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

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Conference paper STRC 2009

STRC

9th Swiss Transport Research Conference
Monte Verità / Ascona, September 9. - 11. 2009

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September 2009

Abstract

Driver behaviour studies in real traffic conditions aim at evaluating the influence of several In-Vehicle Information Systems (IVIS) on individual driver 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 have been performed under real traffic conditions. Depending on the test arrangement, subjects have been driving on selected road sections (urban road and freeway) either with or without the support of IVIS while continuous speed profiles and critical driving situations have been recorded. As experimental vehicle, a passenger car equipped with route guidance system, hands-free mobile phone an FM radio in operation was used. The vehicle also contained custom sensors and data logging capability.

Through comparison of test drives with and without support of IVIS, possible differences in traffic behaviour shall be observed and assessed with regard to possible effects on road safety. Assessing the differences of speed profiles and frequency of categorized critical events allow for relative conclusions regarding apparent potentials of danger or safety gains. For this, investigations at defined cross-sections and along specific sections are performed.

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.

Keywords

In-vehicle information systems – road safety requirements – driver behaviour studies in real traffic conditions – cross-sections

1. Introduction

This paper describes the procedure and analysis of driver behaviour studies in real traffic conditions. Despite the fact, that this research project 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 (IVT), the focus of this paper will be on the investigation of the IVT and therefore on the traffic engineering part of the project. The distinguishing element of this research is to evaluate the influence of a predetermined set of IVIS – when used in combination – on road safety.

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, standard FM radio and hands-free mobile phone was 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, from traffic engineering point of view differences in speed profiles and in occurrence of categorized critical situations allow for relative conclusions regarding apparent potentials of danger or gains in safety.

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. Since the traffic psychological point of view is not object of this paper their results will be show up in the upcoming full length report at the end of the year 2009.

2. Procedure

To evaluate the influence of modern In-Vehicle Information Systems (IVIS) on road safety, driver behaviour studies with 40 selected subjects of two separate demographic groups, divided in 20 younger (around 30 years old) and 20 elderly (around 60 years old) subjects, have been carried out under real traffic conditions. 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.

The test drives take place on two different road types, freeway and urban road. The road types were each divided into a specific number of sections: 7 for the freeway and 6 for the urban road. The freeway has been chosen in the agglomeration of Zurich, featuring dense branching, numerous entries and exits and even tunnels. While the urban road route leads through the city center of Zurich, demanding a lot of attention from the subject due to complex intersections, wealth of information (road markings, direction signing, signals) and concurrence of all kind of traffic participants.

Over the course of 14 weeks a total number of 160 test drives have been accomplished. In this series, 40 individual subjects accounted for each of four experiment modalities. The daily routine has been optimized to accommodate two subjects with two test drives each. In addition that the subjects didn't left the prescribed route and to record the safety related events an, observer have been accompanied the subjects on their test drives.

The experimental design which takes care of all possible permutations has been defined as follows:

Table 1 Experimental Design

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

Around 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

Since the subjects of each main group have been required to driven in four different modalities, twice on freeways with and without IVIS, and twice on urban roads with and without IVIS, possible carry-over-effects have been 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

The primary focus of this research is on the comparison of test drives *with IVIS* against those *without IVIS*. In both parts the subject were allowed to study route information from a map before the trip.

For test drives *with IVIS* the subject has to navigate with the help of the GPS based route guidance system and also has to deal with an incoming call to the vehicle-based hands-free mobile phone. The mobile phone experiment had taken place only at a certain section on the urban road in order to minimized endangerment. The subject was not informed if and when a phone call is coming in during the drive. However, if a call was coming in, the subject has always the possibility to refuse the call. The FM radio was only in operation in this configuration.

For test drives *without IVIS* the subject had received a standardized list of intermediate destinations corresponding to the road-side direction signing. The mobile phone and FM radio were switched off in this configuration.

3. Dependent and independent Variables

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.

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 primary speed and acceleration profiles needs to be acquired and logged by the CAN-BUS. Other data like lateral and longitudinal acceleration as well as brake pedal position have been logged too.

Continuous measurement data as well as observed event data has been aggregated for further statistical processing. Arithmetic mean, standard deviation, and percentiles have been calculated from measured speed and acceleration profiles. Observed event data has been counted in order to derive the frequency of their occurrence. The observed events are listed at the left side of Table 2 where as their description is given at the right side.

Table 2 Observed Variables

Observed event	***Explanation***
- Overtake	A flag is set if observed that subject begin to overtake somebody and at the end of the procedure
- traffic congestion	A flag is set to negate time delays from traffic congestion or red traffic light in order have homogenous speed profiles for the analysis
- Direction given	A flag is set for instructions from the observer in case of subjects wanted left the prescribed route
- traffic interaction	A flag is set if observed excessive driver reaction due to lack of attention
- headway distance	A flag is set if observed a distance to the front driver shorter than 1 second
- critical traffic interaction	A flag is set if observed excessive driver reaction due to unpredictable events
- beginning/end of test drive	A flag is set at the beginning and end of test track
- mobile phone call	A flag is set if subject takes or refuse incoming phone call

To the Independent Variables of the data counts the two different road types, demographic data, IVIS configuration and test procedure. The layouts of the accomplished drives have been recorded on prepared protocols which the observer filled at the beginning of each test drive.

The entire analysis is based on the blackbox data, gathered from the 160 test drives. It contains all important dependent variables – gained from measurement and from observation – with a resolution of 0.1 seconds.

