The Traffic Safety of the Carin Car Information and Navigation system IB

Literature study: Description reports and articles

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A detailed description is given of the reports that have been studied in the framework of a literature study on a number of traffic safety aspects of the Carin Car information and navigation system. Each description contains a summary of the report or article, a valuation, and a subject-categorisation. For the selection of the studied aspects is referred to part IA of the report, where also an evaluation and interpretation of the results can be found.

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Literature study: Description reports and articles

G. Blikman

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PREFACE

Safety is one of the most difficult and complex aspects of the traffic system. The reason hereof is that safety is not simply a matter of averages, but of deteriorations from the average. In traffic numerous actions are executed 100 thousand times effortlessly, but the one time the traffic process is disturbed, an accident is the result with all possible serious consequences. Accidents seldom or never have one cause. Usually they are the result of a critical combination of many circumstances. Traffic safety research therefore concentrates on locating that critical situation, the chance or probability of occurrence of that situation and the consequences hereof.

With regards to the decision process on traffic safety, three phases can be discerned: the risk analysis, the risk assessment, and the risk control.

The risk analysis is directed mainly at locating critical circumstances, the chance of occurrence and the consequences hereof with the aim to give a qualitative and if possible a quantitative description or the risks. This report is concentrated mainly on the risk analysis of the Carin system.

In the risk assessment phase the acceptable risk is weighed out against other aspects, such as comfort, accessibility, speed, costs, and the like.

The risk control phase is pointed at the optimal design of a measurement.

In a well structured decision process, the decision phases are separated as much as possible. If e.g. in the risk analysis phase other interests such as costs already play a role, no objective impression of the actual risks may be received.

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INTRODUCTION

This part of the report on the traffic safety of the Carin car information and navigation system contains descriptions of studied reports and articles on the three traffic safety aspects that have been selected out of a list of 11 aspects in part IA of the report. These aspects have been divided into nine subjects:

4 Distraction by route guiding advices
4.1 The distraction of drivers from their driving task by the presentation of aural route guiding information. The amount of distraction. The variables that are of influence on the amount of distraction
4.2 The distraction of drivers from their driving task by the presentation of visual route guiding information. The amount of distraction. The variables that are of influence on the amount of distraction

7 Untimely presentation of route guiding advices
7.2 The reaction time on aural and visual route guiding messages
7.3 The interpretation time for each of the route guiding pictogrammes
7.4 The time that is needed to execute a necessary action (decelerating, changing lanes)
7.5 The chances that aural route guiding advices are forgotten

11 Avoiding unsafe locations and situations
11.1 The possibility to use traffic safety criteria. The possibility and desirability of accountance for external circumstances
11.3 The (un)safety of certain roads, locations, manoeuvres, and situations
11.4 The dangerous road situations a driver should be warned off

The description of each report consists of three parts: a summary, a valuation of the report, and a subject-categorisation. In the summaries only the contents of the reports is described. Any opinions or comments are exclusively the author's. In the valuation of the reports and articles an estimation is given of it's usefulness for this literature study on the traffic safety of the Carin system. In the subject-categorisation a list is presented of the subjects that are discussed in the article or report.

An oversight of all studied literature is presented at the end of this report.
For the evaluation and interpretation of the results is referred to part IA of the report, where also recommendations for further study are presented.
Summary
In the Federal Republic of Germany a discussion is taking place on new communication techniques in cars. The aim of the article was to present an overview of the questions and difficulties that go with such new techniques.

The demands for an in-car navigation and information system should primarily be set by the needs of the users. Besides that, traffic technology and policy goals should be taken into account also.

In determining the needs of drivers, it should be considered that in-car information and navigation systems are additional to already existing out-car information systems. The surplus of in-car information is the possibility to warn of road situations ahead and to guide a driver to his destination.

The operational demands for an additional (in-car) information and navigation system will be greatest in residential areas and on motorways. In residential areas the driver will be wanting information on the main roads, on congestions and on travel times. On motorways the drivers will mainly be interested in information on traffic flows to be expected, warnings of accidents, road works and the like.

The presentation of the necessary information should be executed modestly in order not to require too much of the driver or distract his attention from the driving task. Recent researches have made it clear that an auditory presentation of information is to be preferred to a visual presentation. The visual presentation that has been tried until now, resulted in a distraction of the driver of about 3 seconds or more, whereas only 1-2 seconds at the most can be tolerated. In general, visual presentations should be interpretable with only an occasional look.

The governmental point of view is that an in-car information and navigation system should contribute to safe and large traffic flows on roads that are most functional for that purpose. This should be done by using the capacities the best and with polluting the environment the least.
The author favours a centrally regulated information and navigation system to be build by the authorities. This central regulation station should be able to communicate with drivers through highly modified radios, thus being able to offer drivers their individual information while restricting to governamental policies and laws. This would also have the advantage of one general, not factory-bound system, that could also internationally become accepted as a standard.

In the future it will be possible and desirable to couple the car information and navigation system to systems for public transport (park and ride) and public services like the police.

The navigational part of the guiding system can be independent for each car (e.g. mapping) or steered by road side signals (ALI). Individual systems have the disadvantage of never being up-dated. Road side steered signals have the disadvantage of having to be very complete to function satisfactory.

Many problems must be overcome before an organisation with one central and many subcentral guiding stations is set up and capable of composing and controlling the necessary traffic models and traffic data. Unfortunately, the public authorities are not prepared for such a complex management system, neither structural nor personnel.

Value of the article
This article has only a moderate value for this literature study. Therefore, two reasons can be put forward. Firstly, it deals only in general terms with in-car route guiding systems and secondly, it discusses a governemental regulated guiding system instead of an independent one like Carin.

The separation between demands for residential areas and for motorways seems rather artificial.

It is a pity that the value of 1-2 seconds for the tolerable interpretation time is not explained.

Subjects
4.1 The distraction of drivers from their driving task by the presentation of aural route guiding information.
4.2 The distraction of drivers from their driving task by the presentation of visual route guiding information.
Berkvens, H.J.F.M.
Nadersnelheden bij kruispunten, pp 14
Veilig Verkeer Nederland
Hilversum, the Netherlands, 1976

Summary
Aim of the report was to provide guidelines for speeds when approaching junctions.

Approximately 30-50% of all accidents happen on junctions. Of these accidents some 80% take place within residential areas. It is assumed that a high speed before junctions is an important cause for accidents.1) In the past, the reaction time has been measured in various tests. A reaction time of 0,5 s must be seen as an absolute minimum, which occurs seldomly. According to Moser, a reaction time of 0,7 s is the best that can be achieved (0,3 s for the realisation of the danger, 0,2 s for starting to brake, 0,2 s between the pressing of the braking pedal and the actual functioning of the braking pads). According to tests, most humans need a reaction time of 0,7-1,0 s. Age plays an important role in the duration of the reaction time: elderly people need a longer reaction time than younger ones. Rompe finds mean reaction times of 1,2-1,4 s. The West-German jurisdiction even calculates with a reaction time of 1,5 s.

The stopping distance is calculated as the sum of the distance covered in the reaction time and in the braking time. For passenger cars calculations have been made with reaction times of 0,7 and 0,5 s and decelerations of 7 m/s² and 8 m/s² respectively. For mopeds the decelerations have been assumed 3,86 and 5 m/s² with the same reaction times. The calculations have been made for normal weather circumstances, a good skidding resistance and a good condition of brakes and tyres 2).

Value of the report
The value of this report lies in the presented data on reaction times. The assumptions on which the advised speeds are based, are incorrect and not thoroughly thought over:

1) and 2): see "value of the report"
1. In contrast to what is written, there is no main cause for an accident. Accidents happen as a result of a combination of a number of circumstances.

2. No account has been made for circumstances with deteriorated braking capacity, although exactly those circumstances are important factors in the discussed accidents (wet road surface, bad condition of the car, worn tyres, etcetera). Furthermore, differences in junctions have been ignored, just like human reactions and even the possibility to influence human behaviour.

Subjects
7.2 The reaction time on aural and visual route guiding messages
Blaauw, G.J.
Car driving as a supervisory control task, pp 139
Graduating paper for a doctor's degree
Instituut voor Zintuigfysiologie TNO
Soesterberg, the Netherlands, 1984

Summary
The report deals with an analysis of multitask driving in terms of supervisory control, in which each singular task is performed more or less automatically under supervision of the driver.

The driving task can be categorized on three hierarchically ordered levels. On the first and strategic level the route selection and following is executed. The second, situational, level describes the manoeuvring tasks. The third level is the control level and describes tasks of vehicle control. The control tasks are usually subdivided into lateral vehicle control (lateral vehicle position inside a lane) and longitudinal vehicle control (velocity).

Skilled drivers cope better with multitask driving situations, because they have to pay less attention to a singular task. Inexperienced drivers continuously need full attention for the driving task. Rockwell and Mourant noticed that experienced drivers maintain a 2,5-3,5 s minimum preview time, while novice drivers use foveal determination for lane positioning in samples with a preview time less than 1 s.

Driver's control strategy may be studied by analysis of the steering wheel reversal rate. McLean and Hoffmann found dominant frequency ranges at 0,1-0,3 Hz and sometimes 0,35-0,6 Hz.

With increasing driving skill, tasks can be combined to a larger extent and be performed more automatically. The driving task then has shifted to supervising control, which allows a more easy detection and handling of unsafe traffic situations.

In addition, car and road designs are better if they allow drivers to behave more as supervising control.

A simulation model has been developed for the description of the supervisory driving task. In the model the driver is described as a combined observer/predictor, controller and decision maker.

A driver's skill is better when the time periods between two observations and control tasks are larger.

In the simulation model the vehicle dynamics are described by a basic theoretical description of vehicle performance. Described are the longitudinal and lateral vehicle dynamics.
In total eight experiments have been conducted to examine the driving task. Some of the experiments used an instrumented vehicle (on a track that was closed for other traffic) and some a driving simulator. The results of two tests were compared with results of the Supervisory Driving Model.

Experiment 1

The aim of experiment 1 was to investigate to what extent and with what consequences for lateral control performance, drivers allow themselves to observe objects which are not directly related to lateral control.

From the literature it is known that drivers fixate at the road edges and markers only a small percentage of the time. Rockwell found that in normal straight road driving, 90% of the fixations fall within 4° from the vanishing point. According to Babkov, 44% of the eye fixations is situated in the direction of the car at the horizon, 29% just in front of the car and 7% at each side of the car.

The visual concentration field (the area which covers 85% of the driver's eye fixation) was found by Babkov and Lobanov to be inversely related with driving speed.

Driving skill also has influence on the eye fixation. Experienced drivers concentrate their eye fixations at the vanishing point and are assumed to use peripheral viewing for lane positioning. In contrast, inexperienced drivers often switch from far fixations to near fixations.

In the experiment nine male experienced test subjects drove the instrumented car. The eye and head movements were recorded automatically through a small video camera attached to the driver's head (head movement) and through electro-oculography (eye movement).

The results show that no specific road object attracted the driver's attention in particular, which seems to confirm the result from the literature that lateral vehicle control on straight roads requires only a small amount of foveal attention. It seems that the drivers visually scan the total environment with a centre position near the vanishing point.

In accordance with the literature, a dominant peak was found in the steering wheel reversal rate frequency band 0-0.3 Hz, and sometimes a second peak in the band 0.3-0.6 Hz.
Experiment 2

In experiment 2 additional tasks were defined so that drivers were not able to continuously attend to lateral control. Consequences for the lateral control strategy and performances were examined. It was decided to minimize the driver's possibilities to obtain visual information about lateral control. Therefore drivers were instructed to scan actively the off-road environment and to mention details of what was seen. In this way foveal and peripheral information on lateral control was assumed to be minimal and drivers could visually verify driving performance only intermittently. This "minimum condition" was complemented by a "maximum condition" in which drivers were urged to do utmost in lateral control.

The experiment was carried out by having three experienced and three inexperienced subjects drive an instrumented car. The two instructions for lateral vehicle control (minimum and maximum condition) were complemented by an instruction for longitudinal control: the subjects were required to concentrate on a velocity of 100 km/h, a velocity of 80 km/h or were not given any longitudinal control instruction. Each subject drove each condition three times in a random sequence.

The results showed that longitudinal instructions did not have a main effect on lateral control, whereas lateral instructions did. Compared with the maximum condition, the minimum condition resulted in:

- a larger distance to the right shoulder line
- a larger standard deviation of the lateral position
- a larger standard deviation of the lateral speed
- a smaller medium left TLC (time to line crossing)
- no differences in the medium right TLC
- a larger standard deviation of steering wheel movements
- higher steering wheel frequencies

Although the lateral instructions did show an effect on lateral control, the absolute standard deviation values and the TLC mediums indicate that both groups of drivers were still quite able to stay within their lane (table 1).
Table 1: Lateral control performance for the inexperienced (INEXP) and experienced (EXP) drivers with two lateral control task demands (MIN and MAX visual needs) and three additional velocity task demands (FREE, +80 km/h and +100 km/h)

Source: Blaauw, 1984

<table>
<thead>
<tr>
<th>Source</th>
<th>S.D. lateral position (m)</th>
<th>S.D. lateral speed (m/s)</th>
<th>median left TLC (s)</th>
<th>median right TLC (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FREE +100</td>
<td>1.87</td>
<td>0.19</td>
<td>8.8</td>
<td>6.4</td>
</tr>
<tr>
<td>+80 km/h</td>
<td>1.95</td>
<td>0.21</td>
<td>8.5</td>
<td>6.4</td>
</tr>
<tr>
<td>+100 km/h</td>
<td>1.84</td>
<td>0.21</td>
<td>9.4</td>
<td>5.9</td>
</tr>
<tr>
<td>KM/H</td>
<td>1.68</td>
<td>0.14</td>
<td>6.3</td>
<td>5.2</td>
</tr>
<tr>
<td>KM/H</td>
<td>1.95</td>
<td>0.11</td>
<td>7.0</td>
<td>5.4</td>
</tr>
<tr>
<td>INEXP</td>
<td>1.96</td>
<td>0.12</td>
<td>6.7</td>
<td>5.0</td>
</tr>
<tr>
<td>EXP</td>
<td>1.98</td>
<td>0.12</td>
<td>6.7</td>
<td>5.2</td>
</tr>
<tr>
<td>S.D. lateral speed (m/s)</td>
<td>0.07</td>
<td>0.07</td>
<td>0.07</td>
<td>0.06</td>
</tr>
<tr>
<td>median left TLC (s)</td>
<td>8.2</td>
<td>9.1</td>
<td>9.9</td>
<td>5.2</td>
</tr>
<tr>
<td>median right TLC (s)</td>
<td>6.2</td>
<td>5.0</td>
<td>5.4</td>
<td>5.0</td>
</tr>
</tbody>
</table>

With respect to the driver's control strategy, it was noted that inexperienced drivers can not continue lateral and longitudinal control sufficiently. They seem to switch between longitudinal and lateral control. Experienced drivers seem to be quite able to perform both tasks simultaneously.

Experiment 3

A study with the Supervisory Driver Model has been conducted to predict the effects on lateral control performance of different combinations of perceptual cues.

As a basic condition, the observation and control of lateral position alone were considered, whereas in the other conditions various cues in the observation/prediction block and control block were added.

The Supervisory Driver Model showed that lateral control improved considerably when the lateral speed cue was used. Hence the lateral speed cue seems to be the most effective within the observation/control block and it aids in achieving an improvement (decrease) of the standard deviations of lateral position and yaw rate.

Experiment 4

The aim of the fourth experiment was to investigate the effects of
lateral acceleration (sidewind) on driver performance.

The experiment was carried out by having 24 experienced and 24 inexperienced subjects drive an instrumented car and a driving simulator. Two conditions were given for lateral vehicle control:

- Free: no specific lateral instruction was given
- Maximum: "to drive as straight as possible" in order to provoke a strict internal criterion for lateral control and to aim at maximum visual needs to do so

Both instructions above were combined with one of the following instructions for longitudinal control:

- Free: no specific longitudinal instruction was given
- 100 km/h: subjects should concentrate on a control velocity of 100 km/h

The results showed no difference in lateral control performance as a result of the conditions free and maximum. The first of in total six trials resulted for all subjects in significantly larger standard deviations of yaw rate and steering wheel angle.

There were considerable differences between the results of the runs in the instrumented car and the driving simulator. Greater driving experience had no overall effect on the measures in the instrumented car, but did have effect in the driving simulator. The 100 km/h condition showed, together with the driving experience, interactive effects on the standard deviations of the lateral position, the lateral speed and the steering wheel angle. The inexperienced drivers had a significant increase in the measures when driving 100 km/h, whereas the experienced drivers then showed a decrease. It is noticed that for the experienced drivers the required higher task demands for longitudinal control are associated with self-chosen higher task demands for lateral control.

**Experiment 5**

In the fifth experiment the driver's strategy and performance during night-time has been tested with the instrumented car in order to study the contribution of visual cues to the observation and control strategy. The effects on longitudinal control were expected to be the greatest, because the velocity can be estimated less accurately during night-time as compared with day-time, whereas the lateral
position can still be estimated from the lining and road markers.

Twelve experienced and twelve inexperienced drivers drove in the experimental car during night-time with dipped headlamps. The data were compared with those from experiment 4. The subjects were given two conditions:

- free: no specific instruction was given
- 100 km/h: subjects were instructed to concentrate on driving with a constant velocity of 100 km/h

In general, the runs during night-time resulted in a significantly larger distance to the right lane marker than during day-time. During night-time the mean velocity was significantly lower than during day-time.

