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Intelligent speed adaptation: accident savings and cost–benefit analysis

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Abstract

The UK External Vehicle Speed Control (EVSC) project has made a prediction of the accident savings with intelligent speed adaptation (ISA), and estimated the costs and benefits of national implementation. The best prediction of accident reduction was that the fitting on all vehicles of a simple mandatory system, with which it would be impossible for vehicles to exceed the speed limit, would save 20% of injury accidents and 37% of fatal accidents. A more complex version of the mandatory system, including a capability to respond to current network and weather conditions, would result in a reduction of 36% in injury accidents and 59% in fatal accidents. The implementation path recommended by the project would lead to compulsory usage in 2019. The cost–benefit analysis carried out showed that the benefit–cost ratios for this implementation strategy were in a range from 7.9 to 15.4, i.e. the payback for the system could be up to 15 times the cost of implementing and running it.

Keywords: Intelligent speed adaptation; Accidents; Cost–benefit analysis; Implementation strategy

1. Introduction

Intelligent speed adaptation (ISA) is the generic name for advanced systems in which the vehicle “knows” the speed limit and is capable of using that information to give feedback to the driver or limit maximum speed. There has been a continual stream of research on ISA in various European countries since a trial with one vehicle conducted in Lund, Sweden in 1991–1992 (Persson et al., 1993). Research projects and trials with ISA are proceeding or have recently concluded in a number of European countries, including Denmark (Lahrman et al., 2001), The Netherlands (Duynstee et al., 2001), Sweden (Swedish National Road Administration, 2001) and the UK (Carsten and Tate, 2000). Sweden currently has several thousand ISA vehicles on the road, most of them with a purely advisory system.

The External Vehicle Speed Control (EVSC) project, funded by the UK Department of the Environment, Transport and the Regions, began in February 1997 and ended in February 2000. Its aim was to review a broad range of factors related to the possible introduction of an automatic system to limit the top speed of road vehicles. Phase I of the project was designed as an introductory stage to prepare for the subsequent detailed design and experimental work. Phase II was the main research phase of the project. Its major work was concerned with the delivery of a prototype vehicle, user trials in a driving simulator and on real roads, simulation modelling to predict network impacts of ISA and a review of how ISA could be put into mass production. The last phase of the project reviewed the implications of the earlier work for implementation and prepared a proposed strategy for implementing ISA. In preparing the strategy, the predictions of the safety benefits of ISA that had been made in Phase I were revised, as was the cost–benefit analysis. The aim of this paper is to summarise the work on the safety impacts and costs and benefits of ISA and to review the proposed implementation strategy.

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2. System typology

An ISA system can be characterised by how *intervening* (or permissive) it is. Here, the variants defined by the project are:

(a) Advisory—display the speed limit and remind the driver of changes in the speed limit.
(b) Voluntary ("Driver Select")—allow the driver to enable and disable control by the vehicle of maximum speed.
(c) Mandatory—the vehicle is limited at all times.

Both the Voluntary and Mandatory are "intervening" in that the information on speed limit is directly linked to the vehicle control system. An additional possible variant between (b) and (c) is a mandatory system which allows excursions, e.g. for overtaking. Such excursions could be limited in number per unit of time or frequency per length of road.

Another dimension for differentiating ISA systems is that of the *currency* of the speed limits themselves. Here, the major typology used in the project has been:

Fixed: The vehicle is informed of the posted speed limits.
Variable: The vehicle is additionally informed of certain locations in the network where a lower speed limit is implemented. Examples could include around pedestrian crossings or the approach to sharp horizontal curves. With a Variable system, the speed limits are current spatially.
Dynamic: Additional lower speed limits are implemented because of network or weather conditions, to slow traffic in fog, on slippery roads, around major incidents, etc. With a Dynamic system, speed limits are current in terms of time.

A third dimension (one that only applies to Voluntary and Mandatory ISA) is the strictness with which the ISA control is applied. To date, the speed-controlled cars built outside the UK have tended to use a haptic throttle, i.e. a throttle pedal that gets more stiff the greater the excursion from the speed limit, and not to apply any braking. This configuration has some shortcomings: feedback is only provided when the driver's foot is on the accelerator pedal; the driver is able to override the feedback quite substantially; deceleration may be very slow so that on entering a slower speed zone the vehicle could be speeding for 0.5 km or even 1.0 km; and the vehicle will be able to overspeed on downward gradients.

Because of these shortcomings of the haptic throttle, the project implemented a vehicle using a combination of "dead throttle" and active braking. The initial retardation was achieved not through feedback through the driver's foot but by intervening between accelerator position and engine control (in our case through a combination of ignition retardation and fuel starvation, but more ideally through a throttle-by-wire system). Additionally, a small amount of braking force was applied when the vehicle was determined to be a certain amount over the set maximum. By locating the onset of the retardation, *before* passing into a lower speed zone, the vehicle could be ensured to be in compliance with legal speeds at all locations.

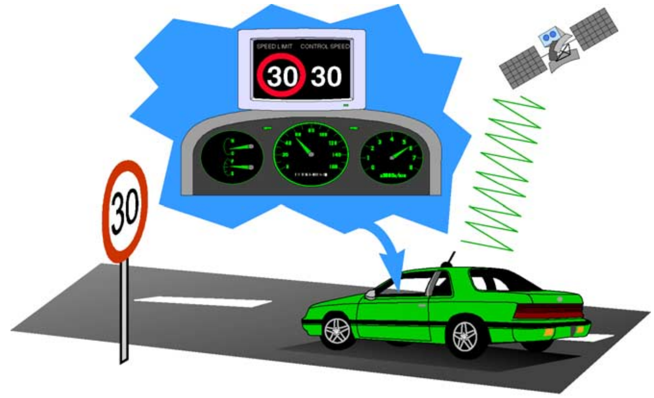

Fig. 1. Concept of autonomous ISA system.

3. System architecture

When the project began at the start of 1997, the general assumption was that a future national or European ISA system would be based on roadside beacons probably dedicated short-range communication (DSRC) beacons. Once the project got underway, the project team discussed the feasibility of alternative system architectures to provide the same ISA functionality as the beacon-based approach. An approach based on an autonomous architecture in which the vehicle would "know" its location from a global positioning system (GPS)-based navigation system and would "know" the speed limit for that location from an on-board digital road map in which the speed limit for each link in the network had been encoded. This concept is illustrated in Fig. 1.

Almost as soon as the UK project team had conceived of this alternative architecture, it emerged that a similar path was being pursued in Sweden and that a practical demonstrator of this concept had been being built by the University of Lund. The Dutch trial of intelligent speed adaptation in Tilburg also used the autonomous architecture.

The autonomous architecture is the one that was implemented in the UK project test vehicle and the vehicle proved to be a hugely successful demonstrator of this autonomous ISA concept. To provide the test route, there were no infrastructure maintenance requirements at all (i.e. no physical beacons to service). This allowed speedy implementation of routes for both experimental investigation and demonstration. In addition, the vehicle performed with a very high degree of reliability and repeatability throughout the 3 months of the on-road trials, with no observed failures of the navigation part of the system (indeed no detected failures at all). This occurred in spite of initial worries about loss of the differential signal, "urban canyons", etc.

The autonomous concept has therefore been shown to be a viable alternative to a beacon-based system, and one that can be reliably implemented with current technol-