Using Automated Assistance Systems - Putting The Driver Into Focus

Dr. Dirk M. Reichardt

FT3/AA – HPC T728
DaimlerChrysler AG

Veröffentlicht in:

Proceedings of the 1998 IEEE Inernational Conference on Intelligent Vehicles,
October 28-30, 1998, Stuttgart, Germany

Using Automated Assistance Systems – Putting The Driver Into Focus

Dirk M. Reichardt

Abstract

Abstract - **Today's sensor technologies together with high quality vehicle controllers already allow automatic driver assistance systems. Automatic adaptive cruise control as a first representative of the new dimension of assistance systems is already available in today's cars. Tomorrow's world will provide the driver with partly autonomous systems that allow him to leave the complete control over his vehicle to a computer in many phases within real traffic.**

At the same time the demand for mobility also influences other fields of research. Telematics technologies already allow the „mobile office“. The combination of these two technologies, telematics and automated driving, by an intelligent driver interface opens a new dimension for the future: While the driver leaves the control over his vehicle to the computer, he can temporarily focus his attention on selected office applications. That is the main aspect this paper deals with.

With a technical feasibility of automated driving functions, the role of the driver becomes more and more important for researchers. Since automated driving functions will first cover certain domains like highway cruising or stop&go traffic, the key question is the hand-over between computer and driver. This hand-over situation is subject of a simulator study and first results and impacts concerning the design of autonomous systems on the road are pointed out.

Keywords - **Autonomous Systems, Human Factors, System Safety, Simulation**

The future of automatic driving

While fully automated driving will still be a long term research subject, some scenarios can already be regarded as short term.* Until now most studies concerned with automated driving dealt with technical feasibility rather than with the human driver who eventually desires to use these new assistance functions.

When looking at the stop&go scenario, an automatic car following function for low speeds in congestions will be feasible from a technical point of view soon. Apart from the vehicle controllers and sensor technologies, the Human-Machine Interface (HMI) will become the crucial point in the layout of a future assistance system.

What's the benefit of an automatic driving function?

With the ability of an assistance function that takes complete control over the car, a completely different driving behavior will be shown by future drivers. The driver can focus his attention on different issues than the driving task.

A possible scenario is the commuter who reads his newspaper in the morning while his car automatically guides him through a congestion. More than that, a complete mobile office functionality (access to email, calendar, documents) could be used during that time. This will increase the productivity of the driver or it will just make the trip more entertaining.

How can we make the hand-over situation safe?

The scenarios in which the automatic driving function is operational will be limited. This implies a point in time when the driver has to take over control again. In the above example this would happen at the end of each congestion.

Disregarding any technical or technological issues for a moment, at this point we run into a safety hazard that depends on the driver's ability to handle such an assistance system.

Most generally speaking, the driver can use the time while the car drives on its own in three different ways:

- *he chose to do something in parallel*

  (i.e. reading, telephone calls, playing games)

- *he can chose to watch the traffic as if he was driving himself*
- *he can chose to do nothing or to sleep.*

One possible answer is to integrate the platform for the „distracting“ secondary activities of the driver into a new cockpit concept.

* Dirk M. Reichardt is with the Research Institute of Daimler-Benz AG, Esslingen, Germany.
Email: reichardt@dbag.stg.daimlerbenz.com

The combination of telematics and autonomous driving technologies by an intelligent driver interface is the approach we are following in order to do both, improving safety and comfort in a future car.

Requirements

The typical scenario described above leads to a requirements list for a functionality concept that consists of three major parts:

- the „drive“ part, which describes requirements for the autonomous driving function,
- the „application“ part, which describes requirements for the access to a selection of services and
- the „interface“ part, which deals with the HMI aspects.

„Drive“ - requirements

To guarantee a safe use of automated driving functions the following conditions must be fulfilled:

- Complete control over the vehicle is taken by the computer.
- Driving functions are capable of a self-diagnosis. The time until the driver needs to take control again must be predictable.
- A safety function needs to be integrated. This function brings the vehicle into a safe state whenever needed.

„Application“ - requirements

There are huge amounts of applications that can be made accessible by telematics. We basically concentrate on office applications only. This means standard applications like phone conferences and engagement calendars in the beginning. The main focus is set on new communication technologies like E-mail, Internet and World Wide Web. Which application can be used in the vehicle? How can these applications be designed for a safe use in the vehicle? These questions need to be answered by a future car concept.