The deteriorated visibility during night-time did not considerably affect the control strategy of inexperienced drivers within the "free" condition, but led to higher frequencies and smaller standard deviations for steering wheel movements of the experienced drivers. Hence, it may be concluded that the experienced drivers use the deteriorated night conditions to select higher task demands for lateral control.

The 100 km/h condition during darkness led for inexperienced drivers to a further deterioration of lateral control performance as compared with the day conditions, whereas the experienced drivers then did not have a further deterioration.

The 100 km/h condition during night-time resulted for both experienced and inexperienced drivers in larger steering wheel movements. That even experienced drivers might have difficulties in combining both the lateral and the longitudinal control task, may be explained by the fact that during darkness the visual field is deteriorated and, as a result, drivers have to estimate their velocity primarily through observations of the speedometer, during which no visual information can be gathered on lateral vehicle control.

Experiment 6

The sixth experiment dealt with the question about driver's observation strategy and the timing aspects of the driver's needs to update his estimates with respect to driving performance.

This was done by Supervisory Driver Model calculations and field experiments with the instrumented car. In the instrumented car the driver's visual cues were occluded for a certain period during which his uncertainty rose. On request the driver could obtain a new
observation whenever his uncertainty rose to too high a level by pressing the horn lever.

Data points were available for lateral position control of experienced and inexperienced drivers for constant speed, straight road driving with and without visual occlusion.

A comparison between Supervisory Driver Model predictions and empirical occlusion times indicated a good correspondence for experienced drivers, but an underestimation of the occlusion times for inexperienced drivers (figure 1).

![Figure 1](image)

**Figure 1**: SDM predictions (symbols: x) for the mean occlusion time as a function of speed during the exclusive observation and control of lateral position (via the inclination angle $a$; figure a) and during the observation and control of all five perceptual cues (figure b); the field data present the mean values and standard deviations of measured occlusion times, for inexperienced (figure a) and experienced drivers (figure b); Source: Blaauw, 1984

**Experiment 7**

In experiment 7 the previous experiment was extended to night-time with various task demands (with and without the 100 km/h condition). The drivers were allowed only to look at the road or at the speedometer whenever they felt necessary.

The experiment was carried out by twelve experienced and twelve
inexperienced drivers, who drove the instrumented car during day-time and did identical runs at night with dipped head lights (no public lighting).

With respect to the occlusion technique, drivers were instructed to occlude voluntary their visual information during the measuring interfalls by looking downwards within the car, instead of at the road or speedometer for as long as possible.

The driver's observation strategy was recorded on tape by a dashboard-mounted camera.

In general, visual occlusion resulted in, compared with the non-occluded runs:

- a larger standard deviation of the yaw rate
- a larger distance to the right shoulder line during day-time
- a larger standard deviation of the lateral position
- a larger standard deviation of the lateral speed
- smaller median left TLC-values during day-time
- smaller median right TLC-values at night

The variations in velocity during the runs with occlusion turned out to be smaller for experienced drivers than for inexperienced drivers, whereas without occlusion no difference had been present.

In general, drivers drove slower during night-time than during day-time.

Table 2 presents the driver's observation strategy in terms of percentages of time spent on each category.

Table 2: Mean observation time(s) to the observation categories for the inexperienced (INEXP) and experienced (EXP) drivers with the FREE and +100 km/h task demands, during day- and night-time; Source: Blaauw, 1984

<table>
<thead>
<tr>
<th></th>
<th>FREE + 100 KM/H</th>
<th>FREE + 100 KM/H</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>day</td>
<td>night</td>
</tr>
<tr>
<td>oclusion</td>
<td>4.5</td>
<td>4.9</td>
</tr>
<tr>
<td></td>
<td>4.3</td>
<td>5.0</td>
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<tr>
<td></td>
<td>5.8</td>
<td>3.9</td>
</tr>
<tr>
<td></td>
<td>4.5</td>
<td>3.7</td>
</tr>
<tr>
<td></td>
<td>INEXP</td>
<td>EXP</td>
</tr>
<tr>
<td>mirrors</td>
<td>0.2</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td>0.3</td>
<td>0.2</td>
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<tr>
<td></td>
<td>0.3</td>
<td>0.2</td>
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<td></td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>INEXP</td>
<td>EXP</td>
</tr>
<tr>
<td>speedometer</td>
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<tr>
<td></td>
<td>0.8</td>
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<td></td>
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<td>0.5</td>
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<tr>
<td></td>
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<td>EXP</td>
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<tr>
<td>road</td>
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<td>2.0</td>
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<tr>
<td></td>
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<td>1.9</td>
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<tr>
<td></td>
<td>INEXP</td>
<td>EXP</td>
</tr>
</tbody>
</table>

The time spent on the road ahead is higher at night than during day-
time and is higher for the inexperienced drivers than for the experienced drivers.
The occlusion percentage is in all conditions higher for the experienced drivers than for the inexperienced drivers. An interaction is found between driving experience and day/night condition with respect to occlusion time: the change to night condition results in shorter occlusion times for the experienced drivers, whereas the inexperienced drivers allowed themselves then larger occlusion times. Together with the increased observation time on the road ahead then, it can be concluded that these drivers have at night less changes in their observations of the different categories than the experienced drivers.

Experiment 8

Experiment 8 was conducted to demonstrate the relevance of the foregoing experiments for the evaluation of road and car design in terms of supervisory driving. Various configurations on road delineation at night have been examined. It is assumed that a better design will result in an increased free time, or occlusion time.

The experiment was carried out by having six experienced drivers drive the instrumented car during darkness with dipped head lamps on a road without lighting. They had to drive with a speed of 80 km/h, which was automatically controlled by maintaining a constant pressure on the accelerator pedal, so drivers could concentrate on lateral vehicle control. Visual occlusion was realised by a pair of spectacles, which in its normal state occluded the visual field of the driver completely. Visual information was given as long as the horn lever was pressed.

The experimental configurations were realised at straight sections and curves with radii of 1000 and 200 m. The spacing distances between the markers were 12, 24 and 36 m. One 3/9 pattern was used that was based on the standard roadway stripes. On the straight sections and the 1000 m radius curves, two control configurations were added, one with the standard motorway striping and one without any delineation. The mean observation times are presented in table 3. There were significant differences between the individual drivers and also between weather conditions. Drivers had a total observation time between 16 and 20 % during dry, clean weather and between 32 and 59 % during wet, gloved weather.
Table 3: Configuration clustering (Experiment BA) based on the driver's observation strategy. The differences between the cluster numbers are related to the total observation time ($p \leq 0.05$); Source: Blaauw, 1984

<table>
<thead>
<tr>
<th>Cluster number</th>
<th>Configuration</th>
<th>Observation time</th>
<th>Occlusion time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Total (%)</td>
<td>Mean (s)</td>
</tr>
<tr>
<td><strong>Straight sections</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>stripes</td>
<td>36.6</td>
<td>1.2</td>
</tr>
<tr>
<td>2</td>
<td>stripes</td>
<td>42.9</td>
<td>1.4</td>
</tr>
<tr>
<td>3/9</td>
<td>stripes</td>
<td>33.7</td>
<td>1.0</td>
</tr>
<tr>
<td>12</td>
<td>stripes</td>
<td>36.7</td>
<td>1.4</td>
</tr>
<tr>
<td>24</td>
<td>stripes</td>
<td>35.3</td>
<td>1.2</td>
</tr>
<tr>
<td>2</td>
<td>none</td>
<td>42.2</td>
<td>1.2</td>
</tr>
<tr>
<td><strong>Curves with 1000 m radius</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>3/9</td>
<td>36.5</td>
<td>1.0</td>
</tr>
<tr>
<td>2</td>
<td>stripes</td>
<td>42.8</td>
<td>1.2</td>
</tr>
<tr>
<td>12</td>
<td>stripes</td>
<td>43.3</td>
<td>1.2</td>
</tr>
<tr>
<td>24</td>
<td>stripes</td>
<td>44.5</td>
<td>1.2</td>
</tr>
<tr>
<td>36</td>
<td>stripes</td>
<td>45.2</td>
<td>1.1</td>
</tr>
<tr>
<td>3</td>
<td>none</td>
<td>53.6</td>
<td>1.6</td>
</tr>
<tr>
<td><strong>Curves with 200 m radius</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>3/9</td>
<td>50.7</td>
<td>1.3</td>
</tr>
<tr>
<td>2</td>
<td>24</td>
<td>46.3</td>
<td>1.2</td>
</tr>
<tr>
<td>3</td>
<td>36</td>
<td>65.3</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Control strategy and driving performance did not interact with the configuration.

Speed reductions and lane errors were not caused at straight sections, but did occur at the 24 and 36 configurations at the 200 m radius curve.

Value of the report

The main value of this report lies in its information on driver behaviour. This may be very useful in the test phase of this investigation.

Indications for the duration of a maximum interpretation time for pictogrammes on the flat panel display with regards to the task to hold course are given by the steering wheel reversal rate, the preview time and the occlusion time.

The effect of a deteriorated visibility caused by observing the speedometer, is an indication for the distraction of a driver by the
route guiding pictogrammes. The time used for observing the speedometer is an indication for the time that is necessary to interpret a pictogramme of the complexity of a speedometer. One critical remark has to be placed on the presented figures and tables: the occlusion times of figure 1 are considerably different from the values that are given in table 2 for the same situation.

Subjects
4.2 The distraction of drivers from their driving task by the presentation of visual route guiding information.
7.3 The interpretation time for each of the route guiding pictogrammes
Carter, R.C. Jr.
Visual search and color coding, pp 5
Pennsylvania State University
Pennsylvania, United States, 1979

Summary
Experiments have been carried out to investigate color coding for visual search tasks. The experiments dealt with the effects of the number of items of the target's color, the number of items not of the target's color, the similarity of the target color and other colors used on the display, the arrangement of the target-colored items, the target position, items near the target, differences among the test subjects and learning by the subjects during the search practice.

The procedure was the same for all experiments. Experimental displays were presented in a circular screen (subtending about 140 visual angle) set at eye level in a console. The subjects were to press a control button (hence producing the display and starting a timer), find the given first two digits of a target number and note its third digit, then immediately release pressure on the control button. The duration of the search was recorded as the search time. In total 14,000 searches were carried out.

The first experiment was carried out to show the effect of the number of items of the same color as the target (target class size). Displays were constructed with randomly dispensed three-digit numbers. The displays were coded with five colors. The target class sizes were 1, 10 and 30 for separate groups of 18 subjects. Another group of 18 subjects searched black and white displays (the target class size was 60 and 30 when the display density was 60 and 30 respectively). The mean search times turned out to be linearly related to the target class size. Search time was reduced by more than 90% when color coding with target class size was used on displays with density 60, compared with the time to search the same displays without color (table 4).
Table 4: Effects of target class size and display density; Source: Carter, 1979

<table>
<thead>
<tr>
<th>Display Density</th>
<th>Target Class Size</th>
<th>Black &amp; White</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>30</td>
<td>0.97(^a)</td>
<td>2.33</td>
</tr>
<tr>
<td>60</td>
<td>1.02</td>
<td>2.81</td>
</tr>
</tbody>
</table>

\(^a\) Mean search time in seconds, \(N = 648\)

In table 4 it can be read that search times are also related to the density, due to the number of background items (density minus target class size).

The second experiment was to examine the effects of the number of background items. The results and the target class sizes and number of background items are pictured in table 5.

Table 5: Effects of Background Items
Source: Carter, 1979

<table>
<thead>
<tr>
<th>Color Contrast</th>
<th>TCS = 1</th>
<th>TCS = 30</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOB = 0</td>
<td>0.53(^a)</td>
<td>4.45</td>
</tr>
<tr>
<td>NOB = 29</td>
<td>2.03</td>
<td>0.62</td>
</tr>
<tr>
<td>NOB = 59</td>
<td>2.82</td>
<td>0.52</td>
</tr>
</tbody>
</table>

\(^a\) Mean search time in seconds, \(N = 648\)

It turned out that the mean search times were completely unaffected by the number of background items when their color was of high contrast with the target color. However, background items produced a considerable effect when their color was similar to the color of the target.

The third experiment investigated the effects of color difference. Experiments were conducted in which the target class size was 1, the display density was 60 and the color difference between target and
background items was controlled. The search time increased progressively as the color difference became smaller.

In the fourth experiment some of the preceding experiments were reanalysed in order to determine whether the position of the target or the number of items adjoining the target affected search times. The findings imply that the target position and the presence of other items adjoining the target may affect search time through complex interaction with other display variables. However, no consistent effect was found on these items.

The position of the target colored items did affect search time. To investigate this, two arrangements have been made. One arrangement had a random dispersion of target items (30, density 60). The other arrangement had a pattern in which most target colored items were grouped. It turned out that, when the target was in the pattern, it was found in about the same amount of time as required to find a target on a random display. When the target was out of the pattern, it was found faster.

These results confirm earlier findings by Brown and Monks (1975) that search times are shorter on patterned displays than on random displays.

In the fifth experiment personnel characteristics were investigated. However, the findings pointed out that none of the variables studied were significantly related to search speed (table 6).

Table 6: Product-Moment Correlations between Search Time and Personnel Characteristics (N = 78)\(^a\); Source: Carter, 1979

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>0.14</td>
</tr>
<tr>
<td>Smoking</td>
<td>-0.05</td>
</tr>
<tr>
<td>Age</td>
<td>-0.11</td>
</tr>
<tr>
<td>Drug or Alcohol Use (in past 24 hrs)</td>
<td>-0.06</td>
</tr>
<tr>
<td>Foveal Acuity</td>
<td>-0.19</td>
</tr>
<tr>
<td>Parafoveal Acuity 1,7(^o)</td>
<td>-0.04</td>
</tr>
<tr>
<td>Parafoveal Acuity 2,4(^o)</td>
<td>0.04</td>
</tr>
<tr>
<td>Parafoveal Acuity 3,0(^o)</td>
<td>0.08</td>
</tr>
<tr>
<td>Parafoveal Acuity 4,0(^o)</td>
<td>0.21</td>
</tr>
<tr>
<td>Stereo Acuity</td>
<td>-0.09</td>
</tr>
<tr>
<td>Reading Speed</td>
<td>0.09</td>
</tr>
<tr>
<td>Color Vision</td>
<td>-0.16</td>
</tr>
</tbody>
</table>

\(^a\) Critical value of \(r(78), p < 0.05\) is 0.22
The effects of learning were investigated by having 108 subjects perform 72 repeated experiments. During these experiments no learning effect showed.

Value of the report
This report can be useful when designing pictograms for the flat panel display. It gives indications of the length of interpretation times and presents variables to which the interpretation time is strongly related.

The absence of a learning effect has not been sufficiently proven. It might well be that learning effects have been neutralized by fatigue-ness of the subjects.

Subjects
4.2 The distraction of drivers from their driving task by the presentation of visual route guiding information.
7.3 The interpretation time for each of the route guiding pictograms
Döring, B.
Analyse des Arbeitsprozesses bei der Fahrzeugführung am beispiel eines Landeanflugs
-eine systemergonomische Simulationsstudie, pp 265
Forschungsgesellschaft für angewandte Naturwissenschaften e.V.
Forschungsinstitut für Anthropotechnik
Wachtberg-Werthhoven, Federal Republic of Germany, 1983

Summary
The aim of the report was to develop a simulation model of normative operator behaviour, using the characteristics of man and machine and their relations and interactions.

The developments of modern vehicles today are directed towards a greater complexity and more automatically performed tasks. However, human beings can only operate a machine if man and machine are made suitable for each other. Therefore it is necessary to have sufficient knowledge of man-machine interaction.

A vehicle guiding task can be divided into three subtasks. At the highest level are the planning activities. The medium level consists of the steering tasks and at the lowest level the stabilizing task is needed.

In vehicles man operates as guiding personnel and forms together with technical equipment a man-machine system. This system and its elements are related to the outside world through the exchange of mass, energy and information.

In the report the attention is focussed on the work load of the operator. Special attention is paid to the dynamic aspect of adjusting machines to the psychophysical qualities of human beings. Dynamic aspects deal with changes in time of the machine or the operating person.

It is important that already in the design phase attention is paid to the ergonomics of a machine (conceptive ergonomics).

In general, meters can be read better if they are grouped according to their function. The grouping of levers or knobs can be done according to the sequence in which they have to be used. The meters and levers that are most important or have to be used most frequently, are to be situated closest to the operator.
The starting point of an ergonomic design should be the thorough analysis of the tasks of the operator, the processes in the machine and the relations between man and machine. A way to execute this analysis before the fabrication of the machine is to use a simulation model. This also has the advantage of being able to quantify the requirements for an ergonomic design and to measure the effects of a change in machine parameters on the performance of the operator.

The development of a man-machine system simulation model is described into full detail. Chosen is for a production system model, which combines the advantage of network models (many different work load tasks, their chronological sequence and their relations) with modular models (description of every single information structure).

Necessary for the modelling is a thorough analysis of the processes in the machine and the relations with the human operator.

Value of the report
The report deals with man-machine interactions. It's contribution to this literature study is very little as the description of the subjects are very general and abstract.

Subjects
4 Distraction by route guiding advices (general)
7 Untimely presentations of route guiding advices (general)
Summary
The aim of the paper was to present the conditions for a credible route guiding system. The attention was focused on an in-car dynamic system (that can present information on the actual traffic situation).

