COST 352
Influence of Modern In-vehicle Information Systems on Road Safety Requirements

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Abstract

Driver behaviour studies in real traffic conditions aim at evaluating and quantifying the influence of several In-Vehicle Information Systems (IVIS) on individual driving behaviour, in order to assess their effects on road safety as a whole.

To evaluate the influence of modern In-Vehicle Information Systems on road safety, driver behaviour studies on selected subjects of defined demographic groups are intended under real traffic conditions. Depending on the test arrangement, subjects are driving on selected road sections either with or without the support of IVIS while continuous speed profiles and critical driving situations are recorded. As experimental vehicle, a passenger car, equipped with route guidance and hands-free mobile phone is used. The vehicle also contains custom sensors and data logging capability.

Through comparison of test drives with and without support of IVIS, possible differences in speed behaviour, following distance behaviour, and driver workload shall be observed and assessed with regard to possible effects on road safety. A clear separation of all external variables conditional to the test arrangement is impossible, not least due to restrictions in the number of test drives. However differences in speed profiles and in occurrence of categorized critical situations allow for relative conclusions regarding apparent potentials of danger or gains in safety.

Keywords

In-vehicle information systems – road safety requirements – peripheral detection task – driver behaviour studies in real traffic conditions – experimental design

1. Introduction

COST is an intergovernmental framework for European Co-operation in the field of Scientific and Technical Research, allowing the co-ordination of nationally funded research on a European level. COST Actions cover basic and pre-competitive research as well as activities of public utility. *(COST 352 IVIS. Official website)*

The main objective of the COST Action 352 is to enhance road safety through the proper use of In-Vehicle Information Systems (IVIS). The programme of the Action can be defined in terms of load on the perceptual (visual, auditory and tactile), central (cognitive) and output resources (hand, foot and vocal). *(COST 352 IVIS. Project website)*

The scientific programme will concentrate on five main Working Packages:

- WP I: Inventory of existing knowledge
- WP II: Round Tables
- WP III: Study preparative (methodology)
- WP IV: Driver behaviour studies by simulation
- WP V: Driver behaviour studies in real traffic conditions

This paper exclusively describes the intention and progress of the Swiss contribution to the Working Package V: Driver behaviour studies in real traffic conditions. This contribution is performed by the collaboration between the Institute for Psychology of the University of Zurich and the Institute for Transport Planning and Systems of the ETH Zurich. The distinguishing element of this research is to evaluate the influence of a predetermined set of IVIS – when used in combination – on road safety.

Through synthesis of the results of several research contributions within the scope of WP V and flanked by results of already completed research, the assessment of individual road safety with regard to improvements and deficits is made possible. As a consequence, recommendations for the reasonable use of IVIS can be formulated.

2. Procedure

To evaluate the influence of modern In-Vehicle Information Systems on road safety, driver behaviour studies on selected subjects of defined demographic groups are intended under real traffic conditions. Depending on the test arrangement, subjects are driving on selected road sections either with or without the support of IVIS while continuous speed profiles and critical driving situations are recorded. As experimental vehicle, a passenger car, equipped with route guidance and hands-free mobile phone is used. The vehicle also contains custom sensors and data logging capability.

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Besides the described traffic engineering approach the experiments are also evaluated from a traffic psychological point of view. In-depth analysis of driver workload data and information gained from videotapes of all test drives complement the research.

3. Driver workload (PDT audible signals)

In-Vehicle Information Systems can only be useful as long as the driver has enough free capacity to pay attention to them. The use of IVIS can also be valuable, if they relief the driver without introducing further workload. However if they lead to overstraining of the driver, IVIS can induce danger instead of offering useful help. In this case the use of IVIS should be discouraged.

The Peripheral Detection Task (PDT) is suited to measure the free capacity of the driver. Next to the primary task of driving, there is a secondary task consisting of responding to simple signals. Once the driver is presented with an audible signal, he needs to answer it as fast as possible by touching a steering wheel sensor. This experiment of reaction time demands few capacity and does not interfere with the primary task of driving. As long as the driver possesses enough free capacity, he is able to properly cope with the secondary task. Criteria for free capacity are:

- Large quota of signals answered
- Short latency (reaction) for signal confirmation

Audible signals should be presented as follows:

- Automatic signal presentation:

Signals are presented at random times, on average once every 15 seconds with a variation of 7 to 30 seconds.

- Manual signal presentation:

By means of a foot switch, the investigator can present signals to the subject during selected events.