4. Results

The analysis described below is subdivided into two parts: the Top-Down-Analysis (TDA) and the Bottom-Up-Analysis (BUA). Whereas the TDA is employed on statistical tests of entire road types, the BUA concentrate on speed profiles of sections and cross-sections of the named road types. Both types of the analysis (TDA and BUA) focus on the comparison of speed profiles of drives with and without IVIS at the urban road route and freeway route.

For the analysis we used low pass filtered average speed profiles in order to exclude arbitrary slow driving situations such as stop and go traffic or traffic congestion. Therefore for urban road all values below 11 km/h have been excluded from dataset and for freeway all data below 30 km/h. This value is said to be $V_{m\_Overlimit}$. Another speed profile which named $V_{85\_overlimit}$ designated the group of speeder. Last named speed profile has result from the cumulative percentage.

4.1 Top-Down Analysis (TDA)

The main object of the TDA is to investigate variations of statistical significance. Beside the influence of in-vehicle information systems (with/without IVIS) there are further influencing variables which have affects to driving behaviour. Therefore we have investigated the data with more factorial Analysis of variance (ANOVA). Since the main object of the analysis lies on the investigation of the road types, we have to considered each road type as a whole without subdivide into sections. Besides this the demographic groups, independent variables and secondary factors were analyzed. As dependent variable to describe driving behaviour speed profiles and event frequency have been used.

The experimental design of this research has been explicitly chosen to enable for ANOVA. The ANOVA is a statistical model for comparing expectancy values of normally distributed variables by partitioning the according variances into components due to different explanatory factors. The statistical test is employed on the entire aggregated dataset in order to look for statistically significant experimental factors. Since the freeway route and urban road route differ greatly in terms of average speed and other factors, all ANOVA evaluations have been performed separately for these two road types.

The following results are based on the entire freeway route and urban road route. Even though ANOVA analyses have also been performed on each of the smaller road sections freeway and urban road, one has to keep in mind that a more fragmented initial dataset results in a weaker level of statistical significance.

4.1.1 Analysis of Freeway Route and Urban Road Route

The figure below illustrates the average speed on the freeway route and urban road route. Each bar represents the arithmetic mean of the part of the dataset matching the experimental factor denoted in the legend. In order to exclude arbitrary slow driving situations such as stop-and-go traffic and waiting for right of way, any speed values below 30 km/h have been excluded from the freeway dataset and values below 11 km/h have been excluded from the urban road dataset ($V_{m\_overlimit}$).

Next to the main factors *IVIS* and *Age group* there are two other factors included. The factor *Observer (Obs)* describes which person was present on the co-driver's seat during test drives. The factor *Vacation* denotes whether the test drive took place during official school vacation time.

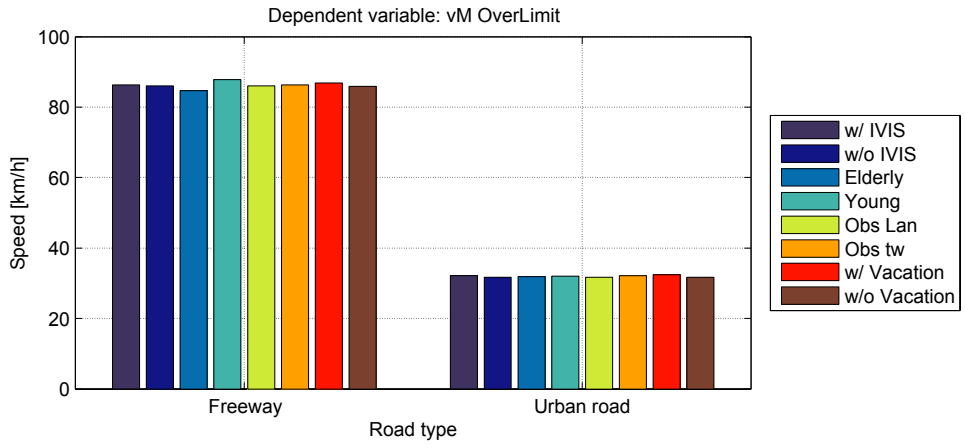
On the freeway, all subjects combined drive 0.33 km/h faster with IVIS than without IVIS.

On the urban road, all subjects combined drive 0.30 km/h faster with IVIS than without IVIS.

On the freeway, young subjects, regardless whether with or without IVIS drive 3.19 km/h faster than elderly subjects.

On the urban road, young subjects, regardless whether with or without IVIS drive 0.16 km/h faster than elderly subjects.

Figure 1 Average speed according to experimental factors



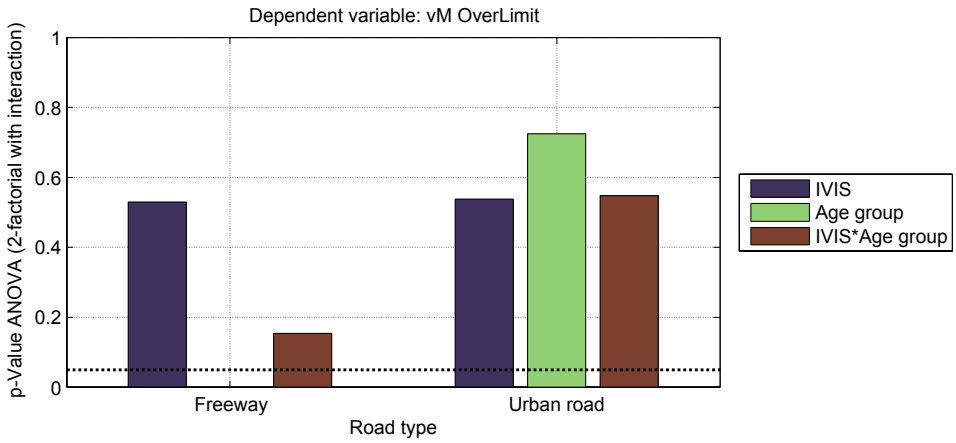
The 2-factorial ANOVA includes only the main experimental factors and their interaction term IVIS*Age group.