The most important feature of a successful route guidance system is credibility, i.e. driver faith in the system. A problem for the credibility are drivers who are familiar with the area, especially commuters. They may have to be convinced that a diversion is in their best interest (in case of congestions, road works and the like). In general, drivers will have positive attitudes about a system that provides them with relevant, reliable, accurate, up-to-date and timely information, displayed in a manner that is clear and can be read in ample time to make a decision.

At a given driving speed, factors that affect the reading time of displays include driver work load, message load, message length, message familiarity and display format. Displays must not present more information than drivers can read and comprehend during the available reading time. When too much information is displayed, drivers can become overwhelmed to the extent that they have difficulty in scanning and reading the message. Driver expectancy and familiarity with messages is a factor that influences the reading time also. Drivers who have seen a message often will more than likely tend to gloss over familiar elements of the message and concentrate on that part of the message that changes from one situation to another. Unfamiliar drivers on the other hand, who see the message for the first time, must read the entire message. Redundancy can be used in the form of repetition or coding. Color coding, for instance, would enhance recognition and shorten the reading time.

Messages should be carefully selected and very precise. The traffic state descriptor "congestion" e.g. is very vague and should not be used. Instead it is better to present the delay duration.

Routing and lane assignment must be given in ample time for drivers
to respond to instructions. Lane assignments must be made far in advance of the turning point and far enough upstream of any possible traffic queues. This means that under heavy traffic conditions, the lane assignment information must be given far away from the turning point as compared with light flow conditions.

Road surveillance must be an integral part of a dynamic route guidance system in order to be able to give reliable and accurate information and thus maintain driver credibility in specific route information that is displayed.

**Value of the paper**

The value of this paper lies in the remarks on the presentation of the visual messages. Although rather general, they may nevertheless be useful when designing pictograms for the flat panel display and testing the interpretation time.

**Subjects**

4.2 The distraction of drivers from their driving task by the presentation of visual route guiding information.

7.3 The interpretation time for each of the route guiding pictograms

7.4 The time that is needed to execute a necessary action (decelerating, changing lanes)
Dudek, C.L. & Huchingson, R.D.
Human factors design of dynamic visual and auditory displays for metropolitan traffic management - Volume I: Summary report, pp 109
Texas Transportation Institute
College Station, United States, 1980

Summary
The report summarizes the findings and design implications of a series of research studies with respect to parameters of dynamic visual and auditory displays.

Part I: Dynamic Visual Displays
The first investigation dealt with the recognition of often used abbreviations. It is recommended to use those abbreviations which were understood by 85 % of the subjects. Abbreviations not investigated in the study should be tested before using them on a changeable message sign.

In the second investigation different types of message format and sequencing were tested. Compared were the formats "vertical" (consecutive words appear directly beneath each other in column fashion), "compact" (the message is compact in a nearly square area with generally two words on a line), "chunk extended" (one complete thought (chunk) on a line, usually containing four words and two units of information) and "message extended" (the entire message is displayed on one line). The sequences that were investigated were word sequencing, which means that each word is displayed on a separate sequence of display, line sequencing and chunk sequencing.

The results pointed out that the recall rate of the messages was poorest in the format "message extended". The poorest sequencing rate was the "word sequence". No significant superiority was found among the other formats.

In a laboratory study the effects of message load and exposure rate were tested. All messages were presented in the chunk sequencing and the compact format. The exposure rate varied from 0,25-1,00 s per word.

It turned out that the best recalls were obtained with the longest exposure rate (1,0 s) and the lowest message loads. Messages of six units may be used, but no more than four units of information will likely be recalled.

Additional field tests showed a recall performance that was about 8-9 % poorer than the laboratory tests. Therefore laboratory data should
be adjusted with this amount.

Investigations have been carried out on the optimum font style for data matrix character recognition. As indication for the legibility has been chosen the mean angle under which a character is first recognised. An analysis has been undertaken for the legibility of both every letter and number and for whole series of characters. The analysis revealed significant differences for the four investigated font styles and characters, except for the B, C, D, F, H, J, L, N, S, T, W and X.

As a second measure of effectiveness for font style, the number of subjects was recorded that confused a character with another one. Out of the results an "optimum" font style was constructed, using distance legibility as most important factor and the percent confusion with other characters as next most important. The constructed optimum font style consisted of the characters of all four font styles.

A study was conducted on techniques to draw a reader's attention to one line of a three-line message. The used techniques were red letters, flashing the message at 0.2 s on and off and the use of thick-thin or double-stroke characters. The results are shown in figure 2. Color accentuation turned out to be most effective.

Since reading top to bottom is a well established habit, it seems preferable to limit the message length to one or two lines instead of accentuating a third line.
Figure 2: Percent of times Accentuated Line was Read First  
Source: Dudek & Huchingson, 1980

A study was conducted to determine whether a margin totally round a bulb matrix sign would increase legibility. Although the average legibility distance turned out to be an average 10% farther with the total margin in place, this difference was not significant due to subject variability.

Part II: Auditory Visual Displays
The second part of the report summarises the findings of a report from Dudek, Huchingson and Stockton that has already been studied for this literature study. Therefore, at this place, it is sufficient to refer to the description of that report.

Value of the report (Part I: Dynamic Visual Displays)  
The value of the report for this investigation is not very large, although it deals with visual displays, because most attention has been paid to legibility and recall rate rather than to interpretation
time.

Subjects (Part I: Dynamic Visual Displays)
7.3 The interpretation time for each of the route guiding pictogrammes
7.5 The chances that aural route guiding advices are forgotten
Summary

The objective of the study was to develop recommendations for the design of auditory displays (Highway Advisory Radio). The research was conducted in the following areas:

1. Language style
2. Information load
3. Redundancy
4. Description of alternate route
5. Order of components
6. Advance road sign for radio tuning

The aim of this part of the study was to evaluate the findings of previous projects. These findings are summarized below.

Findings of previous projects

Language style

The results of laboratory studies clearly showed that important information was retained better when messages were sent in staccato or short language style as compared with conversational style. Repetitions resulted in substantially better recall, but a second repetition had a varying effect on the degree of recall.

Information load

In an instrumental vehicle study, it was found that 79% of the drivers could negotiate an unfamiliar route with five turns, 65% a route with five turns and 50% a route with six turns. It was recommended that the more complex routes should be supplemented with trailblazers to insure a higher percentage of correct responses.

Internal versus external redundancy

Investigation was made whether repeating the entire message (external redundancy) was the better method of communicating a description of a diversion route, or whether it might be better to repeat key elements of the message (internal redundancy). It turned out that familiar
drivers could negotiate a diversion route given both types of redundancy equally well. Unfamiliar drivers could recall the diversion route better with a complete repetition of the message.

Description of alternate route
Subjects were required to describe a route to a person unfamiliar with the area. Out of the results guidelines were developed for constructing messages.

Order of components
It was decided that this topic did not need additional study.

Advance road sign for radio tuning
Research results indicate that the message "Radio traffic alert" elicits the greatest degree of urgency of drivers to respond in comparison with "Radio traffic advisory" or "Radio traffic information".

The study was carried out as in-situ studies and field studies. The in-situ studies involved the use of representative subjects driving a research vehicle. The field studies were to evaluate the variables in the "real-world". Critical measures of performance included diversion routes, driver uncertainty and percent of diverted traffic successfully negotiating the alternative route.

In-situ studies

Language style
Fifty-four subjects were required to drive along three test routes they were unfamiliar with. Every one received a language style (staccato, short form or conversational).

The results are gathered in figure 3. It can be noted that on the 10-unit diversion route the percentage of errors is significantly lower for the short form language style as compared with the staccato and the conversational style. The implications are that errors committed on the 6-8-unit diversion routes were random and that the large percentage of errors on the 10-unit route was largely attributed to the language style.
Information load
The objective of the in-situ study, which was conducted simultaneously with the previous one, was to determine the percentage of unfamiliar drivers who can successfully negotiate a diversion route and to determine the location and types of errors unfamiliar drivers are most likely to make.

The results indicate that almost 90% of unfamiliar drivers were able to follow 6- and 8-unit diversion routes. However, many have difficulty with a 10-unit diversion route (30% failed to complete the diversion). The most driving errors appear at the intersections of diversion route legs.

Internal versus external redundancy
The objective of this study was to determine the success of unfamiliar drivers in negotiating a diversion route after a message in short form language type with internal or external redundancy.

The results show that a slightly smaller percentage of subjects who heard the internal redundant messages committed errors on the 6- and 8-unit routes in comparison with those who responded to external redundant messages. On the 10-unit diversion route the redundancy type had no influence on the percentage of errors. As a whole however, the external redundant messages were easier to recall by the

Figure 3: Subject Errors by Language Style - Street Name Artifact Removed from 6-Unit Route;
Source: Dudek, Huchingson & Stockton, 1981
drivers than the internal redundant ones.

Route description
It was investigated whether the use of route descriptors (landmarks, traffic signals, etc) reduces the driver's uncertainty and errors. The results showed that on the 10-unit route, although the performance with the route descriptor message was significantly better than the staccato and the conversational without route descriptors, it did not improve performance over the short form. Subjects revealed that they had an easier time locating critical intersections with the route descriptor messages than with the basic short form messages.

Advance road signs
Subjects did not have a strong preference for any of the message elements they could choose.

Field study
A field study was held in a city in Texas during a festival with many expected congestions. The findings from this study are presented below.

1. Data from the study show no clear differences in the effectiveness of the three types of messages studied. However, the diversion route was a relatively simple one which may have accounted for the lack of difference.

2. The less familiar drivers were more likely to divert than more familiar drivers. No relationship was seen between driver familiarity and willingness to tune to the Highway Advisory Radio Station.

3. Only 58% of the interviewed festival-bound drivers who drove through the Highway Advisory Radio zone while a message was actually broadcast saw the advance sign. Thus a large percentage of (42%) of the potential audience was not aware of the Highway Advisory Radio.

4. Only 56% of the interviewed festival-bound drivers who saw the advance sign tuned to the Highway Advisory Radio station, and only 33% of all the festival-bound respondents tuned to the station.

5. A comparison of Highway Advisory Radio tuning to diversion
revealed that 67% of the interviewed drivers who tuned to the station diverted. The most frequently requested information that would encourage the others to divert also were event-related, such as assurance of parking space.

6. There was a sense of apathy on the part of the drivers who did not turn to the station.

7. The majority of the responding drivers (99%) and non-diverting drivers (92%) had no difficulty in remembering the message they heard. No difference in diversion rate due to the message form could be determined.

Value of the report
This report is concerned with transmitting a diversion route message through a car radio. Therefore, it deals with a number of aspects that are of no importance to Carin. However, the topics "Language style", "Information load", and "Redundancy" give an impression of the way in which the Carin messages should be presented and the chances that the messages will be forgotten. It must be taken into account that all test subjects were "representative" (although no definition of representativeness has been given). For traffic safety however, the reactions of non-representative subjects are more interesting.

Subjects
7.5 The chances that aural route guiding advices are forgotten
Easterby, R.S. & Cox, D.E.H. & Hughes, A.W.
The perception of variable message symbolic road signs: reaction time studies, pp 49
University of Aston in Birmingham, Applied Psychology Department
Birmingham, England, 1977

Summary
A series of laboratory studies have been carried out to examine different ways of using response time to evaluate the perceptibility of symbolic road signs generated by a discrete 30x30 lamp matrix.

To successfully determine the effects on a driver of a sign display recognition task in a laboratory study, it is necessary that the driving task is simulated through a secondary task that meets a basic requirement of compatibility with the driving task. Thus, the following features were incorporated in the task:

1. Continuous compensatory tracking: "speedometer display" operated by a right foot pedal to follow quasi random disturbances in the indicated speed.

2. Peripheral attention task: when the pointer of either of two meters viewed in either a left or a right hand rear view mirror is deflected, the subject corrects this by a hand switch. The left hand is used to cancel the left hand meter, the right hand to cancel the right hand meter.

3. Presentation of symbols (at approximately 1/4 of the full size): on a matrix presentation of a symbol, the subject was required to name the function associated with the symbol and, as soon as the subject had named the function, he had to give his tracking performance a new speed.

For the first laboratory study 10 test subjects were chosen, who each attended a three hour session. During the experimental sessions, various indices of the subjects' performance were recorded:

1. Verbal response time to naming the symbol
2. Behavioural response time to achieve a new criterion speed on the presentation of a warning sign
3. Dial cancellation latency: the time necessary to cancel the dial after a dial deflection

The results of the first study are shown in figure 4. The response times are not significantly different from one another.
As it turned out to be difficult to obtain discriminable differences between the symbols, a simplified task of naming the symbols was used in a second laboratory study.

In the second study four groups of 10 subjects were used to identify the symbols in two forms: with and without an enclosing red triangle. The subjects were shown the symbols and learnt their meaning, which was tested by measuring the ability to name the symbols correctly three times in succession.

In this second study the reaction time was calculated by subtracting from each individual's response time the base response time. The base response time was measured by the simple disjunctive response to a non-meaningful light display.
### GROUP 01A: WITH TRIANGLES

<table>
<thead>
<tr>
<th></th>
<th>WIND</th>
<th>2 WAY TRAFFIC</th>
<th>ACCIDENT (2)</th>
<th>REDUCED VISIBILITY</th>
<th>QUEUE</th>
<th>FLOOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perception time (sec)</td>
<td>0.245</td>
<td>0.246</td>
<td>0.278</td>
<td>0.328</td>
<td>0.336</td>
<td>0.384</td>
</tr>
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<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>

20 replications, 10 subjects
Results significant $P < .01$

**TUKEY TEST:**
Wind / 2 Way / Accident Better than Flood
Wind / 2 Way Better than Queue
2 Way Better than Reduced Visibility

**FIG. 5(a)** Verbal response task: Perceptual response times for symbol group 01A (with triangles).

### GROUP 01W: NO TRIANGLES

<table>
<thead>
<tr>
<th></th>
<th>ANIMALS</th>
<th>2 WAY TRAFFIC</th>
<th>ACCIDENT (2)</th>
<th>REDUCED VISIBILITY</th>
<th>SLIPPERY ROAD</th>
<th>FLOOD</th>
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</thead>
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<tr>
<td>Perception time (sec)</td>
<td>0.250</td>
<td>0.273</td>
<td>0.306</td>
<td>0.336</td>
<td>0.387</td>
<td>0.442</td>
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<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>

20 replications, 10 subjects
Results significant $P < .01$

**TUKEY TEST:**
Animals / Accident / 2 Way Better than Flood
Animals / 2 Way Better than Slippery Road

**FIG. 5(a)** Verbal response task: Perceptual response times for symbol group 01W (no triangles).

### GROUP 02A: WITH TRIANGLES

<table>
<thead>
<tr>
<th></th>
<th>ANIMALS</th>
<th>ACCIDENT (1)</th>
<th>SLIPPERY ROAD</th>
<th>ROADWORKS</th>
<th>SHED LOAD</th>
<th>BREAKDOWN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perception time (sec)</td>
<td>0.305</td>
<td>0.309</td>
<td>0.345</td>
<td>0.435</td>
<td>0.482</td>
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<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>

20 replications, 10 subjects
Results significant $P < .01$

**TUKEY TEST:**
Animals / Accident / Slippery Road / Roadworks Better than Breakdown
Animals / Accident / Slippery Road Better than Shed Load
Animals / Accident / Slippery Road Better than Roadworks

**FIG. 5(b)** Verbal response task: Perceptual response times for symbol group 02A (with triangles).

### GROUP 02W: NO TRIANGLES

<table>
<thead>
<tr>
<th></th>
<th>ACCIDENT (1)</th>
<th>WIND</th>
<th>QUEUE</th>
<th>ROADWORKS</th>
<th>SHED LOAD</th>
<th>BREAKDOWN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perception time (sec)</td>
<td>0.212</td>
<td>0.222</td>
<td>0.253</td>
<td>0.310</td>
<td>0.375</td>
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<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>

20 replications, 10 subjects
Results significant $P < .01$

**TUKEY TEST:**
Accident / Wind / Queue Better than Breakdown
Accident / Wind / Queue Better than Shed Load
Accident Better than Roadworks

**FIG. 5(b)** Verbal response task: Perceptual response times for symbol group 02W (no triangles).
An analysis of the data revealed significant differences between the symbols in each of the groups. The results are displayed in the figures 5 and 6.

Questions can be asked to the validity of the simple verbal response task as a measure for perception time. A confounding factor is the way in which subjects choose to output the verbal response when engaged in other simultaneous tasks.

To overcome the problem mentioned above, a third laboratory study was set up, in which subjects had to recognise symbols and then push a button that was labelled with the same symbol. For this task a six choice push button board was provided.

For this study only the symbol versions with an enclosing triangle were used. Eight subjects performed two runs using each of the symbol groups. Each run consisted of 20 presentations of each of the six symbols.

![Symbol diagram]

Figure 7: Discrimination choice response task: mean differential response latency for all twelve symbols; Source: Easterby, Cox, & Hughes

The reaction time was calculated as the response time for a symbol subtracted with the base response time of a subject for that push button position. The base response time of a subject was measured by
testing the reaction time on a numeral symbol (1, ..., 6) and numerically labelled push buttons. The results are shown in figure 7.