The described methods allow for comparison of test drives with and without the support of IVIS in order to evaluate, whether IVIS provide the expected useful help or rather place unacceptable strain on drivers. *(Cohen, 1996)*

4. Dependent variables, level of safety

In order to draw conclusions regarding the level of safety during test drives, the safety relevant driving behaviour of all subjects needs to be captured. For this purpose suitable data needs to be acquired and logged. The table below identifies the most important criteria for the level of safety and demonstrates how they can be measured or observed.

Relevant for F: Freeway U: Urban road		**Dependent variables describing level of safety**	**Means of measurement and observation**	**Input type C: Continuous data E: Event data**
F	U	Speed profile	Calibrated speed measurement	C
F	-	Following distance behaviour (time gaps)	Observed when critical	E
F	-	Steering, dodging	Measurement of lateral acceleration / steering wheel position	C
F	U	Braking	Measurement of transversal acceleration / brake pedal position, anti-skid system engaged	C
F	U	Critical traffic situations (overtake, bikes, pedestrians etc.)	Observed and entered manually by investigator (event buttons)	E
F	U	Driver workload	Subject (steering wheel sensor)	E

5. Independent variables, experimental factors

5.1 In-Vehicle Information Systems

The primary focus of this research is on the comparison of test drives with support of IVIS against those without support of IVIS. For both situations the subject's driver workload is always acquired.

For test drives of the case with support of IVIS the subject receives additional assistance by a route guidance system and FM Radio with RDS-TMC. The subject also has to deal with incoming calls to the vehicle-based hands-free mobile phone.

5.2 Road types

Test drives take place on two different road types.

First is a designated section of freeway in the agglomeration of Zurich, featuring an approximate length of 20 to 25 km, dense branching, numerous entries and exits and even tunnels.

Second is a route through the city center of Zurich, demanding a lot of attention from the subject due to complex intersections, wealth of information (road markings, directions, signals) and concurrence of all kind of traffic participants.

5.3 Groups of subjects

Selected subjects are recruited and matched into two main groups.

- Young drivers (around 30 years old)
- Elderly drivers (more than 60 years old)

Although one may consider other demographical groups responding more sensitive to additional information given by IVIS, for an experiment in real traffic conditions every additional risk should be avoided. It is thus suggested to work with experienced drivers only.

Individual attributes of subjects are taken into account by questionnaires given for recruitment, and before / after test drives.

6. Interfering variables, side factors

Side factors beyond controllability will arise during test drives.

- Despite the intention to evaluate for off-peak times, traffic conditions will vary between test drives
- Sudden onset of rain cannot be avoided and should provide data for side analyses
- Individual attributes of subjects are not considered main factors but can provide data for additional conclusions

7. Experimental design

For the analysis of effects of the described independent variables on any of the described dependent variables, an experimental design is proposed below.

Around 30 years old (20 subjects)	w/ IVIS	w/o IVIS
Freeway	1.1	2.1
Urban road	1.2	2.2

More than 60 years old (20 subjects)	w/ IVIS	w/o IVIS
Freeway	1.3	2.3
Urban road	1.4	2.4

In order to minimize the required number of subjects, they should – once recruited – be assigned into as many experiment fields as possible. This basically implies a so-called within-subjects design for the suggested experiment.

- Within-subjects factors: Two road types, with / without support of IVIS
- Between-subjects factor: Two groups of subjects

While this suggested design is advantageous in terms of sample size and precision, it's important to consider possible carry-over-effects which need to be carefully counterbalanced.

Since every subject of each main group is required to drive in four different modalities, twice on freeways with and without IVIS, and twice on urban roads with and without IVIS, possible carry-over-effects may be counterbalanced as follows:

- Sequence of test drives fully permuted with respect to all within-subjects factors
- Only two test drives per subject per day, on different road types, once with and once without IVIS
- Leave sufficient time between driving days of one and the same subject

As shown in the experimental design table above, at present the plans are to organize a total of 40 subjects to conduct four test drives each. Under favorable conditions this will result in 160 test drives of which 20 test drives account for each of the eight experiment fields.

8. Conclusions, Perspectives

During the recent project period a focus was put on preparations of practical test drives and instrumentation of the experimental vehicle according to technical specifications. The experimental vehicle is equipped with route guidance, hands-free mobile phone and radio. It also contains custom sensors and data logging capability, such as CAN-BlackBox for acquisition of driving dynamics data and PDT-BlackBox for acquisition of driver workload and other traffic psychological data.

The test routes could be evaluated as well. They consist of a designated section of freeway featuring high traffic volume and a route through the city center of Zurich. All relevant characteristics of said test routes have been acquired.

Actual test drives with subjects are performed until October 2007. Data processing and analyses are scheduled for Winter 2007/2008.

For most recent news and preliminary results from ongoing test drives please refer to the STRC presentation on 13 Sept. 2007.

9. References

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