„Interface“ - requirements

The link between these two technologies is an intelligent user interface. This interface contains the following three main parts:

- Lay-out and arrangement of the presentation and reception of information. The information interchange with the driver.
- Continuous monitoring of the driver’s general ability to take control.
- An access control component. The allowed application as well as the used medium (optical vs. acoustical information) depends on the traffic situation and the autonomous driving function which is currently activated.

The goal of the overall interface design is to keep the driver in the control loop.

A first concept for a driver interface

The driver interface deals with presentation of information and driver inputs. What we don’t want to see is a driver leaning over to the copilot’s seat working on a notebook. This would neither be comfortable nor safe at all.

Let’s have a look at the safety issues:

- The driver should not release the hands from the steering wheel for a longer time. Abruptly gripping the steering wheel in case of a system warning can lead to loosing control over the car.
- The head and eye movement should be limited to a minimum in order to allow a quick turning back to the traffic scenario. The ideal solution would be the head-up display (HUD) technology that also minimizes the accomodation time of the eye[1].

Since the driver’s seat is optimized to be most comfortable in the usual driving position, the very position should be taken.

An approach that comes close to the requirements is shown in Figure 1. Driver inputs are possible through voice commands and a trackball-like device which is integrated in the steering wheel. Information is presented either acoustically (text reader) or on a special display which is integrated in the dashboard.

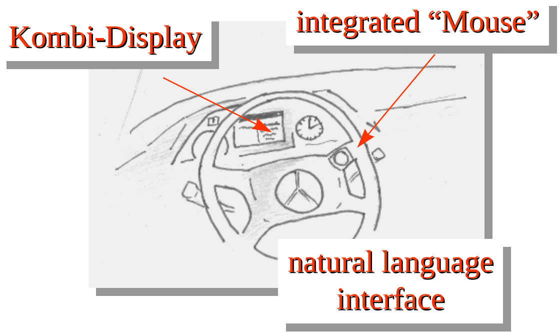

Figure 1: A concept for a future driver interface

[1] The HUD is discussed controversely from a human factors point of view [Mutschler 95] and the technology does not provide the required display capabilities for complex images or text as yet.

If the driver uses the automatic driving time by working on something, does this work influence his ability to take over control if required? A simulator test was designed to answer this question. The results are presented below.

The Simulator Test

The simulator test makes the hypothetical assumption that a safe stop&go function is implemented. The remaining critical point is the hand-over between the automatic driving function and the human driver.

With respect to future office applications the following hypothesis are stated:

a) *Drivers who work during the automated car following will take more time to take over control.*

b) *Drivers who work during the automated car following will react more slowly to braking maneuvers of the leading vehicle immediately after taking over control.*

The idea behind the hypothesis is that the drivers remain mentally involved in the secondary task. In case these hypothesis could be proven or if there were significant hints for their validity, a strong argument against distracting activities would be given. As a conclusion, one of the major benefits mentioned above would not exist.

Layout of the simulator test

The simulator test was done in the Daimler Benz driving simulator in Berlin. The test persons were divided into three groups. All of them passed the same scenario and used the same automatic driving function. Two of them were given different tasks whereas the third group was not given any task to have a comparison of the effects.

The test does not consider exceptions, caused by system failure. The tested situation is the end of a congestion described as follows:

- speed is about 10 m/s
- distance to the leading vehicle is about 20 m
- the leading vehicle gains distance first and then brakes (about 6 m/s^2)

The system displays a sound signal to demand the driver to take over control. The leading vehicle brakes shortly after the driver has taken control. The time span between hand-over and braking is either 0 seconds or 3 seconds.

The tasks

The secondary tasks are designed to completely distract the driver’s attention from the traffic by creating cognitive strain. Since effects are easier to measure in less complex circumstances, we chose basic scalable tasks rather than complex working tasks.

- The first group was given tasks that addressed spacial and verbal mental processing. The theory behind this is based on the „multiple resource model“ by Wickens. The validity of the tasks which were used is proven by [Renner 95].
- The second group was given a different task and the candidates were asked to work either in an exact way or quick. The validity for this task was examined in pretests.
- The third group did not get any task.
- The responses of the test persons are recorded by software and a human operator. The recordings are required to have a means of verification for the actual cognitive distraction of the driver.