On the freeway and the urban road the speed differences regarding the factor IVIS are not significant.

On the freeway the speed difference regarding the factor age group is significant regarding the 5% level of significance.

On the urban road the speed difference regarding the factor age group is not significant.

Figure 2 2-factorial ANOVA with interaction regarding average speed



The figure below illustrates the frequency of traffic interactions, observed upon excessive driver reaction due to lack of attention on the freeway route and on the urban road route. Each bar represents the frequency of this event regarding the part of the dataset matching the experimental factor denoted in the legend.

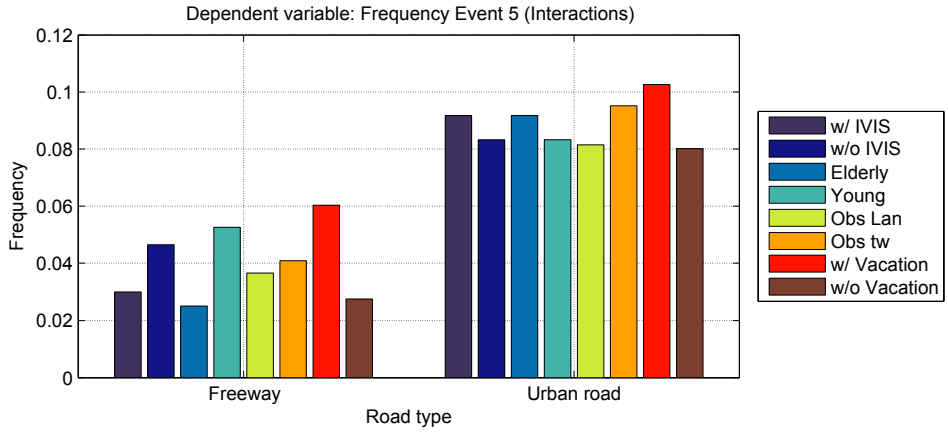
On the freeway, all subjects combined had fewer traffic interactions with IVIS than without IVIS.

On the urban road, all subjects combined had more traffic interactions with IVIS than without IVIS.

On the freeway, young subjects, regardless whether with or without IVIS, had more traffic interactions than elderly subjects.

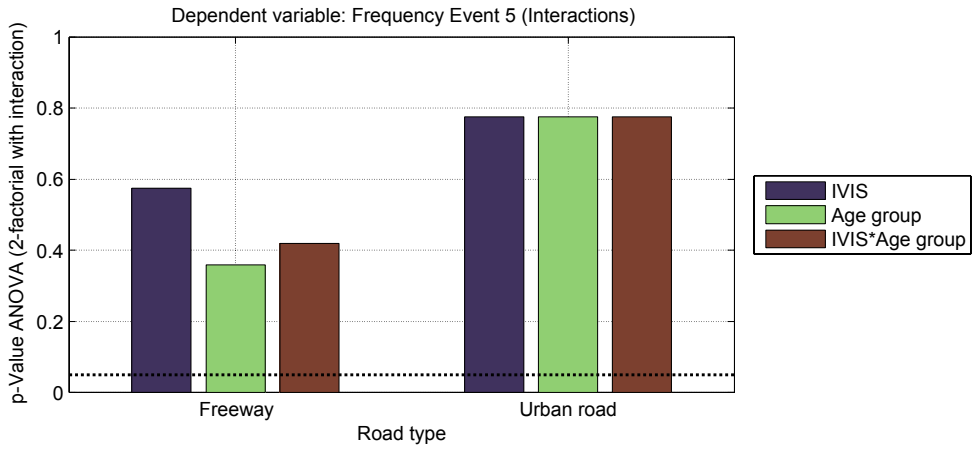
On the urban road, young subjects, regardless whether with or without IVIS, had fewer traffic interactions than elderly subjects.

Figure 3 Frequency of traffic interactions according to experimental factors



On the freeway and the urban road the differences in frequency of traffic interactions are not significant regarding any of the chosen experimental factors, displayed in the legend above.

Figure 4 2-factorial ANOVA with interaction regarding frequency of traffic interactions



In summary we found that the investigation of the freeway has shown no significant effects in usage of IVIS regarding the mean speed $V_{m\_overlimit}$. The existing significant effects of Age Group regarding $V_{m\_overlimit}$ can not direct to the usage of IVIS. The analysis of the security-relevant Events has shown that the two above pointed groups of experimental factors has no statistical significance.

The investigation of the urban road has shown no significant effects neither in use of IVIS or consideration Age Group regarding $V_{m\_overlimit}$. Furthermore no sign of significance of security-regarding Events have been found.