Overlooking the three laboratory studies, it can be noted that the results differ greatly from each other. It can be put forward that the response time differences obtained are probably not attributable to any perceptual features of the symbols, but depend rather more on aspects of the response modality used in each of the studies. It is therefore concluded that reaction times are only marginally useful as an index for discriminating between symbols in terms of their relevant perceptual features. The methodological difficulties of the present study lie in the separation of the time to perceive the symbol and the time to formulate the appropriate experimental task response.

In the verbal task, confounding features are the length of a word, its familiarity and its format. The effects that these have are unknown and uncontrolled.

In the choice response study, the location of the response key and the response processes involved in selecting that key confound the perceptual response times.

Value of the report

The main conclusion that can be drawn from this report is that it is very difficult to formulate an appropriate experimental task that gives an index for the interpretation time for pictograms on a screen. The experimental tasks that have been used in this report certainly are not appropriate.

In the verbal task, confounding features are the length of a word, its familiarity and its format. In the choice response study, the location of the response key and the response processes involved in selecting that key confound the perceptual response times. Furthermore, it is questionable if a verbal response or a choice response is representative for whatever action a driver has to execute after seeing a symbol sign.

It is a pity that no attention has been paid to the influence of the presentation of the matrix symbols on the behavioural response time to achieve a new criterion speed and on the dial cancellation latency.

Subjects

7.3 The interpretation time for each of the route guiding pictograms
Erke, H. & Richter, B. & Richter, S.
Psychologische Untersuchungen zu Unfällen auf innerörtlichen Strassen im Zusammenhang mit Merkmalen der Vorwegweisung.
Köln, Federal Republic of Germany, 1974

Summary
Aim of the investigations carried out by the authors, was to determine the effects of sign posts on accidents. In a before and after study, no effects on accidents could be determined of a change in direction signs.
This both concerned the total number of accidents in the two years before and after the changing of the sign posts, as sign post related accidents such as changing lanes just before the junction or changing lanes without taking any notice of the other traffic.¹)

In a laboratory the legibility and interpretation of the new direction signs were tested. The correct interpretation was checked through the destination points and directions, and the lay-out of the junctions.²)
Six direction signs in the style of figure 8 were presented in two ways: tachistoscopically and through a film, both with and without a small additional task and a more complicated additional task.

![Figure 8: Tested direction sign style; Source: Erke, Richter & Richter, 1974](image)

The results showed that the interpretation times for the direction signs varied from 3-5 s, which is much too high in heavy traffic. The representation of the lanes is difficult to understand for the

¹) and ²) see "value of the article"
drivers.

In the second part of the investigation, the effects on the interpretation time of the following variables were tested: separation of color coded names, horizontal or vertical separation, representation style (quasi-geografic or stylised), arrow length, and arrow configuration.

The above variables were tested in a laboratory by presenting test subjects dia's of 21 different direction signs. By having subjects activate the direction indicator, both the interpretation and the reaction time could be checked.

It turned out that stylised direction signs needed a shorter interpretation time than quasi-geografic ones, that separation of color coded names from the remaining names only leads to shorter interpretation times with pre-informed test subjects, and that vertical separation is better than horizontal separation. Both the direction signs of figure 9 turned out to be favourable.

Figure 9: Favourable direction signs;
Source: Erke, Richter & Richter, 1974

Figure 10: Less favourable configuration of direction signs
Source: Erke, Richter & Richter, 1974
The direction sign of figure 10 turned out to be less favourable for a quick interpretation. Besides, this configuration turned out to provoke interpretation failures.

In general it was found that an explanation on the configuration style improves the interpretation of the test subjects and enables a better differentiation of the configuration styles.

Value of the article
The tests on the interpretation of the different configurations of the direction signs could be useful for the styling method of pictogrammes on the display.

The first part of the investigation seems to have been conducted rather carelessly:

1. Before and after studies seldom have been successful in pointing out the effects of traffic safety measures on a particular spot. Herefore are three reasons. First, the number of accidents on a particular junction is too small to draw conclusions. Second, accidents are not due to one cause but to a critical combination of a number of circumstances. Third, changes in accident patterns may well be caused by changes in one or more of the characteristics of drivers, road, and traffic.

2. Having test subjects describe the lay-out of a junction does not seem to be representative: drivers only have to know the direction and the lane they have to follow.

Subjects
4.2 The distraction of drivers from their driving task by the presentation of visual route guiding information.

7.3 The interpretation time for each of the route guiding pictogrammes
Summary
The report presents the findings of a demonstration project that consisted of an electronic control system for a motorway network, installed between Delft and Rotterdam in the Netherlands. The system, of which the components are shown in figure 11 below, allows rerouting, lane closure, incident detection, speed regulation, variable message signs showing pictogrammes, weather detection, radio rebroadcasting in tunnels, and tv-surveillance.

Figure 11: Overview of the system components

The effects of the motorway control system are summarized below. The system is effective both technically and in the eyes of the road users, road managers and the police. The system is currently being used mainly for traffic control at accidents, congestion, and road works. The system reduces the number of accidents substantially, especially
secondary accidents.
The influence of the system on traffic flow and capacity is relatively slight.
The improvement in the stability of the traffic flow in high density situations was considerable.
The response of drivers to the recommended speeds was rather poor.

The demonstration showed that a comprehensive system of electronic traffic aids can be integrated into a successful traffic management system.

Value of the report
The relation of the discussed demonstration project with this literature study is poor and the fields that are related with this study not worked out. Therefore the report is of no use to this literature study.
The claimed fall in number of accidents is not confirmed by sufficient figures or calculation methods. Neither is the causal relation to the control system proven.

Subjects
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Galer, M. & Baines, A. & Simmonds, G.
Ergonomics aspects of electronic dashboard instrumentation
University of Technology, Loughborough, Institute of Consumer Ergonomics
Ford Motor Company Ltd, Research and Engineering Centre
Loughborough/Basildon, England 1980
in: Oborne, D.J. & Levis, J.A.
Human factors in transport research - volume 1 (301-309)

Summary
The paper describes three prototype liquid crystal dashboard designs
(a dial, a curvilinear, and a digital design) that are being
evaluated by the Ford Motor Company.
The three displays and a normal electro-mechanical display, serving
as a reference, are pictured in respectively figure 12 and 13.

Figure 12: Three prototype liquid crystal dashboard designs;
Source: Galer, Baines & Simmonds, 1980
Three studies were carried out, of which the first assessed the ease and accuracy of reading of photographic representations of the displays presented tachistoscopically. The second study assessed these factors and drivers' preferences using dynamic models of the displays in a driving simulator. Study 3 had not been finished already and is described only briefly. It deals with prototype liquid crystal displays in road trials.

In the first study 75 test subjects were presented the four displays at a viewing time of 450 ms. It turned out that the electronic digital display was read most correctly (98%) and the electro-mechanical the least. The electronic digital display also produced least errors when deciding whether a speed was within a speed limit (98% correct). However the differences with the other configurations were small (varying from 92-98%). Preferences of the subjects showed that the electronic digital display was considered easiest to read by 70%. For the decision on whether the speed was within a certain limit, 47% considered the digital display the easiest.

In the second study the displays were tested while subjects carried out many of the tasks necessary for driving. Some visual and auditory cues were available to the subjects, although the simulation still did not replicate the complexity of a driving task. In the simulator models were installed of the displays. Again, the results showed that the digital displays scored best on accuracy of readings and preference of drivers, albeit with slightly different percentages.

Comparing study 1 and 2, it can be noted that the digital display performed better in both experiments, but the electro-mechanical display improved in performance under the dynamic test conditions of the second study.
The electronic digital display performed less well on the important factor of being distracting. Generally, the electro-mechanical display, the electronic dial display and the curvilinear display tended to group together and the electronic digital display stood apart and usually superior.

Value of the paper
This paper could be useful when determining the styling method of route guiding pictograms, although some aspects have been neglected.

First, it is questionable whether reading accuracy is the most important feature of a display. For most situations it is sufficient to know the speed approximately, for which a conventional display is more suited than an electronic digital one: Through experience a driver can estimate the speed by the direction the hand of his conventional speedometer is pointing at. With a digital display this learning effect will not be possible: every speed has to be read from the display.

Second, the distraction that is caused by the display, is only mentioned briefly.

No information is given on the time subjects had in the second test to read the displays.

Subjects
4.2 The distraction of drivers from their driving task by the presentation of visual route guiding information.

7.3 The interpretation time for each of the route guiding pictograms
Summary
The report deals with four studies on auditory messages. In the first study the retention of navigational messages was examined. Study two was designed to determine the efficiency of auditory messages. In study three the efficiency of general information types were examined. Study four examined the necessary distance between a visual alerting sign for passing motorists and the area of the broadcast.

Experiment 1
Message retention was studied on a group of 30 young people of a moderate educational level and 9 older ones of a high educational level. Recorded auditory messages containing one to six units of information were presented randomly to the subjects while they were driving. Immediately after the presentation of the auditory messages the subjects were requested to read aloud the message that was held on a printed card on the dashboard of the car. The road information on this card was different from the auditory message (route guidance).

The results pointed out that the times between message presentation and message retention (5, 10 and 15 s) were of no influence.

The figures 14 and 15 present retention rates, both for messages that were presented only once and for messages that were repeated.
Figure 14: Percent of subjects making a route error as a function of message length and number of repetitions; Source: Gatling, 1975

Figure 15: Percent of message retention as a function of message length and number of repetitions; Source: Gatling, 1975

It is important to note that (figure 14), with a single message presentation, over 50% of the subjects missed at least one part of a
message that contained only three units of information.
The group of older people did not score significantly worse than the young ones on the criterion "percentage who missed any part of the one to six units of information of the messages" but did score less on the criterion "total amount of units recalled" (see figure 16)

![Figure 16: Percent of subjects making a route error as a function of message length and number of repetitions - Older vs. Young, Single presentations; Source: Gatling, 1975](image)

From the results of this experiment and from previous literature, it is likely that older drivers will demonstrate significantly less retention of auditory messages than younger drivers.

**Experiment 2**

In the second experiment auditory messages were broadcast through car radio. The retention of the messages was tested through slides that were projected in front of the subjects. Some of the slides contained a unit of information that was mentioned in the auditory message and the others did not. The subjects were to state of each slide whether it contained some of the aural information. Throughout the experiments the subjects drove on the right lane of a highway.
The number of subjects was 36. The number of units of information that were presented aurally varied from two to nine. In half of the cases the messages were abbreviatedly repeated once in short style language.
Figure 17: Percent of subjects making a route error as a function of message length and number of repetitions; Source: Gatling, 1975

Figure 18: Percent of message retention as a function of message length and number of repetitions; Source: Gatling, 1975

The results of the experiments are displayed in the figures 17 and
18. In comparison with the figures 14 and 15, it can be seen that the retention was better in experiment 2 than in experiment 1. The author ascribes this to the retention method (recognition against unaided recall).

Experiment 3

In the third experiment 36 test subjects were presented a long auditory message (10 units of information) with information on food or fuel. The message on food contained five route and exit numbers and the message on fuel only one.

The results showed that the information with few numbers was retained far better than the information with many numbers. On average 7.2 units of information were retained from the fuel message against 4.1 from the food message.

Experiment 4

Aim of the fourth experiment was to determine the location of visual alerting signs for auditory messages. Herefore reaction times of subjects to alerting signs were measured and the time necessary to tune in to a specific radio station.

The results showed for three different alerting signs mean reaction values of 5.76, 5.76 and 5.58 s. The mean time required to tune in to the correct radio station, varied from 9.4 to 36.6 s depending on the frequency band width and the radio being on or off when the sign was read.

Value of the report

The report deals with message retention, which is, although essential for the use of the Carin system by future drivers, only marginally important to this literature study on traffic safety aspects. The found high values for the reaction times on alerting signs are noteworthy.

Subjects

7.2 The reaction time on aural and visual route guiding messages
7.5 The chances that aural route guiding advices are forgotten
Gatling, F.P.
Highway advisory radio in construction areas, pp 18
Federal Highway Administration
Washington D.C., United States, 1977

Summary
The aim of the report was to investigate whether subjects preferred route guidance advice in a short, general format (45") or in a long, detailed format (1'45").

Tests were executed in an automobile simulator, in which subjects faced a picture screen. On the screen a trip on a motorway was projected with several construction works. Before every construction work a long or short route detour advice was given, the end of which was respectively 15, 30 and 45 s before the detour started. The subjects (54) were divided into three groups which received either an early, an intermediate or a late route advice. All subjects were presented both the long and the short route guidance advice. The results were gathered by interviewing the subjects and having them fill out a questionnaire.

The results pointed out that 81% of the subjects preferred the short term messages, because of its lack of unnecessary details, that soon were forgotten anyway. No effect could be determined from the time of ending of the messages (15, 30 and 45 s before the detour started). The personal variables age, sex, education and driving experience turned out to have no relationship with the questionnaire data.

Value of the report
The report is useful in pointing out that the chances of forgetting route guidance advice are more related to the length of the advice (the number of information units) than to the time between the end of the route advice and the begin of the detour. The preference for short messages should be seen relatively: the length of the short term messages still is 45 s.

Subjects
7.5 The chances that aural route guiding advice is forgotten
Summary
Aim of the research was to find relations between accidents and road and traffic characteristics. This part of the report was concerned with "raaien", road stretches of about 200 m. The research was carried out on all roads outside residential areas in the county of Noord-Brabant in the Netherlands.

Special attention was given to accidents that previously had turned out to occur relative more frequently in Noord-Brabant than in other parts of the Netherlands:

- head-tail accidents and head-side accidents
- accidents at night, at dusk, or at dawn
- accidents on junctions
- accidents with only one vehicle involved

On the basis of a theoretical analysis on the above accident types, the following characteristics have been taken into account.

Road characteristics:
- road type
- dimensions
- presence of service roads/bycycle paths
- sight distance
- curve radius
- type of pavement
- public lighting
- mandatory or prohibitory signs
- discontinuities

Traffic characteristics:
- daily traffic flows of motor vehicles and mopeds/cycles
- percentage trucks and mopeds
- hourly traffic flows of motor vehicles and mopeds/cycles

Accidents:
- number of accidents with casualties
- number of accidents with casualties per accident type
- number of accidents with casualties on the service road/bycycle path
The relations between accidents and the above characteristics have been analysed with techniques specially suited for qualitative data. The characteristics have been analysed for each road type separately. The road types that have been analysed are the following:

- single-carriageway roads accessible for all traffic
- single-carriageway roads not accessible for slow traffic, cyclists, and moped riders
- single-carriageway "autowegen"
- dual-carriageway roads not accessible for slow traffic
- dual-carriageway "autowegen"
- motorways

The results of the analyses are discussed in the following for each road type separately.

**Single-carriageway roads for all traffic**
On single-carriageway roads for all traffic, accidents mainly happen on roads with high traffic flows. They especially happen at small curve radii, lesser sight distances, and many smaller junctions. Head-tail accidents and head-side accidents frequently occur on roads with heavy traffic flows and good sight distances. Head-side accidents are strongly related to light traffic flows on crossing roads.
Head-on collisions take place especially on roads with small traffic flows and bad sight distances. Often there is no public lighting, a brick pavement, and a low speed limit.
Accidents at night, dusk, or dawn happen on roads without public lighting, with a small width, and with many trees.

Accidents between cars and cyclists or moped riders take place especially at smaller junctions that are hardly visible.

**Single-carriageway roads not accessible for slow traffic, cyclists, and moped riders**
The accidents happen mainly on the roads with heavier traffic flows, with a small width, and with many small junctions.
The accidents are hardly related to the other road characteristics. In general, on roads with many accidents also many head-tail, head-side and head-on accidents happen.
Accidents at night, dusk, and dawn take place mainly at roads without public lighting.

**Single-carriageway "autowegen"**
As a result of the few single-carriageway "autowegen", the results were not always very clear.
The accidents mainly happened at locations that were less good than the other parts of the same road: in curves, at overtaking prohibitions, at speed limits, and at small sight distances. Head-side accidents may happen at small sight distances on smaller junctions. Accidents at night, dusk, and dawn do not happen especially at locations without public lighting, but do happen at heavy traffic flows during dawn or dusk.

Dual-carriageway roads
In general, accidents on dual-carriageway roads are not concentrated on a few locations, but rather spread out. They mainly happen at locations where a change in the homogeneous road characteristics take place: at bad sight distances, at overtaking prohibitions and in curves.
Safe curve radii on motorways have lengths of 1500-3000 m. On "autowegen" the safe lengths are greater than 1000 m.
The absence of crash barriers in the central reservation is related to fatal accidents, especially at locations with good sight distances but the absence of public lighting. Head-side accidents mainly occur at smaller junctions. Head-tail accidents are mainly related to congestions.

Measurements to improve traffic safety need not necessarily be pointed at the elimination of the found accident-related characteristics. If a small curve radius e.g. turns out to be accident-related, it is possible to maintain the curve radius but increase the road width in the bend, improve the skidding resistance of the road surface, improve the road marks, etc.

Value of the report
The found relations between road and traffic characteristics and accidents hardly contribute to an insight in traffic (un)safety. For human behaviour is not induced by physical characteristics but by functional ones. A road width of 6 m e.g. (physical characteristic) does not give information on the manoeuvre space (functional characteristic). With the absence of other traffic the manoeuvre space will be highly sufficient. However, in case of an oncoming wide truck and the presence of cyclists, the manoeuvre space may well be insufficient.
Besides, the analyses do not account for interactions between road characteristics and traffic safety. E.g. bycycle paths may well have been constructed along roads where previously many accidents with cyclists happened; public lighting will have been erected at places where previously many accidents used to happen during nighttime; etc.
Nevertheless do the analyses find a correlation between the
presence of bicycle paths or public lighting and high accident rates.