The course of the test

Each of the 47 test persons passes a preparation, a pre-run and two actual test runs in the simulator of about 10 minutes each. The two test runs contain three congestions each. At the end of the first congestion, the leading vehicle does not brake. At the end of the two others it does after 0 or 3 seconds. The order is varied.

Two scenarios for test runs are defined. They both have the same length and all the generated situations are kept comparable. For each group, one of the conditions (tasks) is associated to a test run.

	test	**spacial/verbal**	**fast/exact**
r1	none	spacial	fast
r2	none	verbal	exact

Then, every run has a preset sequence of three congestions and critical situations. The leading vehicle is braking *n* seconds after the driver takes over control:

congestion	**1**	**2**	**3**
r1	about 60	0 s	3 s
r2	about 60	3 s	0 s

The groups are named as follows:

TG 1 testgroup without a task, order: [r1,r2]
TG 2 testgroup without a task, order: [r2,r1]
SV 1 spacial/verbal group, order [r1,r2]
SV 2 spacial/verbal group, order [r2,r1]
FE 1 fast/exact group, order [r1,r2]
FE 2 fast/exact group, order [r2,r1]

The results

In the following, test measurements and answers to the hypothesis are given. First for the take-over reaction time and then for the brake-reaction of the drivers.

The take-over reaction time

The take-over reaction time gives information about the effects of the tasks on the driver's behavior. The results influence the conceptual design of a automatic stop&go system.

Hypothesis

Drivers who work during the automated car following will take more time to take over control.

Statistics

The results of the first test run. Average values for the take-over reaction times are displayed in Figure 3.

In order to draw conclusions from the measurements, we need to take the variance into account when comparing the groups.

run 1

Situation	TG-FE (1)	TG-SV(1)	SV-FE(1)
(1)	0.503	0.424	0.754
(2)	0.633	0.473	0.269
(3)	0.721	0.834	0.900

Situation	TG-FE (2)	TG-SV (2)	SV-FE(2)
(1)	0.303	0.275	0.835
(2)	0.840	0.820	0.510
(3)	0.622	0.521	0.830

Even if a rather high significance-level of 10 % is chosen, no significant differences can be found that might be depending on the task. This holds true for the second test run as well.(see **Figure 5**)

Interpretation

The test does not give any proof to the hypothesis stated above since no significant differences between the groups could be found.

However, from a system design perspective it is interesting to notice that even after practice, the average time the candidates needed to take over control was about two seconds. It is important to add that the test persons did not associate an immediate risk with the warning signal. Therefore the results cannot be taken to draw conclusions for emergency situations.

The brake reaction time

After taking over control, the driver is facing a critical situation immediately. The question is, if he is able to switch back his concentration to the traffic scene quickly enough to react properly.

Hypothesis

Drivers who work during the automated car following will react more slowly to braking maneuvers of the leading vehicle immediately after taking over control.

Statistics

The brake reaction times are measured from the moment the brake lights of the leading vehicle light up until the driver hits the brake pedal.

The results for the first run are similar to the take-over reactions. There are no significant differences depending on the given task. (See Figure 2 and Figure 4).

For the second test run results look almost the same except for one interesting phenomenon:

The group that was given the motivation to be „fast“ in solving the given tasks showed better results. Their braking reactions were significantly faster in the first situation.

A second test based on the time to collision value (ttc) shows similar results. The idea of the ttc-test is the following:

A low ttc-value at the time the driver starts braking indicates a late recognition of the critical situation (or a low subjective risk estimation).

As in the other tests, no significant differences between the groups concerning ttc-values is found except for three situations in which the „fast“ group was significantly better than the others.

Interpretation

The results from the brake reaction comparison do not contribute any proof to the given hypothesis. However, the only significant differences were caused by the „fast“ motivation, which is an interesting effect but does not lead to any conclusion concerning the hypothesis.

Conclusion

The simulator test does not deliver positive proof for the hypothesis stated in the beginning. No hints towards a negative influence and an increase of risk for the driver caused by the integrated working during automatic driving were found.

This result is considered as a positive motivation for the further pursuit of the idea to combine telematics technologies with automatic driving functions in a new car concept.