4.2 Bottom-Up Analysis (BUA)

The main objects of BUA were investigations of driving behaviour of single drivers at sites of geographical reference. Therefore defined cross-sections and sections of the two road types have been investigated due to variances of test drives with and without IVIS. For the analysis of cross-section the measurements have been determined all of the same positions. The assignment of sections considers several geographical and operating characteristics.

Below some characteristics were named:

Freeway Route:

- long tunnels
- radar devices on roadside
- varying speed limit

Urban Road Route:

- section with mobile phone call
- varying right of way
- simple straight-line roadways with crossroads
- Complex cross-roads

Measurements at sites of geographical reference for data ascertainment of local speed profiles of several road types are long-time experience routine methods in traffic engineering. Therefore sufficient data are available for comparison. ([Lindenmann et al 1993], [Dietrich et al 1998], [BAFU 2008], [Koy et al 2003]) Trough comparison of this empirical values influence of behaviour on road safety requirements can be made.

4.2.1 Analysis of Cross-section

The data shown below (Table 3 and 4) results from the aggregation of the two investigated Age Groups. The following variables have been investigated for 40 drives w/ and w/o IVIS: characteristic data V_{85}, average Speed and standard deviation. Furthermore differences between the speeds (V_{85} and V_m) have been investigated. The gray marked fields in Table 3 and 4 are the negative results of these differences. In that case subject drives faster with than without IVIS.

Table 3 Cross-Sections of Freeway – All Age Groups

Cross-section	without IVIS			with IVIS			Difference	
	$v_{85\%}$	v_m	σv_m	$v_{85\%}$	v_m	σv_m	$v_{85\%}$	v_m
Freeway 1	97.6	89.3	9.4	94.3	87.0	6.9	3.3	2.3
Freeway 2.1	102.7	90.5	9.0	99.7	91.1	7.9	3.0	-0.6
Freeway 2.2	80.2	76.7	7.0	78.3	75.4	4.7	1.9	1.3
Freeway 6	98.4	91.1	6.9	97.4	91.9	6.6	1.0	-0.8

For cross-sections of freeway route (Tab. 3) we found that the speeders (V_{85}) droves faster w/o IVIS than w/ IVIS. Even though the differences are small, it as to be said, that usage of IVIS have rather a positive effect on road safety.

According do test drives w/ and w/o IVIS the speed decrease viewed in cross section Freeway 1 results from complex weaving area, high traffic and high density of signpost, where in cross section Freeway 2.1 the speed limit have risen from 100 km/h too 120 km/h. So there is no geographical reference for the decrease of speed in the mention cross-sections. There are no important changes in speed behaviour at Section Freeway 2.2 and Freeway 6.

According to drives w/ and w/o IVIS we distinguished no important differences in average speed (V_m). So no conclusion between geographical reference and variation in speed behaviour due to usage of IVIS can be made.

According to drives w/ and w/o IVIS the decline of σv_m seems to be huge but according to the values of V_m one can see that the decline of σv_m is in range of few percentages. Nevertheless the speed profiles of drive w/ IVIS are more homogeneous than w/o IVIS.

Table 4 Cross-Sections of Urban Road – All Age Groups

Cross-section	without IVIS			with IVIS			Difference	
	$v_{85\%}$	v_m	σv_m	$v_{85\%}$	v_m	σv_m	$v_{85\%}$	v_m
Urban Road 8	45.2	35.6	8.3	42.2	34.7	9.5	3.0	0.9
Urbahn Road 10	37.6	33.8	5.8	39.0	33.8	4.5	-1.4	0.0
Urban Road 11	47.2	41.0	9.2	49.0	39.7	13.0	-1.8	1.3
Urban Road 12.1	43.7	35.4	9.5	44.5	36.5	9.9	-0.8	-1.1
Urban Road 12.2	39.0	22.4	13.0	34.7	21.1	11.1	4.3	1.3

For cross-sections of urban road route (Tab. 4) we found that the speed behaviour by usage of IVIS is extremely heterogeneous. The difference of V_{85} as well as V_m shows both positive and negative results. Therefore one can make no claim of driver behaviour for the investigated cross-sections.

By comparison of the investigated cross section at urban road route one can regard huge variations both in V_{85} and V_m. The mentioned variations are not related to usage of IVIS but rather to complex crossroads, light signals, roads straight on, high traffic volume, traffic congestions etc which are part of the test track.

4.2.2 Analysis of Sections

The main object of the analysis of sections of the two road types described beneath is the interpretation of speed profiles and frequency of recorded safety related events and thereby the relative changing of drives w/ and w/o IVIS. Furthermore we treat the two age groups separate. Therefore we investigate the average speed V_m as well as the weighted mean of speed V_{Gm}, its standard deviation σ_{VGm} and the difference between drives w/ IVIS and w/o IVIS.