In spite of this, the report is helpful in pointing out road characteristics that under circumstances are accompanied by increased traffic risks.

Whether a major part of the presented data will be able to be used remains questionable, as on the digital map on compact disc only a limited amount of road information will or even can be stored.

Subjects
11.1 The possibility to use traffic safety criteria
11.3 The unsafety of certain roads, locations, manoeuvres, and situations
11.4 The dangerous road situations a driver should be warned off
Summary

Three experiments have been carried out to examine whether a driver's performance will be adversely affected by presenting him with road information aurally rather than visually.

The experiments were carried out by having subjects monitor roundabout information while at the same time they had to steer a model aircraft over a moving paper track and press a foot pedal to indicate that they had detected a $\frac{1}{2}$ s flash of one of the six lights set at 20°, 50° and 80° on either side of the line of sight. The roundabout information was presented either visually or aurally. The visually presented roundabouts appeared as projected transparencies of the white typescript on a black background, in a window 10.2 cm above the moving track. After a warning tone the roundabouts were presented for 5 s. Between roundabouts the window was dark. The time interval between roundabouts varied from 8 to 15 s.

Figure 19: Testing apparatus as seen by experimental subjects;
Source: Holloway & Wright, 1980
The auditory messages were presented through a loudspeaker placed directly above the tracking display. The standard format was to say first the place-name and then the exit name; e.g. Barnstaple, exit 2, etc.

The testing apparatus is shown in figure 19.

Experiment 1
The aim of the first experiment was to compare the effects on peripheral vision of having subjects monitor roundabout information presented either visually or auditorily, while at the same time doing a simulated driving task.

Subjects were asked to "drive" along a route to a known destination. Thirty six different routes and destinations have been used. Every route involved nine roundabouts, which had either 2, 3 or 5 exits, in equal proportions and the position of the critical exit varied randomly.

The results pointed out that errors in giving the correct exit were neglectable but tracking errors were high. However, no differences were found in tracking during visual and auditory presentation. The performance on peripheral light detections did yield differences as a result of the presentation condition. All subjects showed a marked decrement in detection of peripheral lights while the visual message was on. No such decrement occurred for auditory route information, although three of the eight subjects made fewer detections while listening to the auditory messages. Five subjects made more peripheral light detections as compared with the control period between messages.

The reaction time for the peripheral light detection turned out to be greater when the subjects were simultaneously attending to a visual message. When attending to an auditory message, four subjects had a greater reaction time, three subjects had a smaller reaction time and one subject was unaffected by the message.

Concluding it can be said that the performance on peripheral lights leaves no doubt that route messages are more easily processed if presented aurally than visually. However, it must be kept in mind that the absence of performance decrement on peripheral light detection and the presence of high tracking errors accompanying the auditory messages, may partly be a function of the sensitivity of the experiment: the track speed proved to be so fast that subjects may well have decided to adopt a relatively lax criterion for safe tracking and in consequence may have paid less attention to "driving" than they would have otherwise.
Experiment 2

The main aim of the second experiment was to determine whether auditory messages have any effect on driving performance. Besides this, the effect of the duration of messages were also tested.

In this experiment the peripheral lights were disconnected. Twelve subjects drove along 16 routes used in experiment 1, with their right foot operating an accelerator pedal which controlled the track speed. They were instructed to stay on track all the time, slowing down whenever this was necessary. An audible high tone sounded whenever subjects were off-track. The amount of anticipation was altered from 12.7 mm to 21.2 cm.

Within each block of four routes, two had visual messages and two had auditory ones; of the visual messages one was visible for 3 s and the other one for 10 s; the two auditory messages were preceded by a warning tone of either 3 or 7 s before the start of the message.

The visual messages turned out to have a marked effect on speed: subjects slowed down while looking at roundabout signs. There were no statistically significant differences between the short (3 s) and the long (10 s) visual presentation, but subjects maintained a higher speed when they could see the track ahead and anticipate their manoeuvres, than when no such pre-planning was possible (figure 20). The auditory messages resulted in a much smaller drop in speed than the visual ones (figure 21) although the tendency to slow down was statistically significant.

The use of long and short forewarning periods did not significantly affect performance. Subjects maintained a faster overall speed when they could plan ahead.

The tracking accuracy was heavily affected by the presentation of the visual messages. It was clear that with visually presented information the amount of slowing down did not compensate for the added processing load and consequently tracking errors increased. This was not so for auditory information where the initial deceleration was accompanied by a drop in tracking errors, which then rose only to their pre-message performance level during the auditory message itself.

The results suggest that subjects are waiting for easier stretches of track when this was feasible: when the visual message could be seen for 3 s, the mean response latency was 1.1 s, where it was 1.5 s when the message could be seen for 10 s.
Figure 20: Tracking speed while attending to visual messages; 
Source: Holloway & Wright, 1980

Figure 21: Tracking speed while attending to aural messages 
Source: Holloway & Wright, 1980
Summarizing experiment 2, it can be concluded that it only partially confirms the findings of experiment 1. Again it is found that visual route information produces a larger performance decrement than auditory messages, and this decrement involves both speed and tracking errors. But there was also a small but nevertheless detectable change in the speed of tracking, associated with auditory route information. The effects of early and late warning tones before auditory messages were negligible. The duration of the visual information affected response latency, but not tracking behaviour.

Experiment 3
The aim of experiment three was to examine the effect on both tracking skill and peripheral vision of increasing the difficulty of identifying the auditory messages.

The experiment was carried out by varying the way in which the target was specified. Eighteen subjects were to identify target words in a list of ten words.
Three levels of identification were chosen for the target identification task. These were: target specified exactly, target specified by category membership and target identified by number of letters.

The results showed a drop in peripheral light detection when the target was specified by number of letters; fewer lights were detected than when there was no target at all. When the target was given in terms of category membership, only the detection of the middle lights (at 50° on the line of sight) was statistically significant lower. When the target was a specified word, the detection rate for all lights was indistinguishable from performance when no target message was being presented. A very similar result was obtained for reaction latency.

Summarizing experiment 3, it can be concluded that the results are consistent with the previous findings that auditory tasks which require only item recognition have no effect on peripheral vision although they do result in a slight decrement in tracking skills. The results also serve to emphasize that it is not simple the occurrence of the auditory message which affects performance; a more critical factor is what the listener does to the message, i.e the amount of cognitive processing involved.

One final limitation to the conclusions to be drawn from the three experiments is, that subjects tend to accept the priorities assigned
by the experimentor (accuracy of tracking had strong priority). It remains an open question as to whether drivers on the road would have similar priorities.

Conclusions
1. Visual route information is likely to be more detrimental to peripheral vision than the same information presented aurally.
2. Even simple auditory messages, involving only the recognition of a specified word, may cause drivers to slow down or suffer some loss in tracking accuracy. The corresponding visual information causes both a decrease in speed and an increase in tracking errors.
3. As the complexity of the auditory messages increases, so both peripheral vision and tracking accuracy deteriorate. Clearly auditory information transmitted to drivers should be designed to require very little thought or interpretation by the driver before it can be understood and acted upon.

Value of the report
This report is very useful for this literature study as it deals with the distraction of a driver by auditory and visual messages. However, it should be kept in mind that the driving task was simulated by steering a model aircraft over a moving track and detecting a peripheral light. When actually driving, the consequences of tracking errors, decrement of peripheral vision and not receiving the (correct) route information may be judged otherwise and as a consequence, the driver's attention may be divided differently. Furthermore, it remains questionable whether the detection of a \( \frac{1}{2} \) s flash is representative for the task to watch the traffic and the traffic environment. In the first experiment the speed was imposed on the driver, which is not realistic. Under more difficult circumstances drivers will compensate for the heavier workload by slowing down, as is confirmed by the second experiment.

Subjects
4.1 The distraction of drivers from their driving task by the presentation of aural route guiding information.
4.2 The distraction of drivers from their driving task by the presentation of visual route guiding information.
Jacobs, R.J. & Cole B.L.
Searching vertical stack direction signs, pp 5
Proceedings of the 9th conference of the Australian Road Research Board, Volume 9, Session 38
Brisbane, Australia, 1978

Summary
The aim of the report was to investigate how fast a target destination could be identified in a vertical stack of direction names.

The test was carried out by requiring 36 observers to locate a destination name in a vertical stack, which varied from 2 to 9 names.

According to a study by Mitchell and Forber (1942) three words can be read every second, so for every word $1/3$ s reading time is needed. By doubling these times, a sufficient safety margin was incorporated into their formula, which is:

$$T = \frac{2}{3} \cdot N,$$
with a minimum of $T = 2$ s

$T$ = time in seconds
$N$ = number of words

Moore and Christie (1968) found that these times were actually used by drivers to read all the names on a list, so the formula contained no safety margin.

Odescalchi et al. (1962) found that the average time required to read a list was 1.47 s for three names, 1.92 s for six names and 2.37 s for nine names, although there was a high variability. Times were approximately doubled when the name sought was the last one read. They proposed the following formula:

$$T_{\text{max}} = \frac{N}{3} + 2$$

The experiment was carried out with 36 observers, searching for a target name in stacks varying from two to nine names. The stacks were presented for exposure durations varying from 250 to 1500 ms.

From the data, the proportion of correct identifications was obtained as a function of each exposure duration, stack length, position in the stack and name length.

The stacks were projected on a screen in such a way that they were equivalent to letters 320 mm high observed from a distance of 100 m.

The figures 22 and 23 show the percentage of correct identifications for each viewing time and each of the three word lengths.
Figure 22: The percentage of correct identification of the 4-letter target destination (left) and of the 7-letter target destination at each viewing time for each stack length from 2 to 9 names; Source: Jacobs & Cole, 1978

Figure 23: The percentage of correct identification of the 10-letter target destination at each viewing time for each stack length from 2 to 9 names; Source: Jacobs & Cole, 1978
It can be noted that words of 7 letters are not identified to 95% reliability within 1500 ms. Clearly, the length of the words assisted the search process.

The position of the target name in the stack plays a very important role also. The probability of correct identification was greatest for a location of the target word in the fourth position of a nine name stack and were greater for locations at the top of the stack than for locations at the bottom.

The relationship between search time and the number of names in the stack can be approximated by \( T = 0.25N - 0.17 \) and if allowance of 200 ms is made for an eye movement back to the road, the equation simplifies to give the time diverted \( T_D \):

\[
T_D = 0.25 \cdot N
\]

Value of the report
The subject of this report, the identification time for a target name in a vertical stack of names, is vaguely related to the interpretation time for pictograms on a flat panel display. Of importance for pictograms on a flat panel display are the length of words and the place of the target name (conspicuousness of the target name) and the length of the stack (complexity of the stack). It is a pity that the exposure time of the stacks (250-1500 ms) is not explained.

Subjects
7.3 The interpretation time for each of the route guiding pictograms
Summary
The aim of the report was to determine indicator numbers for traffic safety on roads outside residential areas.

Indicator numbers will have to be based on accidents with casualties for reasons of registration reliability. In general, the number of accidents in a certain area during a certain time period are determined by:
- the number of traffic situations (road lengths, junction lay-outs, and the like) and the registration period
- the number of road users in the area during the registration period
- the traffic risks in the area during the registration period

The traffic risks, that can be defined as the chance on damage, depend on:
- the number of encounters with obstacles and other traffic
- the vehicle type
- the type of manoeuvres that are enabled by the design of roads and surroundings and the traffic regulation
- the behavioural aspects of vehicles and humans in traffic
- the risk-increasing psychological and physical characteristics of traffic participants
- the lighting conditions

On the basis of the present knowledge on traffic safety, it is (yet) not possible to give traffic safety indicator numbers for any combination of the above characteristics and circumstances. Therefore, a less detailed distinction has been made on the basis of the traffic processes that can occur. These are related to the movement possibilities for each vehicle. With the absence of more accurate data, the distinction has been made on the basis of road characteristics.

Distincted are:

a: outside residential areas, road sections, respectively junctions of:
- motorways, 2 x 2 lanes
- motorways, 2 x 3 or more lanes
- "autowegen" 1 x 2 lanes
- "autowegen" 2 x 2 lanes
- roads that are not allowed for vehicles slower than 20 or 40 km/h, 1 x 2 lanes
- roads that are not allowed for vehicles slower than 20 or 40 km/h, 2 x 2 lanes
- other roads

b: within residential areas, road sections inclusive junctions of:
- traffic streets
- residential streets.

With the available data and budget, accidents could only be distinguished into two groups:
1. accidents with casualties in which only motor vehicles were involved
2. accidents with casualties in which at least one non-motor vehicle was involved

Traffic flow numbers were only available for motor vehicles on the roads. Traffic flows of non-motor vehicles or of crossing vehicles were not known.

The indicator numbers that have been determined are based on the average number of accidents with casualties per vehicle kilometre driven on road sections and per junction. It has turned out to be hardly possible to relate the accident number to traffic flows. Only for road sections on motorways, moderately useful functions have been determined.
The indicator numbers for the estimation of accidents have been displayed in table 7.
For the estimation of the casualties and deaths also indicator numbers have been determined, which are shown in table 8. These indicator numbers have been calculated the same way as those of table 7.

Value of the report
The report is very useful for it's presentation of traffic safety indicator numbers, with which the safety of certain roads and junctions are described. However, it must be considered, and this is also put forward by the author, that the presented values are averages and that no distinction has (could) be made between different roads, traffic flows, traffic composition, kind of manoeuvre, and the like. On the other hand general values are well
suited for the Carin system, as it has no information on actual data.

Subjects
11.1 The possibility to use traffic safety criteria
11.3 The (un)safety of certain roads, locations, manoeuvres, and situations
11.4 The dangerous road situations a driver should be warned off

Table 7: Indicator numbers for the estimation of accidents with casualties; Source: Janssen, 1985

<table>
<thead>
<tr>
<th>Kencijfers voor de schatting van het aantal letselongevallen voor wegvakken per miljoen gere­den motorvoertuig­kilometers</th>
<th>per kruisingen per jaar totaal</th>
<th>ongevals­groep 1</th>
<th>ongevals­groep 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>autosnelweg</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 x 2 rijstroken</td>
<td>$f_1$ *</td>
<td>0,82</td>
<td>0,54</td>
</tr>
<tr>
<td>2 x 3/4 rijstroken</td>
<td>$f_2$ **</td>
<td>1,03</td>
<td>0,92</td>
</tr>
<tr>
<td><strong>autoweg bubeko</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 x 2 rijstroken</td>
<td></td>
<td>0,08</td>
<td>0,70</td>
</tr>
<tr>
<td>2 x 2 rijstroken</td>
<td></td>
<td>0,04</td>
<td>1,27</td>
</tr>
<tr>
<td><strong>gesloten verklaring bubeko</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 x 2 rijstroken</td>
<td></td>
<td>0,25</td>
<td>0,36</td>
</tr>
<tr>
<td>2 x 2 rijstroken</td>
<td></td>
<td>0,08</td>
<td>0,68</td>
</tr>
<tr>
<td><strong>overige weg bibeko</strong>*</td>
<td>0,37</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>verkeersaders bibeko</strong>*</td>
<td>1,79</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

* $f_1 = 1,12 \times I \times 0,34 \times 10^{-3}$; bij $I = 40.000$ motorvoertuigen per dag

** $f_2 = 1,09 \times I \times 0,31 \times 10^{-3}$; bij $I = 80.000$ motorvoertuigen per dag

*** inclusief kruisingen
Table 8: Indicator numbers for the estimation of the number of casualties (deaths and injured); Source: Janssen, 1985

Kencijfers voor de schatting van het aantal slachtoffers

<table>
<thead>
<tr>
<th></th>
<th>aantal slachtoffers per letselongeval</th>
<th>verhoudingsgetal doden per slachtoffer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>wegvak kruising ongevalsgroep</td>
<td>wegvak kruising ongevalsgroep</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

**autosnelweg**

<table>
<thead>
<tr>
<th></th>
<th>1,44</th>
<th>1,41</th>
<th>1,04</th>
<th>0,06</th>
<th>0,02</th>
<th>0,03</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 x 2 rijstroken</td>
<td>1,46</td>
<td>1,45</td>
<td>1,00</td>
<td>0,05</td>
<td>0,03</td>
<td>0,03</td>
</tr>
<tr>
<td>2 x 3/4 rijstroken</td>
<td>1,70</td>
<td>1,55</td>
<td>1,08</td>
<td>0,11</td>
<td>0,05</td>
<td>0,17</td>
</tr>
</tbody>
</table>

**autoweg bubeko**

<table>
<thead>
<tr>
<th></th>
<th>1,17</th>
<th>1,51</th>
<th>1,00</th>
<th>0,07</th>
<th>0,01</th>
<th>0,17</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 x 2 rijstroken</td>
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<td>1,61</td>
<td>1,08</td>
<td>0,06</td>
<td>0,03</td>
<td>0,18</td>
</tr>
<tr>
<td>2 x 2 rijstroken</td>
<td>1,22</td>
<td>1,55</td>
<td>1,02</td>
<td>0,06</td>
<td>0,05</td>
<td>0,07</td>
</tr>
</tbody>
</table>

**Gesloten verklaring bubeko**

<table>
<thead>
<tr>
<th></th>
<th>1,37</th>
<th></th>
<th></th>
<th>0,07</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>overige weg bubeko*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>verkeersaders bibeko*</td>
<td>1,13</td>
<td></td>
<td></td>
<td>0,02</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* inclusief kruisingen
Jansen, W.H.
Routeplanning en -geleiding - een literatuurstudie, pp 51
Instituut voor zintuigfysiologie TNO
Soesterberg, the Netherlands, 1979

Summary
The aim of the report was to examine the characteristics of an optimal route guiding system (from the point of view of psychology and ergonomy). Attention was paid to the route planning process, the expectations of drivers and the route guiding itself.

