# UK Work on Automatic Speed Control

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## 1 Introduction

In the UK, there has been quite extensive discussion of the potential benefits of automatic speed control of vehicle, to the extent even of one book on the subject (Plowden and Hillman, 1996). Plowden and Hillman suggest that "the adoption of lower speed limits, enforced by variable speed limiters, will save lives and make our towns safer for all road users, especially children and old people. It will also reduce pollution and fuel consumption, weaken still further the case for major new roads, and minimise the need for police involvement in enforcement. Speed control is an immensely powerful instrument of transport policy which has so far been little exploited." There has, however, until recently been comparatively real research on such a system. This paper reports on the results of one completed research project, funded by the UK Engineering and Physical Sciences Research Council (EPSRC) as well as on the work which has started for a new research project, funded by the Department of Environment Transport and the Regions (DETR), formerly Department of Transport.

## 2 Aims of the Research

As already indicated, there has been virtually no empirical investigation of how British drivers would behave in cars whose maximum speed was controlled to the legal speed limit and perhaps additionally to prevailing traffic and road conditions. There had also been comparatively little study of what might occur when, because of the gradual process before the system became pervasive, only part of the vehicle fleet was equipped. Therefore the objectives of the EPSRC-funded project "Response to Automatic Speed Control in Urban Areas", completed in 1996, were:

- To predict the safety benefits of systems that would automatically control maximum vehicle speed in urban areas.
- To identify undesirable side effects of such systems resulting from behavioural adaptation (risk compensation) or from drivers having difficulty in adjusting to the system.
- To identify whether problems might occur if not all vehicles are equipped.

## 3 Method

The investigation was conducted on the University of Leeds Advanced Driving Simulator (Carsten and Gallimore, 1993). This facility is a sophisticated, static-base simulator where the "driver" sits in a complete car, with all the basic controls and dashboard indicators fully operational. Using a complex vehicle handling model and sophisticated visualisation software, animated images of the scene are projected around the driver in real time. At the time of this project, there was only a single projector providing a 60° field of view to the front. Other traffic can be programmed into the scene. The road layout, the general scene, the vehicle dynamics model and the behaviour of the other traffic can all be constructed "to order", providing an ideal facility for testing new systems and new concepts, such as speed control. Major advantages of a simulator for investigating systems such as automatic speed control are the comparatively low cost of modifying the vehicle behaviour, the capability to investigate risky situations and the assurance that all the subjects have driven the identical road in the identical traffic conditions.

The speed limiter was implemented by altering the vehicle dynamics model. When operational the speed limiter prevented the driver from exceeding the legal external speed limit (here 30 mph) on the roads within an urban area. In addition, a limited amount of braking (a maximum of 10 bar) was applied to the vehicle as it entered the 30 mph zone, if the subjects did not slow down enough of their own accord. A road network was simulated incorporating junctions and links into an urban scene. The general hypothesis was that the subjects would engage in more aggressive driving when they were speed controlled, and that this more aggressive driving style would be exemplified by the acceptance of smaller gaps, by a greater propensity to red-light violation and by shorter headways in car following.

Therefore the route was built to allow investigation of these behaviours. At a number of points on the route, the subjects had to make right-turning manoeuvres across oncoming traffic, after being forced to come to a complete stop. They thus had to carry out a gap acceptance task. In addition to speed, car following behaviour and traffic light violations were recorded. For the car following, the drivers were deliberately subjected to a slow moving car in front, and the traffic signals were in some cases changed to red just as the drivers approached a junction. The scenarios under investigation were incorporated into a continuous road network, allowing natural movement from one scenario to the next. At the end of each run, the drivers' mental workload was assessed using the NASA RTLX adapted from Byers et al. (1989).

Thirty subjects completed the experiment. The sample included 15 males between the ages of 23 and 54 (mean age: 37 years) with a reported annual mileage of between 7,000 and 40,000 miles (mean = 17,600 miles); and 15 females between the ages of 24 and 49 (mean age: 37 years) with a reported annual mileage of between 6,000 and 25,000 miles (mean = 15,200 miles).

Subjects encountered all of the following four conditions is successive trials.