Figure 5 Sections of Freeway Route (1 – 7) and Urban Road Route (8 – 13)

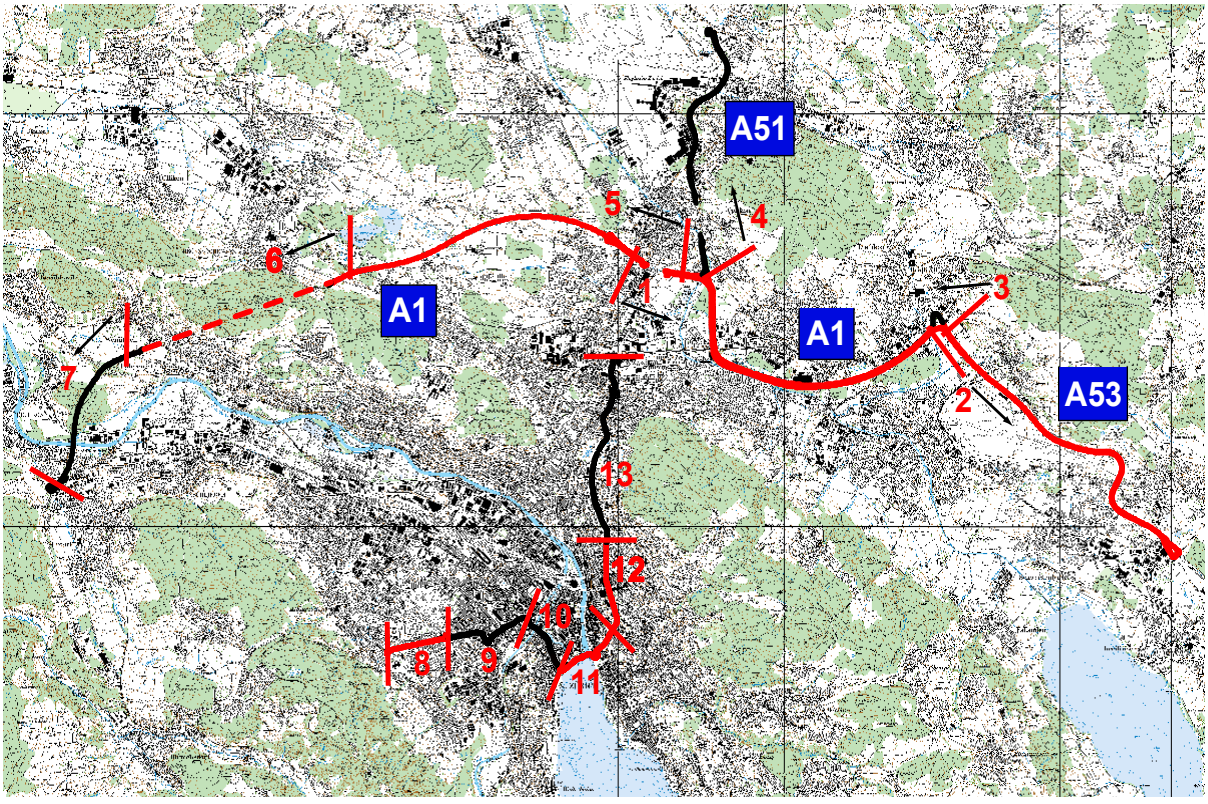


Table 5 Sections of Freeway – Younger Subjects

Group of Young	Freeway1			Freeway2			Freeway5			Freeway6		
	v_{Gm}≥30 [km/h]	σ_{vGm}	Sum of Events	v_{Gm}≥30 [km/h]	σ_{vGm}	Sum of Events	v_{Gm}≥30 [km/h]	σ_{vGm}	Sum of Events	v_{Gm}≥30 [km/h]	σ_{vGm}	Sum of Events
MIVIS	89.06	1.91	14	87.85	4.70	7	98.02	1.96	5	91.24	1.00	2
OIVIS	88.26	1.90	11	87.60	5.05	7	101.50	2.25	6	93.19	0.98	2
Differenz	0.80		3	0.25		0	-3.48		-1	-1.95		0

At freeway route V_{Gm} for the younger subjects (Tab. 5) doesn't change between drives w/ IVIS and w/o IVIS for section Freeway 1 and Freeway 2. The difference doesn't change related to σ_{VGm}. For Freeway 5 and Freeway 6 V_{Gm} is by usage of IVIS clearly smaller than w/o IVIS.

σ_{VGm} hasn't change compared to drives w/ and w/o IVIS. The high value of σ_{VGm} at Freeway 2 is related to the variation of speed limit at this section (from 80 km/h to 120 km/h).

The comparison of Sum of Events shows no noteworthy difference between drives w/ and w/o IVIS.

The Analysis of the elderly subjects (Tabl. 6) shows changes of V_{Gm} in all investigated section of freeway. Whereas V_{Gm} has increased by usage of IVIS at Freeway 1, 2 and 6 at Freeway 5 V_{Gm} has decreases related to usage of IVIS. Furthermore it is recognizable that the elderly subjects driven faster w/ IVIS compared to younger subjects (Table 5). The variation of V_m of elderly subjects is in the range of σ_{VGm}. Remarkable is the fact that in section Freeway 5 the elderly subsjects as well as the younger subjects driven slower with IVIS.

Table 6 Sections of Freeway – Elderly Subjects

Group of Elderly	Freeway1			Freeway2			Freeway5			Freeway6		
	v_{Gm}≥30 [km/h]	σ_{vGm}	Sum of Events	v_{Gm}≥30 [km/h]	σ_{vGm}	Sum of Events	v_{Gm}≥30 [km/h]	σ_{vGm}	Sum of Events	v_{Gm}≥30 [km/h]	σ_{vGm}	Sum of Events
MIVIS	87.07	1.76	0	84.02	4.40	4	92.48	1.84	4	90.19	1.09	3
OIVIS	84.58	1.64	8	82.99	4.22	14	94.15	1.71	4	88.27	0.98	11
Differenz	2.49		-8	1.03		-10	-1.67		0	1.93		-8

σ_{VGm} doesn't differ much related to drives w/ and w/o IVIS. The high values of σ_{VGm} at section Freeway 2 have been described further up.