First, the behaviour and needs for information of drivers were analysed. Distinction was made between three levels of driver behaviour: the microscopic, the mesoscopic and the macroscopic level. On the microscopic level (performance level) the driver has the task to keep his vehicle on the road. On this level exists a preview of only seconds and tasks are performed automatically. The mesoscopic level (manoeuvre level) consists of tasks like overtaking and has a preview of tenths of seconds. The macroscopic or strategic level distinguishes the process of route planning and the following of a route with the aid of guiding accessories. This level has a very long preview. The frequency with which a driver needs information is adversely related to the length of the preview. The tasks for which a high frequency is required have to have priority above less demanding tasks. However, if a driver, for whatever reason, changes his priorities, an undesired or even dangerous situation exists. It is the responsibility of designers of route guiding systems to take care that the necessary information on lower levels is disturbed as little as possible by the route information. A way to achieve this is to present route information well ahead of junctions, roundabouts, etc. The levels of driver behaviour have an arrangement, according to which the high levels set goals for the lower ones. The strategic level is the highest and the microscopic level the lowest.

One of the disturbances that are a result of inadequate supplyance of information, is getting lost. It is a result of the shortcomings of the present route guiding system. The results of an investigation by King and Lunenfeld (1974) pointed out that a high percentage (30%) of drivers in unknown cities is lost (table 9).
Table 9: Percentage of drivers that got lost in an unknown area

<table>
<thead>
<tr>
<th>percentage that felt lost</th>
<th>yes</th>
<th>no</th>
</tr>
</thead>
<tbody>
<tr>
<td>percentage</td>
<td>30%</td>
<td>27%</td>
</tr>
<tr>
<td>that felt lost</td>
<td>1%</td>
<td>42%</td>
</tr>
<tr>
<td></td>
<td>31%</td>
<td>69%</td>
</tr>
</tbody>
</table>

Concluding it can be said that the driving behaviour at the highest (strategic) level may be markedly disturbed by insufficient route information. Therefore it seems worthwhile to go into the details of route planning and guiding.

From the literature it becomes clear that there is a large part of the drivers in unknown areas who do not plan their route.

The most important criterion for route planning is time. In the literature it can be read that for route planning, travel time is far more important than travel distance (or travel costs). To most persons minimal travel time is more important than safety, distance, costs, recreational aspects and congestion.

Stress is, according to Michaels (1965), also an important criterion for route planning. People tend to choose routes which cause as little stress as possible. Michaels calculated that the greatest contribution to stress is the interference of other vehicles. He found that the stress generated by a motorway : dual carriage way : rural road : urban road = 1 : 1,8 : 2,5 : 3,3.

For correct route guiding, information on three points is essential: on the route and destinations, the directions and the locations.

Generally speaking, a route can be described in three ways: by naming the route, by giving the route an arbitrary code (letter or number) and by naming the route after its destination point.

The author favours a route description by code, because, without needing a large space, it supplies relevant information to all travellers, whatever their destination. Only the destinations themselves need to be described by their names.

The way in which route information should be presented to the road user, is described in general by Schoppert, Moskowitz, Hulbert and Burg (1960):

- All messages should be clear and only interpretable in one way.
A series of messages should be continuous.
Information has to be given well ahead of junctions.
The information of road maps and the route guiding information should be compatible.
The route guiding information should be presented in such a way that it distinguishes itself from other information given to the driver.
The information should be given especially at locations where unexpected actions of the driver are needed.

In the United States investigations have been made on the applicability of simple pictures for route guiding. The main conclusions of these studies are:

1 Route guiding pictures should not be applied in complex situations. The impression exists that pictures can be used when unexpected manoeuvres are required, on condition that the pictures are simple.

An important study on this subject was carried out by Eberhard and Berger (1972) who compared five route guiding configurations, among which three with pictures (figure 24).

<table>
<thead>
<tr>
<th>Systeem:</th>
<th>Collect./distr.</th>
<th>Direkt open-</th>
<th>Linker</th>
<th>Multiple afritten</th>
<th>Work</th>
<th>Klaverblad</th>
</tr>
</thead>
<tbody>
<tr>
<td>Konventioneel</td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
</tr>
<tr>
<td>Aangepast konventioneel</td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
</tr>
<tr>
<td>Perspektivisch</td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
</tr>
<tr>
<td>Vogelvlucht</td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
</tr>
<tr>
<td>'Performance' gericht</td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
</tr>
</tbody>
</table>

Figure 24: Route guiding configurations and road situations used by Eberhard and Berger (1972)
Test persons were shown diags of actual situations with the five different route guiding accessories. The results are shown in table 10 below.

Table 10: Percentage of correct lane choice as function of different route guiding configurations and road situations according to Eberhard and Berger (1972)

<table>
<thead>
<tr>
<th>Systeem</th>
<th>Collect. distr.</th>
<th>Direkt opvolgende afrit keuzepunten</th>
<th>Linker Multiple afritten</th>
<th>Vork Klaverblad</th>
</tr>
</thead>
<tbody>
<tr>
<td>Konvencioneel</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aangepast konvencioneel</td>
<td>54</td>
<td>94</td>
<td>96</td>
<td>88</td>
</tr>
<tr>
<td>Perspektivisch</td>
<td>50</td>
<td>98</td>
<td>86</td>
<td>78</td>
</tr>
<tr>
<td>Vogelvlucht</td>
<td>70</td>
<td>96</td>
<td>96</td>
<td>82</td>
</tr>
<tr>
<td>&quot;Performance&quot;-gericht</td>
<td>49</td>
<td>92</td>
<td>94</td>
<td>82</td>
</tr>
</tbody>
</table>

* Gegevens verwijderd omdat de betreffende borden niet exakt aan de konvencionele standaard voldeden.

Especially in complex situations like the cloverleaf and the multigore the guiding with pictures turned out to be less succesful than the conventional way of route guiding.

The results of Eberhard and Berger are supported by those of Mast and Kolsrud (1972): very complex junctions are faced with the impossibility to design a picture that is both simple and an exact representation of the geometry; most advantage of route guiding pictures is to be gained at left exits.

2 Drivers need more time to understand route guiding pictures than conventional signs. Besides, the time necessary to "read" the pictures becomes larger more than linear with the complexity of the picture.

3 Pictures can sometimes give usefull additional information on the geometric situation.
4 Out of the investigations, four conclusions can be formulated:
- The pictures must give only that information that the drivers need to be able to execute a manoeuvre
- The amount of information given by a picture should not be too great
- The components of the picture should form one figure
- The most important road should be accentuated visually

Value of the report
The report deals with route planning and guiding by accessories outside the car and is therefore not entirely adjusted for an information and navigation system within the car. However, many of the remarks that have been placed are also applicable for in-car route guidance. What is said on the requirements and shortcomings of pictures on sign posts is also of the utmost importance for the functioning of route guiding through the flat panel display.

Subjects
4.2 The distraction of drivers from their driving task by the presentation of visual route guiding information.
7.3 The interpretation time for each of the route guiding pictograms
Summary
New developments in micro electronics have produced a series of new application possibilities in cars, which are discussed in the article: traffic management, information, route guidance, hazard warning, emergency calls and keeping safe distance.

Communication between in-car electronic systems and the outside world is possible in many ways: through area broadcast (one way system), local roadside transmitters (one way), walkie-talkie and car telephone (two way) or through local beacons along the road (two way).

The information can be presented aurally or visually. Problems can be caused by the limited capability of the human brain to process information. Information can not be processed above a certain limit. If more information is presented, either visually or aurally, part of the information will get lost.

Aural messages do not have to be transmitted in their original form, but can be coded before transmitting. The advantages of coding are: the ability to be processed by a micro computer, a choice of transmission duration, a choice of means of presentation, the possibility of route control, the possibility to store information and a choice of language presentation.

Basically, there are three possible methods of radio messages. The first one is the simple spoken traffic information that is used momentarily. The second method consists of messages accompanied by a coding signal, which makes it easier for the driver to receive the specific information he needs at a certain moment. The third method is a totally coded message. For this use a radio channel is already reserved on which experiments with RDS (Radio Data System) soon will start.

Experience in the past years has shown that an automatic traffic measurement system is essential to provide accurate information in time. However, it is not to be expected that an extensive measuring system will be installed in the near future.

For the introduction of a general European system it is necessary to standardize the way in which the car position is determined and the
way in which information is send to the driver. The determination of the car position can be done by beacons or, in the near future, through the NAV-STAR satellite navigation system.

Value of the article
The information given in this article on electronics in traffic is so general that it's value for this literature study is only very small.

Subjects
4.1 The distraction of drivers from their driving task by the presentation of aural route guiding information (general).
4.2 The distraction of drivers from their driving task by the presentation of visual route guiding information (general).
Summary

The article deals with the findings of a four year investigation on noise in motor vehicles. Two of the main conclusions were that humans can get used to many noises, but not to all noises and that different people react differently to a certain noise level.

It turned out that quite a lot of the tested drivers even liked a noise level of 85-90 dB, because it gave them a feeling of driving a sports car and as a consequence, their driving concentration was very high. On the other hand, many drivers with very quiet cars tended to drive very fastly, because they did not perceive the real velocity of the car. The drivers with very quiet cars tended to get annoyed with little noises more than owners of noisy cars.

Surprisingly, one investigation pointed out that noises of a particular level (dB) were not equally perceived in two different cars. It seems that in more comfortable cars the noise level is judged higher than in less comfortable cars.

The effect of a noise impact on humans is dependent upon age and sex: it is greater for elderly people than for young ones and more irritating for females than for men.

The distraction of radios is also very dependent on age and sex. Ninetyfive percent of all tested women (3458) declared to be distracted by car radios to the extent of switching off the radio when driving on a motorway or a secondary road. They were distracted both by music and by the spoken word.

In contrast with the previous findings, young male subjects declared to be even stimulated by music. Elderly male drivers declared not to be disturbed by light background music, even at high speeds. These drivers also declared that heavy music or the spoken word did distract them.

All the examples above lead to the conclusion that noise can not solely be measured by technical standards, but that subjective circumstances play an important role as well.
Value of the article
The part of the article that deals with the distraction of drivers by car radios is interesting for this literature study on the traffic safety aspects of Carin. It shows that people can be distracted by the spoken word and that this distraction varies from one person to another. This should be kept in mind when testing the distraction of the driver by spoken route guidance advice.

Subjects
4.1. The distraction of drivers from their driving task by the presentation of aural route guiding information.
Summary

The article provides an oversight of old techniques for controlling and regulating traffic flows and discusses new ones.

Since the mid sixties traffic flows have been controlled and regulated electronically with the aid of TV cameras, induction detectors, microprocessors and the like.

Compared with other means of transportation however (airplanes, boats, etc.) road traffic uses very little electronic data equipment for controlling and regulating tasks. In spite of this, the needs for using electronic equipment are equal for road transport as compared with the other transportation methods.

Momentarily, new technological means of navigation are being developed of which the ALI (Autofahrer Leit- und Informationssystem) and EVA (Elektronischer Verkehrslotse für Autofahrer) guiding systems are examples. Both systems have in common that they determine the destination with the aid of signals they receive from beacons along the road. The main difference between ALI and EVA, is that the intelligence of the ALI system is outside the car and of the EVA system within the car. The applicability of the latter solution becomes greater as the costs of microelectronics become smaller.

A third microprocessing device for in-car use that is momentarily investigated, is MAIA (Mikroprozess Anwendung im Automobil). Unlike ALI and EVA, its function is not to guide the driver, but to check the level of attention of a driver. The system is to give a warning sign when a change in bioparameter manifests itself. It is meant to reduce the accident rate caused by a low level of attention of drivers.

Value of the article

As this article presents only a general description of electronic equipment for controlling and regulating traffic flows, it is of no use to this literature study.

Subjects
Summary
The aim of the report was to present an oversight of literature on the interpretation and retention of messages presented aurally and visually. Examined were the effects of the length and the contents of messages. A comparison was made between visual and aural messages. A study was made on the location and configuration of in-car keyboards and displays.

Length of messages

Gatling (1975) investigated the effects of the length of aural messages, the time between a message and the retention of the message, and the number of times a message was presented. The number of test subjects was 30. The length of a message turned out to have an important effect on the ability to recall the entire message (figure 25) and on the navigational errors that were made (figure 26).

Figure 25: Percent of message retention as a function of message length (source: Gatling)
Messages with one or two units of information caused few difficulties, in contrast to longer messages. Repetition of the messages hardly caused any effect on the retention or the number of errors. The time between a message and the retention of the message did not have any effect on the retention rate.

In a second series of tests Gatling controlled the message retention visually. Subjects were to indicate whether an exit number that was displayed within the car, was the same as the number that had been broadcast on the radio. The results turned out to be better than during the first tests (figures 27 + 28).
Figure 27: Percent of message retention as a function of message length (source: Gatling)

Figure 28: Percent of subjects making a route error as a function of message length (source: Gatling)

Huchingson (1978) repeated the second series of tests of Gatling. The
retention performance of these tests turned out to be much better than were found by Gatling (figure 29). Paradoxically, the performance for eight units of information turned out to be better than for six units. This may be explained by the experience of the subjects with the messages and the methods: the messages containing six units of information were tested first.

Figure 29: Percent of subjects making a route error as a function of message length.

The differences between the results of Gatling and Huchingson may be explained by differences in their methods. Gatling tested the recollection of route numbers, exit numbers, and distances on subjects that were not given an itenerary, whereas Huchingson tested the recollection of street names on subjects that had been given an itenerary.

Wagenaar and Visser (1978) carried out laboratory experiments on the amount of information that can be recollected (25 subjects). The results pointed out that the recollection performance improved as an itenerary was given to the subjects before each message and that an itenerary through a map gave better results than without a map. On average subjects recollected five units of information, varying from 3.2 to 7.5, dependent on the testing method (with or without
Contents of message

Gatling found that the contents of a message has influence on the retention: route and exit numbers are more difficult to remember than route and exit names. Wagenaar and Visser found similar results: of a route guiding message, the routes and places were well remembered, in contrast to route numbers and lengths of traffic jams.

Comparison between aural and visual messages

In a comparison between aural and visual route advices, Gatling found no significant difference between retention rate, provided the aural signals were presented automatically. Nevertheless, the results for aural messages tended to be slightly better. Huchinson and others compared diversion routes with 6-12 units of information, presented aurally with and without diversion signs with schematised visual information along the route. The number of errors turned out to be much smaller on the routes with diversion signs. It was also found that, in the case of assistance by visual signs along the road, a short message style produced less errors than messages with an extensive description of the mental workload necessary to interpret the verbal description. Gatling repeated his experiments with messages containing road numbers. He found that messages containing one or two road numbers were retained better when presented visually, but that above two road numbers auditory messages resulted in the least errors.

Keyboards and displays

Bouis and Haller (1983) have conducted experiments on the configuration and location of keyboards and information displays. They found that sequential keyboards (with the keys located in a row) could be operated faster than keyboards with a telephone configuration and were preferred by test subjects. Combinations of keyboard and display produced the least distraction when the keyboard was situated in the dashboard above the gear lever and the display as high as possible in the dashboard. Rüenaufer (1983) has written a report on the experimental German ALI-system. His investigations comprised of safety and distraction. On questioning, 10% of the test subjects declared to be distracted by the ALI-system, against 67% who declared not to be distracted at all. 4% of the subjects declared to be exhausted sooner with the presence
of the system. It was found, that the interpretation time for the visual information display and the number of eye movements required were comparable to those required for other in-car information systems (table 11).

Table 11: Comparison of the reading time and the number of eye movements (source: Rüenhauser)

<table>
<thead>
<tr>
<th>Tâche de prise d’information</th>
<th>Durée de regard (s.)</th>
<th>Nombre de mouvements des yeux</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture du compteur de vitesse</td>
<td>0.6</td>
<td>1</td>
</tr>
<tr>
<td>Lecture de signaux autoroutiers</td>
<td>0.5 - 1</td>
<td>1 - 2</td>
</tr>
<tr>
<td>Lecture de l’afficheur ALI</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>Régler la ventilation</td>
<td>1 - 1.5</td>
<td>4 + 3</td>
</tr>
<tr>
<td>Sélectionner une station radio</td>
<td>1 - 1.5</td>
<td>6 + 3</td>
</tr>
</tbody>
</table>

Value of the report
Although the subjects discussed in this report are closely related to the functioning of the Carin system, they are no part of the traffic safety aspects of the system. The report may well serve as background information.

Subjects:
7.5 The chances that aural route guiding advices are forgotten
Summary
The report presents an oversight of investigations carried out to obtain information on traffic accidents that were caused by keeping insufficient distance.