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| NSL/NSL | This was the control condition. Neither the subject's car nor any of the other cars on the road were fitted with a speed limiter. |
| NSL/50SL | This condition represented the 'mixed-fleet' scenario. The subject's car was not fitted with a speed limiter but approximately 50% of the other cars on the road had one. |
| SL/SL | Here the full implementation stage was reached. Both the subject's car and all the other cars on the road were fitted with a speed limiter. |
| SL+/SL+ | Both the simulator and all the other cars on the road have been fitted with a speed limiter. In addition, a secondary implementation of the speed limiter is also present in all cars. This secondary speed limiter automatically slowed the cars to a maximum of 25 mph around the vicinity of junctions. |

The order of the trials was balanced across subjects.

# 4 Results

Where appropriate the data were analysed with multi-factorial analysis (ANOVA), with one within subjects factor (System) and two between subjects factors (Age and Sex). There were no statistically significant differences between the two speed limited conditions (full implementation and secondary limiter) nor between the two non-speed limited conditions (control and 50% implementation). Therefore the rest of the discussion refers only to differences between the combined conditions of System On and System Off.

## 4.1 Approach to junctions

A significant main effect of System was found ($F(3,87)= 50.87$; $p<.001$) indicating that the speed limiter condition produced lower average approach speeds (mean = 22.42 mph) than the non-speed limited condition (mean = 24.08 mph). However post-hoc analyses (Tukey's HSD) subsequently revealed that this reduction in speed is statistically reliable only in the approach sections between 80–31 metres from the junction. So although speeds were lower on approach when drivers were speed limited, they were very similar for the main deceleration profile on the immediate approach to the junction. A significant main effect of Age ($F(1,29)= 47.96$;$p <. 001$) indicating that those subjects under the age of 35 overall drove faster than those over the age of 35, is accompanied by a significant interaction between System and Age indicating that the effect of the System is not consistent across Age groups: the higher speeds for younger drivers were not observable in the condition in which they are speed limited.

## 4.2 Speed on curves

There were no effects of System on speeds at curve entry, curve apex or curve exit. However, there was an effect on speed variance over the whole curve such that speed variance was lower when the subjects were speed limited. Variance was reduced from 1.28 mph to 0.63 mph ($F(3,87)= 3.29$;$p <. 05$).

## 4.3 Traffic light violations

A chi-square test for independence revealed a significant difference in the number of traffic light violations committed ($\chi^2$= 4.358, df=1, p<0.05). When drivers were speed limited, they tended to commit fewer traffic light violations.

## 4.4 Car following

For each subject, the percentage of headway time occupied in each half second unit between 0–6 seconds was calculated. A mean percentage was then derived across subjects in each condition. With the speed limiter, there was reduced positive skewness in the distribution, i.e. following behaviour became safer by there being less tendency to adopt short headways.

## 4.5 Gap acceptance

A value for the mean gap accepted in turning manoeuvres across on-coming traffic was calculated for each condition. There was a main effect of System on size of gap accepted, (F(3,87)= 6.23, p<0.01). Subjects accepted smaller gaps when they were speed limited (mean = 46.69) than when they were not speed limited (mean = 54.15). There was also a significant main effect of Sex such that males (mean = 47.25) accepted smaller gaps than females (mean = 52.25).

## 4.6 Mental workload

In completing the NASA RTLX after each trial, the subjects rated rate the task they had just completed in terms of mental demand, physical demand, time pressure, performance, effort and frustration level. An average score for each dimension was calculated. Compared to the control condition, subjects reported they experienced less physical demand, and that their driving performance improved when the car was fitted with a general speed limiter. However they reported that their frustration level was significantly higher in the speed limiter condition compared to the control condition.

# 5 Interpretation

The results in general indicate that driver behaviour does change when speed limiters are in use. In car following scenarios there appears to be a shift towards safer behaviour whereby less time was spent at short headways. This can not be attributed to a system effect, as the lead car was travelling slower than the subject's maximum speed of 30 mph. It is possible that being speed-limited discouraged subjects from attempting to overtake. Such an effect on car following, for roadside signs forbidding overtaking, was found by Summala (1980). Where subjects were not speed limited they could not overtake, due to oncoming traffic, but in the process of attempting to, adopted short headways. The results suggest that if drivers are waiting for an opportunity to overtake, accident risk increases by inducing very short following distances.