Regarding the Sum of Events at Freeway 1, 2 and 6 (Tab. 6) one can see a higher value of events by drives w/o IVIS. The level of security raises by usage of IVIS though the elderly subjects driven faster.

According to test drives w/ and w/o IVIS no changes of V_{Gm} were found consider urban road sections for younger subjects (Tab. 7). Also no changes were found consider σ_{VGm} between variants of IVIS.

By analysing the safety relevant events at urban road we found that only section Urban Road 8 differs between drives w/ and w/o IVIS. It is assumed that this behaviour comes from first usage of IVIS by the younger subjects. Probably at beginning the subjects look at GPS more often than after a time of driving. Remarkable is that there is no increasing of events in section Urban Road 12 where the mobile phone task was taking place. That could mean that younger subjects won't distracted by mobile phone during driving task.

Table 7 Sections of Urban Road – Younger Subjects

Group of Young	Urban Road8			Urban Road11			Urban Road12		
	$v_{Gm}\geq 11$ [km/h]	σ_{vGm}	Sum of Events	$v_{Gm}\geq 11$ [km/h]	σ_{vGm}	Sum of Events	$v_{Gm}\geq 11$ [km/h]	σ_{vGm}	Sum of Events
w/ IVIS	36.88	2.37	11	25.34	2.16	36	32.18	2.42	16
w/o IVIS	36.61	2.22	2	25.02	2.02	34	32.30	2.28	14
Difference	0.28		9	0.32		2	-0.12		2

By the elderly subjects (Tab. 8) V_{Gm} only differs in range of standard deviation. But for that all the value of difference between V_{Gm} w/ and w/o are three time grater than by younger subjects. So we can say at this point that the influence of usage IVIS is at these regarded sections nonexistent.

For test drives /w IVIS the sum of safety relevant events (Tab. 8) is higher than that of test drives w/o IVIS. Also by elderly subjects we observe a high level of events in section Urban Road 8 like by the younger subjects. The explanation for this behaviour as is the case with the younger subjects described above. The explanation for the increasing number of events in section Urban Road 12 is due to the mobile phone task which is taking place at this section. That could mean that elderly subjects will distract more by mobile phone during driving task than younger subjects. This assumption is approved by the decreasing value of V_{Gm} at this section. This behaviour can be a clue due to influence of IVIS on road safety.

Table 8 Sections of Urban Road – Elderly Subjects

Group of Elderly	Urban Road8			Urban Road11			Urban Road12		
	$v_{Gm}\geq 11$ [km/h]	σ_{vGm}	Sum of Events	$v_{Gm}\geq 11$ [km/h]	σ_{vGm}	Sum of Events	$v_{Gm}\geq 11$ [km/h]	σ_{vGm}	Sum of Events
w/ IVIS	36.48	2.30	15	25.05	2.02	42	30.56	2.33	41
w/o IVIS	37.05	2.30	6	24.45	2.01	30	31.25	2.51	20
Difference	-0.57		9	0.60		12	-0.69		21

The results describe beneath focus on single driver analysis. The demographics groups will consider like described above (both younger and elderly subjects separate). The only variable regarded will be the velocity $V_{m\_overlimit}$. The index overlimit designate values of velocity over 11 km/h for urban road route and 30 km/h for freeway route.

Figure 6 Single Driver Analysis Freeway – w/ IVIS vs. w/o IVIS – Younger Subjects

