WORKLOAD-STUDY OF ISA-DRIVERS
A METHOD DESCRIPTION

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INTRODUCTION

The Swedish government has commissioned the Swedish National Road Administration (SNRA) to run a large-scale trial involving Intelligent Speed Adaptation (ISA) in urban areas. There are both informative and actively supporting systems tested and the trial is being carried out in four cities. In Lund a system called *active throttle* or *speed limiter* (SL) with a possibility to override (kick-down) is used.

As with most new technologies a number of effects on the driver and his behaviour can be expected. The primary probable effect of this system is a change in speed behaviour but there are also other possible effects. One hypothesis is for instance that the communication and interaction with other road users will be improved due to lower speeds. When it comes to driver's workload little is known about if and how it will be affected by the SL, the hypothesis is that the mental demand on ISA drivers will be lover and that he will have more spare capacity to focus on surrounding traffic due to lower speed. There can also be an increase in workload in form of stress when faster traffic is pushing from behind.

AIM

The aim of this study is to evaluate the workload induced to the drivers of SL equipped cars by using an instrumented vehicle in real traffic. While driving the test persons will carry out a secondary task called Peripheral Detection Task (PDT)

HYPOTHESIS

1. The mental demand on ISA drivers will be lower.
2. ISA drivers will have more spare capacity to focus on surrounding traffic.
3. ISA drivers will feel stress from faster traffic coming up from behind in the initial phase of using the system, this stress will be reduced or disappeared after a long time of using the system.

The hypothesis is that the SL will reduce the mental demand on the driver. This is due to the knowledge that they cannot go any faster even if they want to (unless using the kick-down continuously), and maybe even plan their trip to avoid time pressure. It is also hypothesised that he will have more spare capacity to focus on surrounding traffic due to lower speed. The workload induced on the driver can be increased as well due to time pressure or as a result of stress from faster traffic pushing from behind or. This stress will be reduced or disappear entirely after a long time of using the system.

METHOD

Workload

In this study workload will be assessed by two methods, apart from the primary measures of driving related variables, a self-reported measure in the Raw Task Load Index (RTLX) and a secondary measure in the Peripheral Detection Task (PDT).

The RTLX method was proposed by Byers et al (1989) as a simplified but as effective method as the NASA-TLX. The test subjects have to rate six different workload aspects, namely mental demand, physical demand, time pressure, performance, effort and frustration level on continuos scales from “very low” to “very high”. The RTLX method does not require task paired comparison as the NASA-TLX does. Byers and his colleges found that the two methods correlated above r=0.95 and these findings were supported by Fairclough (1991). The simplicity of the RTLX compared to the NASA-TLX makes it more suitable to use in a car.

The Peripheral Detection Task originates from TNO where an old idea of measuring workload (Winsum et. al) was improved. The task consists of responding to stimuli from two red lights mounted on the dashboard (L in Figure 1). When the light is lit the driver should respond by pressing a micro-switch placed on his thumb (S in Figure 1). There will be three variables extracted from this, reaction time, percentage missed signals and number of responses without stimuli. The method is not yet sensitive enough to give an absolute indicator of workload but it is very well suited to do comparative studies.

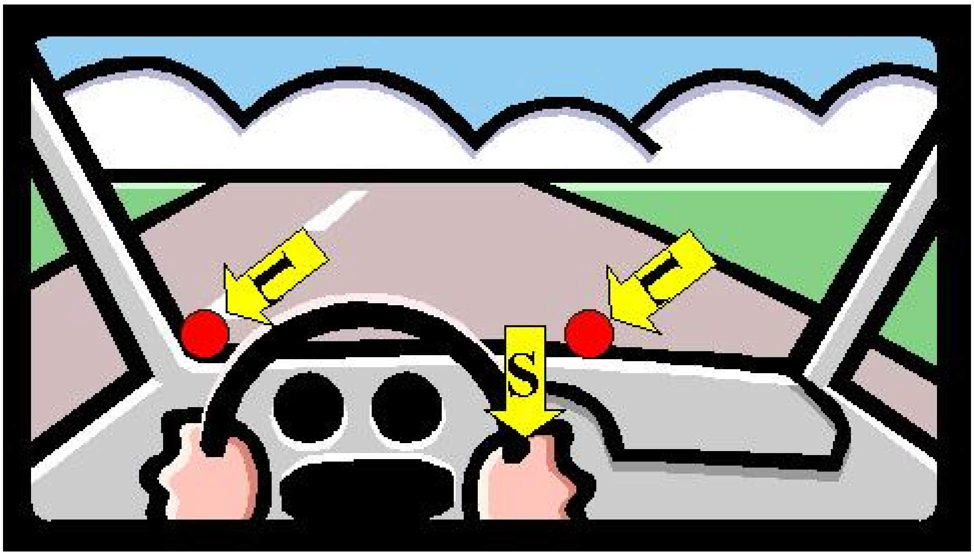

Figure 1 *Positioning of the secondary task equipment*

Selection

In total there will be 20-25 subjects selected for the workload study and they will be selected from the total population of 300 ISA-drivers in Lund. The test-persons will be evenly distributed regarding gender. For age-groups however it is not possible so we will focus on middle-aged drivers.