Along with the work on the technological preconditions, further investigations need to be done in the field of ergonomics and system safety to eventually provide a driver's mobile office.

References

[Mutschler95] Hartmut Mutschler, „*Informationsdarstellung im Fahrzeug mit Hilfe eines Head-Up-Displays*", Berichte der Bundesanstalt für Straßenwesen, Heft F 11, 1995

[Renner 95] Goetz J. Renner, „*Fahrzeugführung unter kognitiver Belastung - Eine Simulations-studie*", Dissertation, Rheinisch-Westfälische Technische Hochschule Aachen, Institut für Psychologie, 1995

Figures:

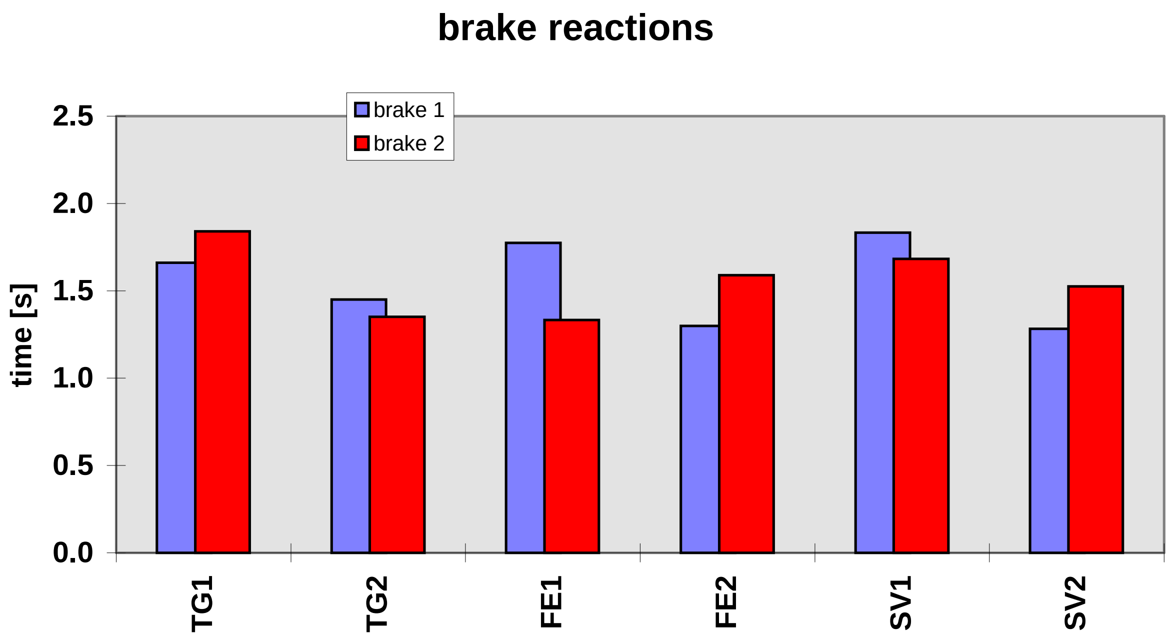

Figure 2 : brake reaction times in the first test run.

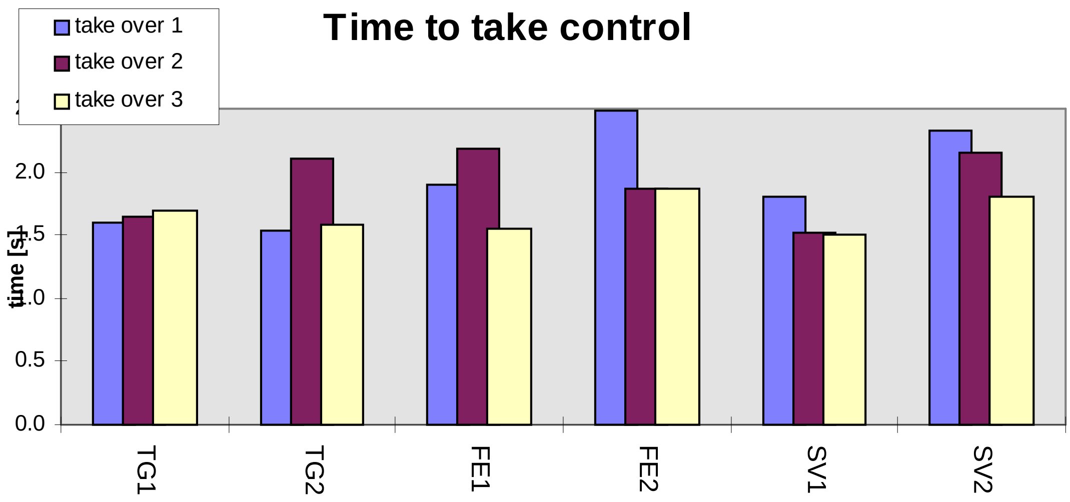

Figure 3 : Take-over reaction times in the first test run.

