motorway (formerly F3) is an important part of the National Highway network with a total length of 127 km providing a link between Sydney and Newcastle and the regional areas of Central Coast. This road is one of the most significant transportation routes (for both people and goods) in the country, carrying an average Annual Average Daily Traffic (AADT) of 37,000 vehicles in each direction. The M1 is reported to have one of the highest numbers of crashes for this type and capacity of the road mainly due to its curvilinear alignment, filled batters and deep cuttings. The section of the road between Hawkesbury River to Mount White Heavy Vehicle Checking Station (HVCS) is particularly prone to a higher rate of crashes as the curvilinear road is in addition subject to steep grades. In this Intelligent Transport Systems (ITS) deployment, the stated goal was to reduce speed during Wet weather condition.

15 Benefits and evaluation of ITS projects - Examples from China

p. 345 –368 (24)

Compared with the traditional transport infrastructure projects, although Intelligent Transport Systems (ITS) projects are of higher amount of investment, their impacts on society, economy, and environment are not easy to predict. On the other side, policymakers, investors, and the public are all very concerned about the benefits brought about by construction of ITS projects on the society, the economy, and the environment, as well as potential risks and possible negative impacts. In consequence, how to evaluate the benefits of ITS projects and how to select right indexes for evaluation have been hot topics in recent years. Since the evaluation of ITS projects contains many aspects including social, economic, and environmental, very often we need to use different methods for evaluation including qualitative and quantitative

methods, according to what factors to be evaluated. In general, many ITS projects use both quantitative and qualitative evaluation including methodologies of the traditional cost-benefit analysis and the multi-objective analysis. These evaluation methods serve for the purpose of ITS project feasibility study and the provision of a scientific basis for optimization of the operation of existing systems. This chapter includes two typical examples of ITS project evaluations in P.R. China.

16 Overload control benefit and cost considerations

p. 369 –386 (18)

This chapter has given a broad overview of the various aspects of overload control. It has shown the context for technology applications as a supporting element of overload control systems. The typical ITS control system components were identified and clearly defined. The role of various technology components must be clearly mapped to an operational concept. It is noted that benefit and costs analysis for overload control system should incorporate all aspects, and not consider the ITS elements in isolation.

Part IV: Discussion and conclusions

- **17 Evaluation of intelligent road transport systems: key findings, challenges and future work**

p. 389 –400 (12)

Intelligent Transport Systems (ITS), based on Information and Communication Technologies (ICT), have been developed and deployed for more than three decades. The core technologies in the ITS domain are positioning (both relative and absolute, and using various sensors) and telecommunication, and different options can be combined in different ways to create stand-alone in-vehicle systems and cooperative systems (using communication between vehicles and with the infrastructure) (Lu et al., 2005). ITS applications cover all transport modes (road, rail, waterborne and air), and both for people (mobility) and goods (logistics). This chapter targets road transport - part of surface transport.

- **Biographies**

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Bibliography of further reading

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