Test route

Each test person will drive a specific route of approximately 33 kilometres and they will do the test drive three times. The first time before installation of the SL in their car, the second time after driving with the SL a short time and finally after one year with the SL. The test drives will be carried out in an instrumented vehicle which allows video-filming and data-logging and there will be no observers present in the car. This is to make the observation as unobtrusive as possible. The test route consists of varying driving conditions including all the legal speed-limits in Sweden, both inside and outside Lund. It is divided into smaller parts with the same characteristics, e.g. one part with a 30 km/h speed limit with a high degree of pedestrians, one part with 50 km/h speed limit few pedestrians etc. During the test-drive a number of variables will be logged in the onboard computers.

Instrumented vehicle

The instrumented car is a Toyota Corolla, model 1999 and its instrumentation is designed and installed by VTT, Technical Research Centre of Finland.

There are three cameras in the car, one facing forward, one facing backward and one facing the driver. The camera in the front is used to monitor traffic in front of the vehicle. The camera in the back shows the corners of the vehicle which makes it possible to study the lane positioning of the vehicle. Since the distance from the lens to the corners of the car is constant it is possible to add a ruler to the image and thereby study the car's lateral position. The rear camera also shows when there is another vehicle present behind which allows to study how SL drivers react to faster traffic from behind. The camera facing the driver is used to study eye and head movements, for instance glance frequency in the rear view mirror. In the front of the vehicle there is also a laser radar measuring the distance to the vehicle in front.

Picture 1 *The shooting direction of the three cameras.*

There will be two different data-loggers in operation, the instrumented vehicle's and the speed-limiter's and they will work individually. The logger in the SL will be used for validation and for registering kick-down, the logger of the instrumented vehicle will be used for among others speed-profiles, steering wheel rotation, secondary task and use of indicator. The loggers in the car will store data with a 5Hz frequency, except for the PDT data that will be stored on demand.

Table 1 *The variables stored by the in-car equipment*

Variable	Data-log		Video		
	Speed-limiter	Instrumented vehicle	Camera 1	2	3
Time	✔	✔			
Position	✔	✔			
Engine rotation	✔				
Kick-down	✔				
Speed	✔	✔			
Frontal headway		✔			
Brake fluid pressure		✔			
Steering wheel position		✔			
Secondary task		✔			
Use of turn signals		✔			
Acceleration (X,Y,Z)		✔			
Traffic in front				✔	
Lane position					✔
Traffic behind					✔
Glance frequency, rear view mirror			✔		
Glance frequency, speedometer			✔		

ANALYSIS

The results from the test drive will be analysed for the different sections but there will also be some junctions and roundabouts that are specially analysed. The data that will be analysed from the video recordings are lane position, glance frequency – speedometer and glance frequency – rear view mirror in conjunction with traffic behind.

The lane positioning will be divided into three zones, extremely left, extremely right and middle and the time spent in each zone will be registered. The frequency of changing between zones will also be registered.

The glance frequency on the speedometer, or rather on all the instruments behind the steering wheel since we cannot see exactly where they are looking, will be registered in form of frequencies and glance duration.

The glance frequency at the rear view mirror will also be registered in form of frequencies and glance duration. With the rear view mirror special attention will be paid to the difference if there is a vehicle behind or not.

Table 2 *Rear view mirror glance frequency*

	Before SL	After short time with SL	After one year with SL
Vehicle behind			
No vehicle behind			

The data that will be analysed from the logger are speed-profiles, frontal headway and steering wheel position.

The speed profiles will be analysed with regard to mean speed and jerk (m/s^3). If fluctuation in speed is increased it is an indicator of that the workload has increased. For headway it is the mean distance and standard deviation in car following situations that are interesting. The position of the steering wheel will be measured in degrees from centre position and will be analysed as number of times the steering wheel passes the centre line per second.

Reliability

The effect from driving with another car than ones own will be studied by comparing the logged speed-profile from the test route with speed profiles from the test-persons everyday driving on the route. The whole route could probably not be validated for all the drivers, but a greater part of it since it is in or in the vicinity of Lund.

REFERENCES

Byers, J. C., Bittner, A. C. Jr., Hill, S. G. (1989) *Traditional and raw task load index (TLX) correlations: Are paired comparisons necessary?* Advances in Industrial Ergonomics and Safety I, pp 481-485.

Fairclough S.H. (1991). *Adapting the TLX to measure driver mental workload* (Report V1017/BERTIE/No. 71). Loughborough, Leics, UK: HUSAT Research Institute

Hancock Peter, Meshkati Najmedin. (1988) *Human Mental Workload*. Elsevier Science Publishers B.V. Amsterdam.

Malaterre Gilles. (1993) *Methods for Measuring Driving Performance and Workload, on a Simulator and in Real Driving conditions*. VTI konferens 1A part 2.

Várhelyi Andras, Mäkinen Tapani. (1998) *Evaluation of in-car speed limiters. Field study*. MASTER report R 3.2.2

Verwey Wim. (1995) Measu*ring Workload Peaks While Driving. A comparison of nine common workload assessment techniques.* TNO-report TNO-TM 1995 B-4. TNO Human Factors Research Institute.

Verwey Wim (1990). *Adaptable driver-car interfacing and mental workload: a review of the literature*. DRIVE Project V1041. Deliverable report GIDS/DIA/1.

Winsum W., Martens M., Herland L. (1999) *The effects of speech versus tactile driver support messages on workload, driver behaviour and user acceptance*. TNO-report TM-99-C…

Hart S.G., Staveland L.E. (1988) *Development of NASA-TLX(Task Load Index):results of empirical and theoretical research.* In P.A. Hancock & Meshkati N. Human mental workload (p. 139-183) Amsterdam