In addition, the frequency of traffic light violations decreased when drivers were speed limited. The frequency is partly attributable to a system effect, as being speed limited meant drivers were travelling slower and thus had more time to make the decision as to whether to run the red light or not. But being speed-limited, they may also have felt unable to put on extra speed in order to jump the lights.

In many respects, therefore, driver behaviour improved in scenarios where there was an opportunity for behavioural adaptation to the system, so that the speed control had a calming effect. In addition, the impossibility of exceeding the speed limit would of itself bring about substantial safety benefits. The effects of the system on younger drivers — the inability to drive fast on the approach to junctions — is particularly gratifying, as is the reduced speed variance on curves.

On the other hand, the results of the subjective mental workload measures indicate that feelings of frustration increased when drivers were speed limited. This increased frustration is possibly reflected in the riskier gap acceptance that was observed in the speed limited condition. Junctions account for 70 percent of injury accidents on urban roads (Department of Transport, 1995), and thus the introduction of a system that increases risk-taking at junctions is likely, in this respect at least, to have detrimental effects on the number of accidents.

# 6 Further Issues

There remain a large number of unresolved issues, before a decision is made on whether to implement speed control on a national or even a European basis. Among these are:

- Hardware design: What is the most effective and tamper-proof mechanism for limiting vehicle maximum speed? Should an element of automatic braking be incorporated, so that retardation is not too slow?
- Communications: Should the communications be beacon-based, perhaps using the Dedicated Short-Range Communications (DSRC) architecture, being adopted for other telematics systems? Or should the system be basically autonomous, relying on an on-board CD-ROM combined with a Global Positioning System?
- Fleet: Should all the motorised vehicle fleet, except perhaps for emergency vehicles, be fitted? If so, how are motorcycles to be equipped and if they are not will this result in the unfortunate effect of making motorcycles especially attractive to habitual speed violators?
- Implementation strategy: Should the initial implementation be on urban roads, where there are particularly large benefits to be secured in terms of pedestrian accidents? Or should it be on rural roads, where there are particularly large numbers of accidents involving loss of control and overtaking where excessive speed is perhaps the major factor? If an infrastructure-based system is chosen in the form of roadside beacons, should these first be installed at accident blackspots or would it be more cost-effective in the long run to equip all roads early? This question is particularly relevant for the rural non-motorway roads, where speeds are not generally higher than the speed limits, but are excessive at certain locations, particularly on substandard horizontal curves.

- Effects on safety: What are the predicted benefits in terms of accident savings from a full implementation of speed control? Estimates of the safety effect of speed control vary from a UK estimate of an 8 percent reduction in injury accidents from a system that enforced current speed limits (Perrett and Stevens, 1996) to a Swedish estimate of a reduction in injury accidents from a more sophisticated system in the range of 19–34 percent when estimating conservatively and in the range 24–42 percent when estimating optimistically (Várhelyi, 1996).
- Alternatives: How does speed control compare in cost-effectiveness with more traditional approaches to safety engineering, in particular to traffic calming?
- Side effects: Would the system have benefits or disbenefits in terms of traffic efficiency, fuel consumption and emissions?
- Attitudes: What are current public attitudes towards speed control and indeed towards some of the alternatives, such as traffic calming?

These and other questions are currently being addressed in the new project "External Vehicle Speed Control", funded by the UK Department of the Environment, Transport and the Regions, in which the University of Leeds and the Motor Industry Research Association are partners. This is a three-year project, beginning in February 1997, which includes both simulator work and on-road trials with one or more equipped vehicles. It is not currently envisaged, however, that there will be any large-scale demonstration of speed control in this project. Instead a more experimental approach is being used to address specific issues in controlled conditions. This approach would appear, therefore, to be complementary to that being adopted in other countries and in particular to the large-scale trials being planned for Sweden and the Netherlands, which should provide information on behavioural adaptation in the longer term.

# 7 References

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