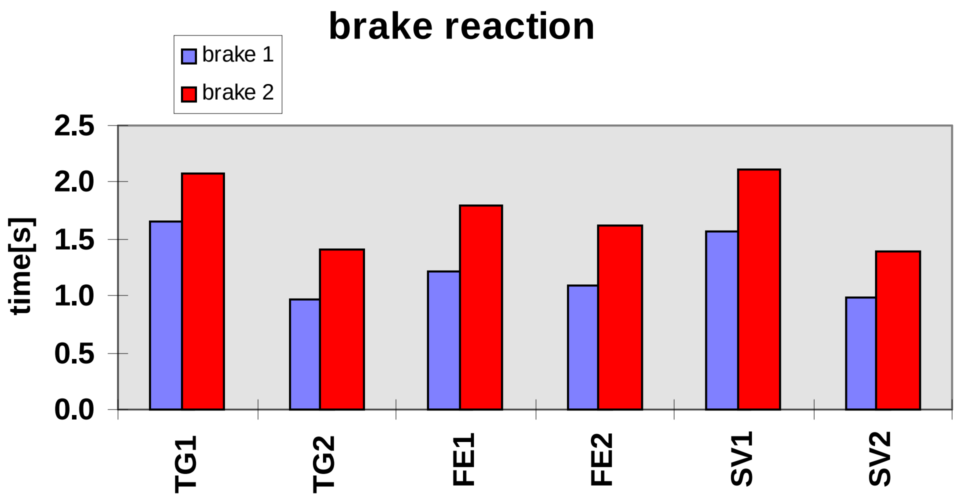

Figure 4: Brake-reaction times in the second test run.

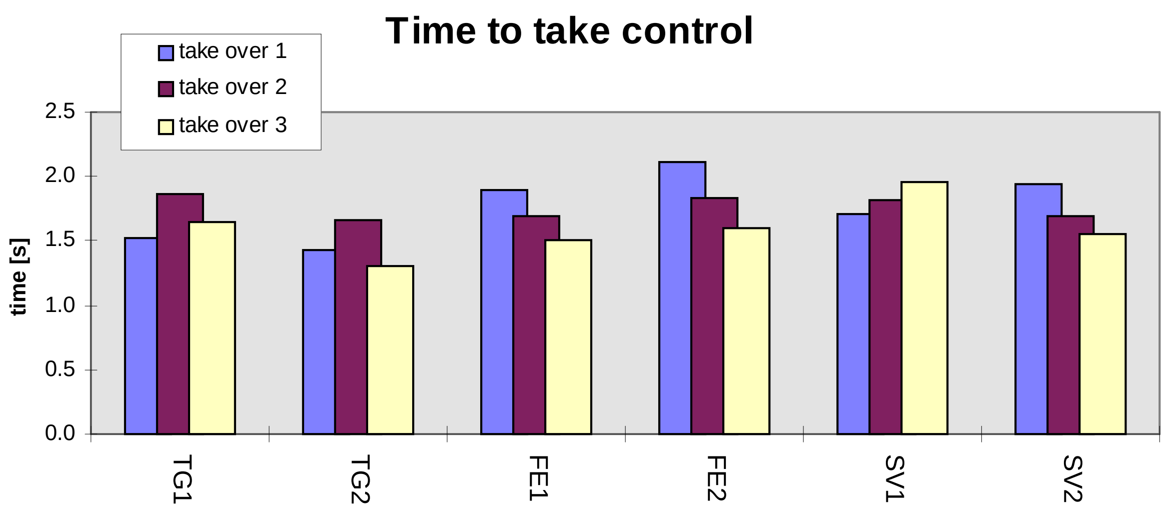

Figure 5: Take-over reaction times in the second test run.