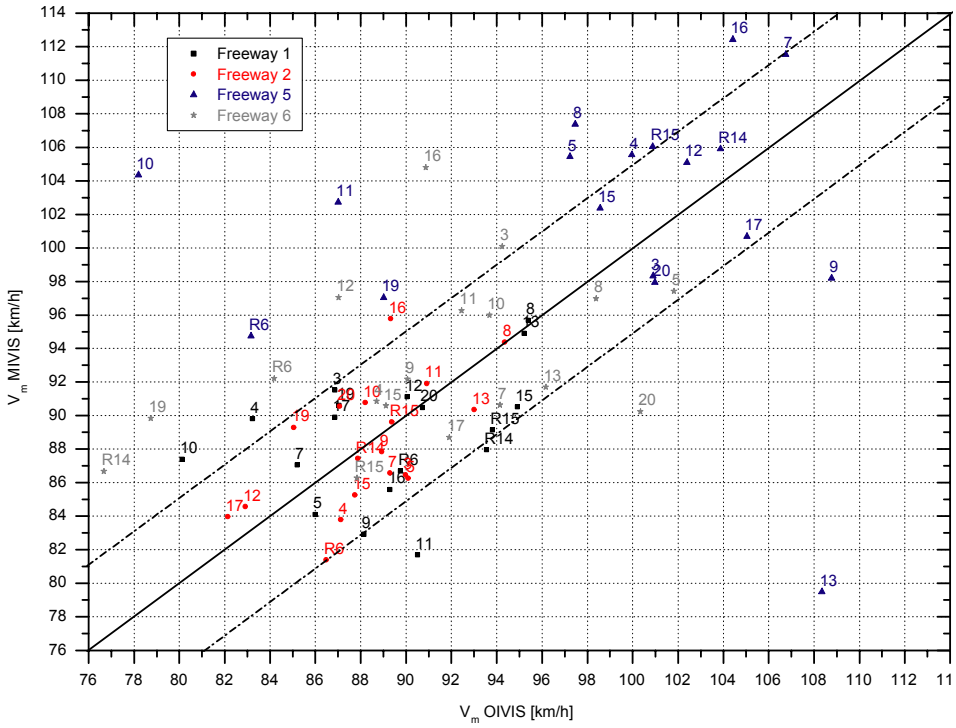


Figure 6 illustrates the velocity $V_{m\_overlimit}$ for test drives w/ IVIS (OIVIS – X-Axis) and w/o IVIS (MIVIS – Y-Axis) for younger subjects on the investigated freeway section. The number above the symbols denotes the number of the subjects. For the analysis only data beyond the marked interval (dot-dash line), which denoted 5 km/h differences between drives w IVIS and w/o IVIS, were uses. Data below 5 km/h were considered as statistical coincidences.

The main result from Figure 6 is that at freeway sections the majority part of younger subjects drove faster w/ IVIS (17 out of 80 data points). On the other hand only 6 data points indicate test drives significantly faster w/o IVIS than w/ IVIS.

Figure 7 Single Driver Analysis Freeway – w/ IVIS vs. w/o IVIS – Elderly Subjects

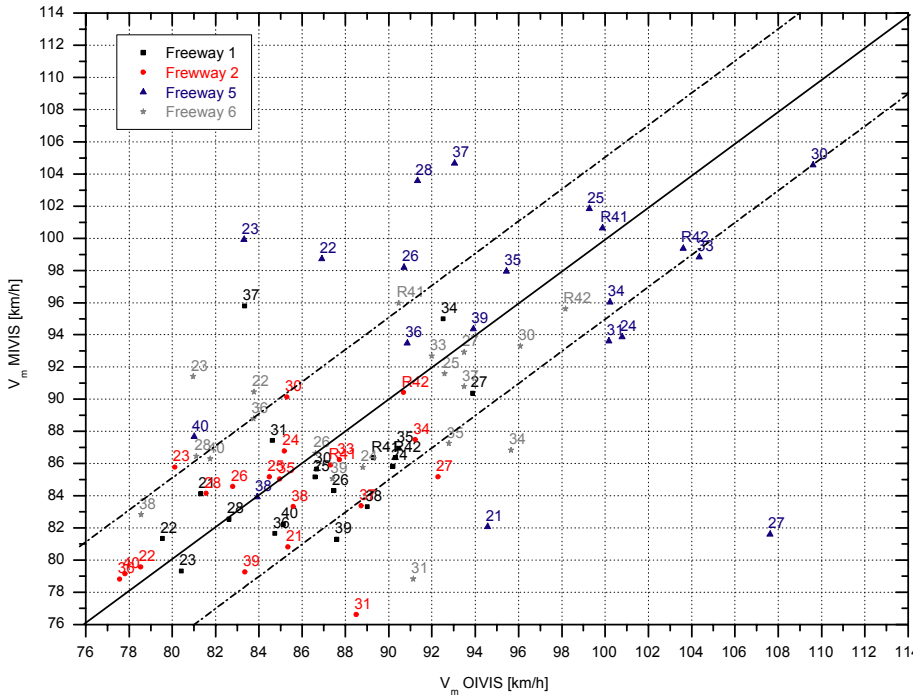


Figure 7 below illustrated the same circumstance as Figure 6 only for elderly people at freeway sections. Unlike to the result of the younger subject no trends for drives w/ IVIS or w/o IVIS have been recognized for the elderly subjects.

By analysis of freeway sections for elderly and younger subjects we found, that both groups differ between driver behaviour w/ IVIS and w/o IVIS. While both demographic groups drive in section Freeway 1 slower w/ IVIS than w/o IVIS only the elderly subjects droves in the other sections slower. In contrast to that behaviour younger subjects drove faster w/ IVIS.

The same analysis done for the freeway sections have been made for the urban road sections too (Figure 8 and 9). The regarded differences between speed w/ IVIS and w/o IVIS at urban road section have been defined about 3 km/h.

For the younger subjects (Figure 8) we have fond no clear variations in speed behaviour according to usage of IVIS. The number of the positive and negative differences is almost balanced.

Figure 8 Single Driver Analysis Urban Road – w/ IVIS vs. w/o IVIS – Younger Subjects