Almost 300,000 accidents have been statistically analysed on their causes, caused injuries, the lighting conditions and time of the day, weather conditions, the road surface, the road type, and the situation. 1) In 9% of the cases, keeping too short a distance was the main cause of the accident. 2)

The stopping distance is the sum of the distances covered in the reaction time and the braking time.
In the past, the reaction time has been measured in various tests. A reaction time of 0.5 s must be seen as an absolute minimum, which occurs seldomly. According to Moser, a reaction time of 0.7 s is the best that can be achieved (0.3 s for the realisation of the danger, 0.2 s for starting to brake, 0.2 s between the pressing of the braking pedal and the actual functioning of the braking pads). According to tests, most humans need a reaction time of 0.7-1.0 s. Age plays an important role in the duration of the reaction time: elderly people need a longer reaction time than younger ones. Rompe finds mean reaction times of 1.2-1.4 s. The West-German jurisdiction even calculates with a reaction time of 1.5 s.
Legally, the braking deceleration has to be 5.2 m/s². In the Netherlands the medium braking force is about 7.5 m/s².

It was decided to advice drivers to keep a distance to the car in front of them that is the same as the car travels in 1.5 s (maximum reaction time). It was not found necessary to stay at stopping distance behind the car in front, because that car does not stop immediately after touching the braking pedal, but has its own braking distance too. 3) Because it is difficult for drivers to calculate the distance that is covered in 1.5 s, it is decided to

1) see "value of the report"
advice the distance that is driven in 2 s or the distance in meters that is the same as half the velocity in km/h.

It is acknowledged that the advised distance is insufficient if the car in front, as a result of a crash, stops faster than would be possible by braking. However, it is posed that these situations hardly occur on motorways.4)

A social-scientific investigation was carried out to examine the knowledge of drivers on the duration of the reaction time and the braking distance. It turned out that drivers do have insight in the reaction time, but insufficiently realise the distance that is driven in that time and do not realise the braking distance.

The findings of the investigations have been the basis of the publicity campaign "keeping distance".

Value of the report
The value of this report lies in the presented data on reaction times and braking performances. The advices on the distances that drivers should keep to cars in front of them should be forgotten as quickly as possible, because they are based on incorrect assumptions and are not thoroughly thought over. This can be illustrated by the following remarks:

1) The analysis of the accidents is of little value as it is carried out without a vision or theory: no search is usefull unless it is known for what information is searched.

2) In contrast to what is written in the report, there is no main cause for an accident: accidents happen as a result of many causes, a combination of critical circumstances.

3) The advice on the distance to the car in front does not account for the multitask driving performance, which can prohibit an immediately detecting of the lighting of the stopping lights of the car in front. Furthermore, it does not account for differences in braking performance: accidents still will happen if the car in the rear has a smaller braking capacity than the car in the front.

4) No account has been made for the situations at the tail of chain crashes, where cars do come to stop much faster than would be possible by braking.

Subjects
7.2 The reaction time on aural and visual route guiding messages
Meyer, F.
Reaktionsanlass und Reaktion im Strassenverkehr
Der Verkehrsunfall 16, Number 12, pp 255-259
Braunschweig, Federal Republic of Germany, 1978

Summary
The reaction time is defined as the time between the begin of a stimulus and the begin of a reaction. The time necessary to execute an action is not part of the reaction time.
A reaction can be executed in two ways: unknowingly through a reflex or a chain of reflexes or in full consciousness through directed actions.
Reflexes are very important and necessary for driving and executing emergency manoeuvres.
In general, the consciousness of a reaction becomes smaller with the number of repetitions, until information and reaction are so integrated that every stimulus automatically results into the correct reaction.
Not always the correct reaction to a stimulus manifests itself. Herefore are two reasons. Firstly, the capability to react disappears when the reaction has not been practised for a long time and secondly, sometimes a chain of reflexes is necessary, requiring a reaction at the same time or shortly after each other and thus demanding too much of a person.

The hypothesis that the drivers who have the highest percentage of reflexes in their driving performance are the best drivers, is not always correct. Sometimes the reflexes produce a wrong reaction which could have been avoided by analysing the situation more thoroughly.

Reactions to the actions of other road users are very complicated and depend upon the impression one has of the movements and plans of the opponent.

Many values have been given for the actual length of reaction times, but small values should be treated carefully, because they are usually the result of laboratory studies which are not always applicable in actual traffic situations.
The length of the reaction time is influenced by the following circumstances:

- Conflict of reactions.
The reaction time becomes larger if it not distinct which reaction to a stimulus is the correct one.
- Uncertainty of events.
The reaction time rises with the number of possible events, if persons do not know which of the possible events will actually take place, c.q. what action will be necessary.

- Compatibility of stimulus and reaction.
The more related a stimulus and the necessary reaction are, the shorter the reaction time will be.

- Learning effect.
The more experience a driver has in a particular situation, the faster and more correct his decision will be.

- Probability of a situation.
Experiments have showed that the length of the reaction time is adversely related to the probability of a situation actually taking place.

- Uncertainty of time.
The uncertainty of time plays a role if a person is warned before an event, but does not know the length of time between the warning and the event. An enlargement of this time leads to an enlargement of the reaction time also.

- Physical stimulus variables.
The effect of physical stimulus variables, like the duration, the conspicuousness and the frequency of a warning signal have been researched very little and can not be given a general opinion upon. Reaction times can be reduced by correctly used warning signals.

Value of the report
This article deals with the human reaction and reaction times in general and is therefore of only moderate importance to this literature study.

Subjects
7.2 The reaction time on aural and visual route guiding messages
Michaelis, P.R.
An ergonimist's introduction to synthesized speech
Texas Instruments Incorporated, Computer Science Laboratory
Dallas, Texas, United States, 1980.
in: Oborne, D.J. & Levis, J.A.
Human factors in transport research - volume 1

Summary
The paper briefly describes how voice synthesizers work and then discusses psychological considerations on ergonomist needs to know before using them.

As voice synthesizers are a model of a human speaker, along with the actual words also the tonal aspects of the speaker's voice are captured. Thus subtle nonverbal cues remain, such as whether the speaker is perceived as being sincerely helpful and friendly, or condescending and even threatening.

It is absolutely essential that the ergonomist learns to evaluate these nonverbal cues. Ignoring these cues could lead to a system people do not want to use. The author describes an example of a voice that was thought to be very pleasant, but was rejected by test subjects as the most sinister thing they had ever heard. Therefore, products should always be tested on the ergonomic criteria, even if the designers are satisfied with the product.

Value of the report
The paper is only marginally of importance to this literature study, as it is not concerned with an application of voice synthesizers in particular but to ergonomics of voice synthesizers in general.

Subjects
4.1 The distraction of drivers from their driving task by the presentation of aural route guiding information.
Oborne, D.J. & Levis, J.A.
Human factors in transport research - volume 1, pp 441
Proceedings of the International Conference on Ergonomics and Transport held in Swansea from 8-12 September 1980
Swansea, Wales, 1980.

The report contains 47 papers presented to the ICET held in Swansea in September 1980.
Out of these papers, on the basis of the abstracts that proceed all papers, the following four have been selected for this literature study that are described on other places in this report:

Watts, G.R.
The evaluation of conspicuity aids for cyclists and motorcyclists
Transport and Road Research Laboratory, Vehicle Safety Division
Crownthorne, England.

Michaelis, P.R.
An ergonomist's introduction to synthesized speech
Texas Instruments Incorporated, Computer Science Laboratory
Dallas, Texas, United States.

Priest, J.
Synthesized speech: ergonomic implications for the transportation industry
Texas Instruments Incorporated, Human Factors Research Laboratory
Dallas, Texas, United States.

Galer, M. & Baines, A. & Simmonds, G.
Ergonomics aspects of electronic dashboard instrumentation
University of Technology, Loughborough, Institute of Consumer Ergonomics
Ford Motor Company Limited, Research and Engineering Centre
Oei, H.L.
Route information systems
Man and information technology; Towards friendlier systems, pp 19-27
The Netherlands

Summary
The aim of the article was to examine the user-affinity aspects of route information systems, particularly signposting.

The formal sources of route information are maps, alternative route maps, fixed signposting, alternative signposting (fixed or flexible), traffic information on the air, visual route information on a screen and individual route information in the vehicle. The better a driver's knowledge of the area, the less will be his need for information en route.

The present information system is capable of improvement in various aspects. The various sources of information must be better attuned to one another. A relatively large amount of prior knowledge is needed before signposting can be used effectively. The amount of information which drivers have to assimilate must be kept within reasonable limits. This applies both to information to be assimilated before a journey and to information fed to the driver en route. As far as possible route information should not compete for the driver's attention with the information he needs to keep the vehicle on the road and to carry out manoeuvres.

For future use, a number of individual route information systems are being developed, like the German ALI and the Dutch ARIADNE system. The success of these systems will depend largely on the savings that can be achieved compared with the level of investment that will be necessary.

Value of the article
This article is of little importance to this literature study as it's accent is directed towards present information systems and very little attention is paid to future systems. It is a pity that the remark on the distraction of the driver by the route information is not explained further. (In the text it appears for the first time in the conclusions.)
Subjects
4 Distraction by route guiding advices (general remarks)
Poppe, F. & Oei, H.L.
De verkeersonveiligheid in de provincie Noord-Brabant IX D.
Het relatie-onderzoek: Resultaten van het deelonderzoek Analyse kruispunten, pp 68.
Stichting Wetenschappelijk Onderzoek Verkeersveiligheid SWOV.
Leidschendam, the Netherlands, 1984.

Summary
Aim of the research was to find relations between accidents and road and traffic characteristics. This part of the report was concerned with major junctions. The research was carried out on all roads outside residential areas in the county of Noord-Brabant in the Netherlands.

Of each of the studied junctions detailed data were gathered of each joining road, Characteristics that have been taken into account are:

- the direction of the main and minor road(s)
- the number of roads joining on the junction
- the presence of traffic lights
- physical separation of carriageways
- facilities for cyclists and moped riders, service roads
- presence of left and right exit lanes
- pavement
- the right of way
- the presence of public lighting
- the angle between the roads
- the sight distance
- the number of lanes
- traffic flows
- curve radii
- location of the accident (on or near the junction)
- the number of accidents
- fatalities
- accidents at night, dusk, or dawn
- wet road surface
- rain
- use of alcohol
- the manoeuvres of the vehicles
- kind of vehicle

The analyses indicated that many accidents happened on larger junctions with traffic lights and with many potential conflict points. Crossroads were more unsafe than T-junctions, which can be explained through the greater number of possible conflict points.
The characteristic "presence of traffic lights" was dominating. On junctions without traffic lights the traffic flows turned out to have different effects on T-junctions than on crossroads. On T-junctions accidents had happened at high motor vehicle flows in the main direction and high motor vehicle flows in the minor direction. On crossroads a high number of accidents was accompanied by a high motor vehicle flow in the main direction, but a low motor vehicle flow in the minor direction, and a high flow of cyclists and moped riders in the minor direction.

In the following a presentation will be given of the accident-related characteristics on junctions without traffic lights, with distinction according to the roads on which the vehicles drove before the accident.

**Vehicles from the same road**
Most accidents in which only vehicles from one of the joining roads are involved, are head-tail accidents. Important for these accidents are a great road width, the absence of exit lanes, a wide central reservation, (10 m) and no special arrangements for the right of way.

**Vehicles from two roads at right angles to each other**
Distinction has been made between junctions with 4 and with 3 joining roads.
On junctions with four joining roads accidents turned out to be related to great widths of the central reservation (15 m), a great width of the right road, a physical separation of the carriageways of the right road, a bicycle path along the left road that crosses the right road separately, an exit lane for turning left on the right road.
On T-junctions the most important characteristics that are related to accidents are the following: a great width of the left road, the presence of merging lanes on the left road, obstacles on the central reservation, a bad sight distance from the right road on the left one.

**Vehicles on roads that are in a direct line with each other**
Most of the accidents of vehicles on two roads that are in a direct line with each other consist of a vehicle driving straight ahead and an oncoming vehicle turning left.
On crossroads the following characteristics play a role: a high traffic flow on the south-west road, obstacles along the left side of the north-east road, obstacles along the left side of the south-west road, a good sight distance on both roads from 200 m before the
junction.
On T-junctions accidents are related to a bad sight on the traffic driving straight ahead and to high traffic flows.

Value of the report
The found relations between road and traffic characteristics and accidents hardly contribute to an insight in traffic (un)safety. For human behaviour is not induced by physical characteristics but by functional ones. A road width of 6 m e.g. (physical characteristic) does not give information on the manoeuvre space (functional characteristic). With the absence of other traffic the manoeuvre space will be highly sufficient. However, in case of an oncoming wide truck and the presence of cyclists, the manoeuvre space may well be insufficient.

Besides, the analyses do not account for interactions between road characteristics and traffic safety. E.g. bicycle paths may well have been constructed on junctions where previously many accidents with cyclists happened; traffic lights will have been erected at places where previously many serious accidents used to happen; etc. Nevertheless do the analyses find a correlation between the presence of bicycle paths or traffic lights and high accident rates.

In spite of this, the report is helpful in pointing out road characteristics that under circumstances are accompanied by increased traffic risks.

Whether a major part of the presented data will be able to be used remains questionable, as on the digital map on compact disc only a limited amount of road information will or even can be stored.

Subjects
11.1 The possibility to use traffic safety criteria
11.3 The unsafety of certain roads, locations, manoeuvres, and situations
11.4 The dangerous road situations a driver should be warned off
Prentice, H.A.J.
Drivers' limitations
Transport and Road Research Laboratory

Summary
Aim of the report was to examine the abilities of drivers to assimilate and correctly analyse the information that is received. For the greater proportion of time drivers can handle the amount of information without any difficulty. However, when a driver is required to perform several different functions at the same time the load on him increases considerably, greatly increasing the probability of making errors.

For a correct analysis of information, accurate perceptual judgements are essential. Road users continually make three perceptual judgements:
- the judgement of distances
- the judgement of speeds
- the comprehension of time required for a manoeuvre

Experimental studies have shown that road users lack the inbuilt ability to make the more critical judgements on speeds and distances. This suggests that aids in or on the vehicle or on the roadway would have a considerable potential to reduce accidents. These possible aids are discussed in the following.
Radar and related systems are momentarily investigated in many countries. However, no system known at present can meet all requirements:
- self containing
- able to operate in all weathers
- able to detect and respond quickly to sudden brake applications of the vehicle ahead
- fail safe
- able to detect road side obstacles as well as vehicles
- cheap and reliable
- able to handle lane changing and merging as well as simple following

Electronic speed control may be a suitable device for preventing accidents as long as electronic aids for headway control will not be available before some years. Electronic speed control is usually
proposed as a system of roadside units transmitting maximum speed commands to passing vehicles.

Head-up display speedometers project the speed upward onto the windshield without requiring the driver to look away from the view ahead of him. Experiments have shown that the average time required to read an ordinary speedometer is 1.6 s and this is probably the reason why in heavy traffic or during difficult manoeuvres the drivers do not look at their speedometer.

Station keeping indicators are devices that show the distance to be kept from a leading vehicle.

An automatic headlight dimming system could provide a sufficient illumination level when necessary, without being a source of annoyance in well lit streets.

Value of the report

The report deals with a subject that has hardly any relation to this literature study.

However, the remarks on the interpretation of a normal speedometer may be useful because of the similarity with the interpretation of the Carin display.

On the report itself can be stated that all discussed systems for driver aids do not account for the variables that are important to traffic safety (consequences of slippery roads, wet or frozen road surfaces, a bad condition of the car, and especially drivers' reactions on the technical devices). Moreover, the potential of aids for the estimation of speeds and distances to reduce accidents is not as considerable as the article suggests: drivers know their shortcomings in estimating and compensate these by keeping a safety margin. If future aids would reduce or even abandon this safety margin, the overall effect could well be minimal or even negative.

Subjects

7.3 The interpretation time for each of the route guiding pictogrammes
Summary
The paper briefly reviews the role of the ergonomist in applying synthesized speech and its implications for the transportation industry.

Voice synthesizers can reduce or even eliminate visual display requirements and therewith an operator's workload. However, ergonomic considerations of synthesized speech for the transportation industry are enormous and little research has been carried out in this field until now.

The role of the ergonomist in the application of synthetic speech is to:

- identify potential applications
- determine user information requirements and preferencies
- evaluate feasibility
- develop specific design criteria and word lists
- test and evaluate the final system

In transportation speech has the advantages of reducing the visual workload, a high detectability, a high number of discrimination levels, multiple systems capability, message/information format, and instruction-tutorial capability.

To properly utilize speech, specific design criteria are needed, in which the ergonomist plays a critical role. Design considerations playing a role herewith are user/listener parameters (expectations/perception, situational experience, familiarity with phraseology and speech feedback) and psycholinguistic factors (information type presented, word and phrase complexity and length, word lists/semantics, and the like)

Value of the report
The paper deals with speech synthesizers in rather general terms and is therefore only usefull for this study as background information.
Subjects

4.1 The distraction of drivers from their driving task by the presentation of aural route guiding information (general)

7.5 The chances that aural route guiding advices are forgotten (general)
Summary

Aim of the research was to find relations between accidents and road and traffic characteristics. This part of the report was concerned with "strengen", road stretches of greater length. The research was carried out on all roads outside residential areas in the county of Noord-Brabant in the Netherlands.

For the purpose of this research a "streng" was defined as a stretch of road outside built-up areas on which the main part of the road users (90%) drives without turning left or right. In total 190 "strengen" have been selected for analysis.