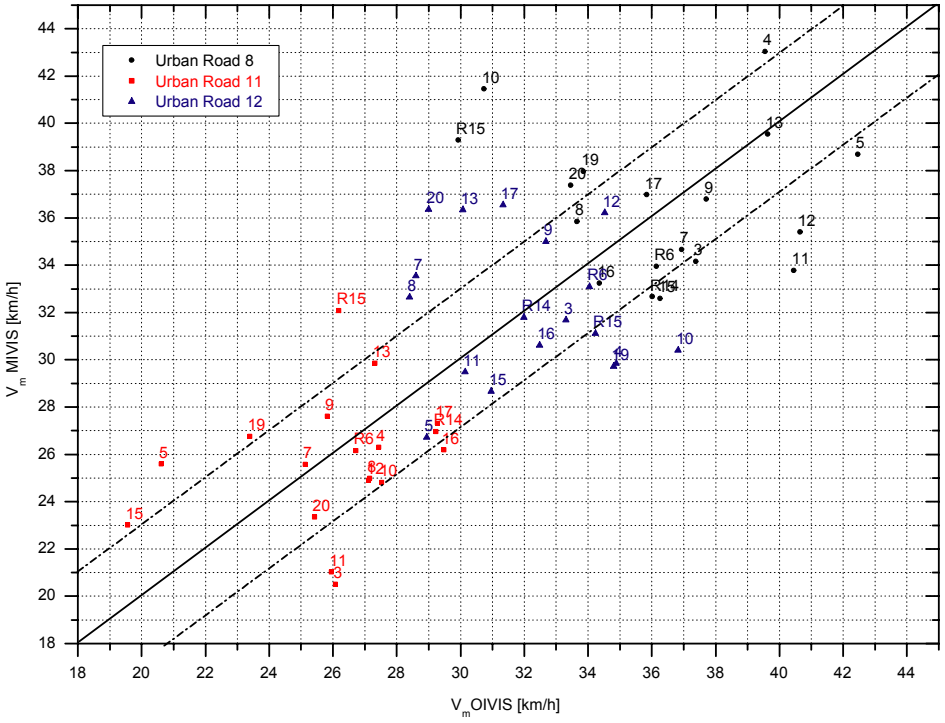
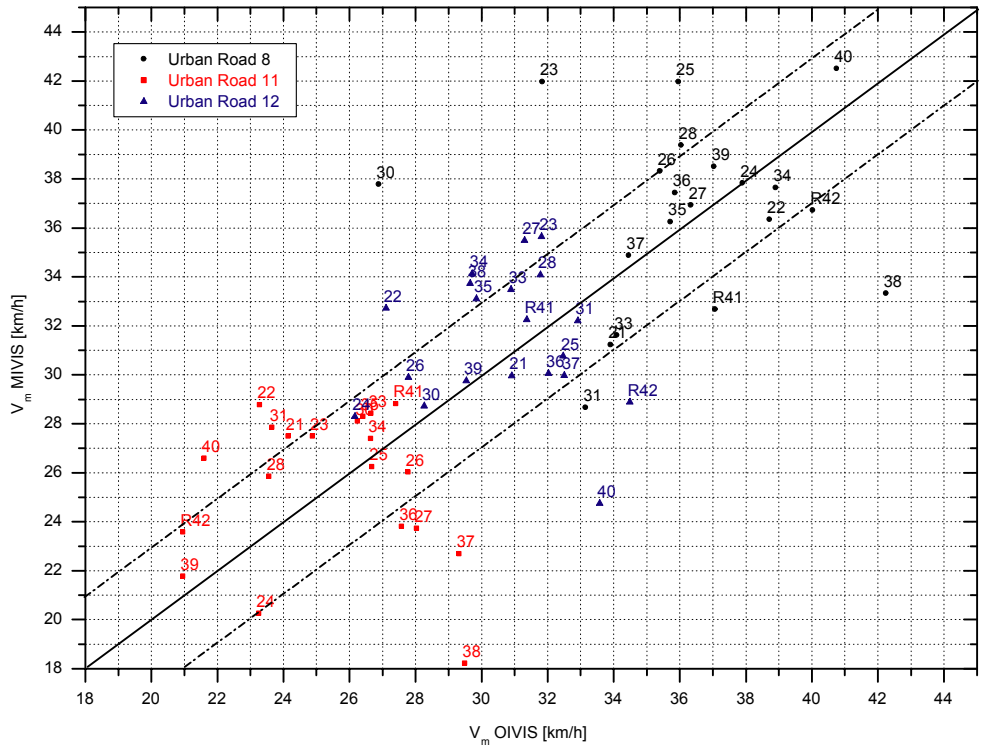


Figure 9 Single Driver Analysis Urban Road – w/ IVIS vs. w/o IVIS – Elderly Subjects



The examination of V_m differences for elderly subjects at urban road sections shows no clear variations in speed behaviour by usage of IVIS (Figure 9).

In summary we have found, that the younger subjects drove at the investigated urban road sections w/o IVIS slower. In contrast to this results the elderly subjects drives at all section faster w/o IVIS. Compared to the results of the freeway sections mentioned above the driving behaviour of both groups at urban road sections is converse to that of the freeway sections.

Since a difference from V_m w/ or w/o IVIS from 3 km/h in driving behaviour is extremely high considered drives at urban roads, we interpreted this variation to influence in usage of IVIS.

5. Conclusions

According to the current results from this research under real traffic conditions regarding the dependent variables which are essential for the interpretation of safety from a traffic engineering point of view (continuous speed and acceleration data and frequency of observed critical events) there are neither positive nor negative significant effects of the specified and investigated set of IVIS devices – when used in combination – on road safety.

Significant differences between drives w/ and w/o IVIS at both road types results mainly from the individual subjects. The single drives analysis describe at chapter 4.2.2 shows that the driver behavior of the individual subjects of both age groups differs much. So we can't say definitely that IVIS have or haven't an influence on road safety. For sure an influence of IVIS on road safety does exist. But the influence seems very small. Mainly it lies in regions of the standard deviation (Vm).

Another example shows, the group of younger subjects drive w/o IVIS faster on freeway route (Freeway 5 & 6) otherwise the group of elderly subjects drives faster w/o IVIS (Freeway 5) and on the other hand they drives slower w/IVIS(Freeway 6).

The final report of this research project will be available at the end of 2009 and contains all investigated variables and the following results.

6. References

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