The main characteristics that have been taken into account are the road category, lengths of the road stretches, road function(s), the number of carriageways, distances between locations with crossing or merging traffic, the use of the shoulder, the right of way, the presence of traffic lights, the pavement width, cycle/moped facilities along the road and/or on junctions, service roads, the number of lanes, obstacles, bends, left or right exit lanes, physical carriageway separation, traffic flows, kinds of pavement, capacity, speed limits, overtaking prohibitions, sight distances, public lighting, and accident type.

The results have been analysed for all selected road stretches together, and separately for the road stretches prohibited for slow traffic, cyclists and moped riders and for road stretches accessible for all traffic. Furthermore, analyses have been made of all accidents on roads with low traffic flows (4000 motor vehicles per day), on roads with intermediate traffic flows (4000-8000 motor vehicles per day), and on roads with high traffic flows (8000 motor vehicles per day).

All accidents, all road stretches

A high accident rate turned out to coincide with
- a small median distance between crossing or merging places
- the presence of junctions with traffic lights
- high motor vehicle flows
- many sequential junctions with and without left exit lane
- many major junctions
- the presence of public lighting
- a high road category

It was presumed that both public lighting and traffic lights had been installed at places were previously many accidents had occurred. These measurements may well have increased traffic safety without making the roads and/or junctions very safe.

**All accidents, road stretches prohibited for slow traffic, cyclists and moped riders**

Many accidents took place on roads with:
- a high median motor vehicle flow
- the presence of public lighting along a main part of the stretch
- a small median distance between obstacles
- a great variance of the motor vehicle flow
- many succeeding junctions with and without left and right exit lanes
- a high road category

**All accidents, road stretches for all traffic**

On road stretches for all traffic a high accident rate per km was accompanied by:
- a high median motor vehicle flow
- a small median distance between all crossing or merging places
- the presence of public lighting along a main part of the stretch
- a high cycle and moped flow
- a high road category
- a main part of the stretch with concrete pavement
- a relative long distance with two lanes
- many succeeding junctions with and without left exit lanes
- a small number of divisions into halves of the sight distance

**All accidents, road stretches with less than 4000 motor vehicles per day**

The most important characteristics that are related with a high accident rate per km are:
- a high median motor vehicle flow (of course within the category below 4000 per day)
- the presence of public lighting on a main part of the stretch
- a main part of the stretch with obstacles on less than 1.5 m from the pavement
- many lanes accessible for all traffic
- a main part of the stretch with two lanes
- a high road category
- a great variance of the motor vehicle flow
- a small median distance between obstacles

All accidents, road stretches with motor vehicle flows between 4000 and 8000 per day
The accident-related characteristics on roads with intermediate traffic flows are the following:
- a small median distance between all crossing or merging places
- many succeeding junctions with and without traffic lights
- the presence of public lighting along a main part of the stretch
- a small number of lanes for all traffic
- a low motor vehicle flow (within the category 4000-8000 per day)

All accidents, road stretches with median traffic flows of over 8000 motor vehicles per day
Many accidents on roads with high traffic flows are related to:
- many major junctions with a right of way
- many lanes prohibited for slow traffic, cyclists, and moped riders
- a great part of the stretch belonging to a junction
- many succeeding junctions with and without left and right exit lanes
- many junctions with traffic lights

The report ends with a number of recommendations based on the findings of analyses. The recommendations are based on the characteristics with strong relations to accidents: traffic flows, discontinuities in the road, discontinuities in the design of junctions on a stretch, the presence of certain junction types, the distribution of crossing and merging places along a stretch, obstacles, and public lighting.

Value of the report
The found relations between road and traffic characteristics and accidents hardly contribute to an insight in traffic (un)safety. For human behaviour is not induced by physical characteristics but by functional ones. A road width of 6 m e.g. (physical characteristic) does not give information on the manoeuvre space (functional characteristic). With the absence of other traffic the manoeuvre space will be highly sufficient. In case of an oncoming wide truck and the presence of cyclists, the manoeuvre space may well be insufficient. Besides, the analyses do not account for interactions between road characteristics and traffic safety. E.g. a bycycle path may well have been constructed along roads where previously many accidents with cyclists happened; traffic lights will have been erected at junctions where previously many accidents used to happen; etc. Nevertheless do the analyses find a correlation between the presence of bycyle paths or public lighting and high accident rates.
In spite of this, the report is helpful in pointing out road characteristics that under circumstances are accompanied by increased traffic risks.

Whether a major part of the presented data will be able to be used remains questionable, as on the digital map on compact disc only a limited amount of road information will or even can be stored.

Subjects
11.1 The possibility to use traffic safety criteria
11.3 The unsafety of certain roads, locations, manoeuvres, and situations
11.4 The dangerous road situations a driver should be warned off
De verkeersonveiligheid in de provincie Noord-Brabant X.
Eindrapport, pp 25
Stichting Wetenschappelijk Onderzoek Verkeersveiligheid SWOV
Leidschendam, the Netherlands, 1984.

Summary
The report is the final one of a series that describes an extensive study on the traffic safety in the county of Noord-Brabant. The aim of this study, that was started in the mid seventies and lasted about 10 years, was to reduce traffic unsafety on short notice and find relations between road, traffic, and accident characteristics for the long term planning.

In the first phase of the study it was found that the traffic unsafety in Noord-Brabant was large in comparison with other counties. A number of subjects on which Noord-Brabant scored relatively bad was chosen for further study.

The second phase consisted of the study on the subjects that had been chosen in the first phase. It was focused on relations between road, traffic, and accident characteristics.

To determine which road and traffic characteristics would be examined, a number of hypothesisses on possible accident causes were formulated. These could be divided into two groups: one attributing accident causes to location characteristics and the other one explaining accidents by characteristics of road sections upstream of the accident location.

The analysis has been conducted separately for small road sections and junctions. In a following analysis attention has been paid to road stretches of greater length inclusive the junctions.

The results of the analyses have been compiled in three ways. Firstly, the results were grouped and statistically analysed. Secondly, it was examined whether the found relations fitted into existing opinions and theories on traffic unsafety. Thirdly, the interpretations were translated into measures and a policy on traffic safety.

The results of the three compilations can be summarized along two main lines: the complexity of a traffic situation and the expectancy of traffic participants. The effects of complexity were most evident at the traffic flow characteristics.

At low traffic flows (- 4000 motor vehicles per day) an increase of the traffic flow will be accompanied by an increase in accident risks. At 4000-8000 motor vehicles a day, an increase in traffic flows is more or less accompanied with a decrease in accident risks and at high
traffic flows the number of vehicles hardly influences the accident risks (although no traffic flows near the road capacity have been analysed).

Out of the above, it follows that the traffic should be concentrated as much as possible on roads with high traffic flows and abandoned from roads with little traffic. Traffic safety measures should be different for different roads. On roads with high traffic flows, continuity of road and traffic characteristics should be paid priority to. Disturbances should be avoided as much as possible and junctions should be alike. On quiet roads the effects of continuity are less prominent and measures for raising attention levels are likely to have more effect.

Value of the report
The report presents in an abridged and rather general way the results of an extensive study on the traffic safety of different traffic situations.

For two reasons the report is, in spite of it's discussion on traffic safety, not very useful for the determination of the safety of roads, locations, manoeuvres, and situations. Firstly, the report is rather general. For details is referred to previous reports. Secondly, the report points out that traffic safety depends on a number of variable circumstances on which the Carin system has no information.

Subjects
11.1 The possibility to use traffic safety criteria.
11.3 The (un)safety of certain roads, locations, manoeuvres, and situations.
11.4 The dangerous road situations a driver should be warned off.
Triggs, T.J. & Harris, W.G.
Reaction time of drivers to road stimuli, pp. 97
Monash University, Department of Psychology
Melbourne, Australia, 1982.

Summary
Aim of the study was to obtain representative data for reaction times on a range of stimuli.

Reaction time is not a fixed value but depends on the conditions under which stimuli are presented. The variables that influence the reaction time are discussed in the following.

The reaction time depends on the number of possible alternatives that can occur. For a reasonable number of alternatives there is a linear relation between the reaction time and the log of the number of alternatives.

Reaction time depends on the ease with which the one signal (stimulus) can be distinguished from the other.

Reaction time and the accuracy of the response are highly associated. Often humans can respond faster if necessary but at the cost of reduced accuracy.

Reaction time depends on "depth of processing" involved (amount of cognitive processing). For instance, purely physical changes in simple stimuli are coded faster than symbolic information and symbolic or pictorial information is processed faster than verbal or semantic information, as long as the symbols used are highly familiar and legible.

Reaction time depends on the association between input stimulus and response codes. Although some of the effects of the use of incompatible codes can be offset by significant practice, when the human is placed under stress the disadvantage of the incompatible code is again shown.

Reaction time depends on the expectancy and preparatory processes. It is almost self-evident that a subject's reaction will be faster if he is alerted to an upcoming stimulus and has had the opportunity to prepare to respond before the signal actually occurs.

A literature study has been carried out on recorded reaction times directly related to the driving environment. The literature study concerned laboratory-based studies, simulation studies, and in-vehicle measurements.

The values found in the laboratory studies varied strongly (+500-2200 ms), depending on the conditions (kind of stimulus, background distraction, and the like). The design response time standard of 2500
ms was found to be suitable.

In most of the simulation studies, subjects were required to brake after the presentation of an unexpected stimulus. The drivers' brake reaction times were found to vary from 500 to 1500 ms. These values are expected to be lower than in real life situations. Herefore are two reasons. First, the subjects only had to perform a simple stimulus-reaction task (in real life a driver has to perform many additional tasks and is the required reaction on a stimulus not always immediately clear). Second, the subjects were in an experimental setting and for that reason can be classified as having a reasonable level of alertness. Simple reaction times were found to increase reliably with age. Mean values of 438 ms were found for 15-19 year olds and 522 ms for 65-69 year olds.

In-vehicle measurements have been conducted both on closed tracks and on public roads. Often referred to in traffic accident and engineering literature are some early reaction time data reported by the Massachusetts Institute of Technology (M.I.T.) (1934). The reaction time when the driver responded to the brake lights of the leading vehicle was 640 ms on average, with 5% of the observations exceeding 1,05 s. A noteworthy result was that one driver in five had response times exceeding 1,0 s on occasion. The reaction times tended to be shorter for audible (warning) signals. Normann (1953) also found a 95% limit of the brake reaction times to be 1,0 s. However, his test subjects were alerted and young. Laurell and Lisper (1978) required subjects to react by pressing a switch on which their foot already rested. The mean reaction time to an auditory signal was 450 ms. This value increased after continuous driving over a long period. The increase was greatest for the inexperienced drivers.

The reaction times as presented above comprise of a time for the foot movement between accelerator and brake pedal. Mean movement times have been found of 149 ms for males and 194 ms for females for coplanar accelerator and brake pedals and 309 ms for brake pedals that are higher off the floor than accelerator pedals. The values were not significantly related to the lateral distance between the pedals.

No data have been found to confirm or deny that reaction times are related to speed.

Several observations of real world driving have been conducted. However, the results tend to be very much dependent on the measuring conditions: values varying from 479 to 4900 ms have been found. In spite of this the literature review did show that data obtained in unalerted conditions on rural roads yielded much higher reaction time values than the estimates from laboratory studies or when subjects were alerted.
The aim of the experimental work carried out by the authors was to expand the range of relatively unalerted reaction time situations studied in rural or semi-rural environments. Stimuli were presented on suitable crests or in horizontal curves, on which the point of the road was identified where car drivers could first observe the stimulus provided, and on level crossings where red lights were actuated on the approach of a vehicle. All tests were recorded with a video camera. A video time clock, accurate to one hundredth of a second, was used to facilitate the analysis. Stimuli presented to the drivers in the curve or on the crest were signs, police cars on the shoulder, vehicles protruding on the road with tyre change in progress, speed control through amhometers, and car following (measuring brake response times to the brake lights appearing on the leading vehicle).

The results of the experiments show a great variation (figures 30 - 36, tables 12, 13, 14). In general it can be stated that there exists no such thing as the basic response time of drivers on public roads. The response time greatly depends on the type of situation, the degree of urgency, and the speed of the vehicle. In more urgent responding situations, most unalerted drivers have shown themselves capable of responding in less than 2.5 s. An increase in response time can reliably be predicted for situations where the critical stimulus is not as discriminable, more complex in structure, or requires a greater change in cognitive set in order to be responded to. Driver response times can be expected to frequently exceed the commonly accepted design value of 2.5 s. Excluding the car following, seven of eleven situations produced 85th percentile values above 2.5 s (table 4), and four of these had values of 3.0 s or more. Discriminability of a stimulus played an important role in the recorded reaction times. During the day, the reaction times to flashing railway signals were approximately 50% higher than at night (statistically significant). The effects of vehicle speed are demonstrated by the amhometer speed control and railway-crossing data. Overall, drivers of higher speed vehicles responded faster than those at lower speed. This effect may not have been due to greater alertness levels only. Faster drivers may have adopted a different criterion for the urgency of braking required. Differences of up to 500 ms were found in the study. Urgency of the response situation has been found associated with the response time.
Value of the report
The thoroughness of the study, the many variables that have been paid
attention to, and the extensive literature study make this report
almost a handbook on reaction times. The impact of the report on this
literature study may be quite considerable. For one thing, it makes
clear that often used reaction times of 0.5 - 1.5 s only stand in
situations of great urgency. In other situations much longer reaction
times are to be expected.

Subjects
7.2 The reaction time on aural and visual route guiding messages

Figure 30: Amphometer braking response times at Beaconsfield site
(n = 35, mean = 2.46 s, standard deviation = 1.04 s,
skewness = +0.25); Source: Triggs & Harris, 1982
Figure 31: Amphometer braking response times at Dandenong North site (n = 100, mean = 2.45 s, standard deviation = 0.92 s, skewness = -0.03); Source: Triggs & Harris, 1982

Figure 32: Amphometer braking response times at Gisborne site (n = 85, mean = 2.54 s, standard deviation = 0.66 s, skewness = +0.34); Source: Triggs & Harris, 1982
Figure 33: Amphometer braking response times at Tynong site
(n = 485, mean = 1.75 s, standard deviation = 0.70 s,
skewness = +0.64); Source: Triggs & Harris, 1982

Table 12: Amphometer reaction time results;
Source: Triggs & Harris, 1982

<table>
<thead>
<tr>
<th>SITE</th>
<th>RESPONSE RATE</th>
<th>NUMBER OF RESPONSES</th>
<th>MEAN</th>
<th>STANDARD DEVIATION</th>
<th>SKEWNESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beaconsfield</td>
<td>30%</td>
<td>35</td>
<td>2.46s</td>
<td>1.04s</td>
<td>+.250</td>
</tr>
<tr>
<td>Dandenong North</td>
<td>24%</td>
<td>100</td>
<td>2.45s</td>
<td>0.92s</td>
<td>-.027</td>
</tr>
<tr>
<td>Gisborne</td>
<td>12%</td>
<td>85</td>
<td>2.54s</td>
<td>0.66s</td>
<td>+.340</td>
</tr>
<tr>
<td>Tynong</td>
<td>31%</td>
<td>485</td>
<td>1.75s</td>
<td>0.70s</td>
<td>+.637</td>
</tr>
</tbody>
</table>
Figure 34: Cumulative reaction time distribution for railway level crossing signals for both the general driving population (n = 171, mean = 1.18 s, standard deviation = 0.36 s, skewness = +1.36) and a rally driver group (n = 91, mean = 1.14 s, standard deviation = 0.34 s, skewness = +1.80); Source: Triggs & Harris, 1982

Figure 35: Cumulative reaction time distribution for railway level crossing signals during daytime for the general driving population (n = 104, mean = 1.77 s, standard deviation = 0.84 s, skewness = +1.22); Source: Triggs & Harris, 1982
Table 13: Railway level crossing reaction time results;  
Source: Triggs & Harris, 1982

<table>
<thead>
<tr>
<th>CONDITION</th>
<th>RESPONSE RATE</th>
<th>NUMBER OF RESPONSES</th>
<th>MEAN</th>
<th>STANDARD DEVIATION</th>
<th>SKEWNESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Night (normal drivers)</td>
<td>171</td>
<td>1.18s</td>
<td>0.36s</td>
<td>+1.36</td>
<td></td>
</tr>
<tr>
<td>Night (rally drivers)</td>
<td>91</td>
<td>1.14s</td>
<td>0.34s</td>
<td>+1.80</td>
<td></td>
</tr>
<tr>
<td>Night (composite)</td>
<td>262</td>
<td>1.16s</td>
<td>0.35s</td>
<td>+1.44</td>
<td></td>
</tr>
<tr>
<td>Day (normal drivers)</td>
<td>70%</td>
<td>1.77s</td>
<td>0.84s</td>
<td>+1.22</td>
<td></td>
</tr>
</tbody>
</table>

Figure 36: Cumulative reaction time distribution for brake light signals on leading vehicles when car following (n = 42, mean = 0.92 s, standard deviation = 0.28 s, skewness = +0.62); Source: Triggs & Harris, 1982

Table 14: 85th percentile reaction time values;  
Source: Triggs & Harris, 1982

<table>
<thead>
<tr>
<th>Condition</th>
<th>Reaction Time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C.R.B. &quot;Roadworks Ahead&quot; Sign</td>
<td>3.0s</td>
</tr>
<tr>
<td>Protruding vehicle with tyre change</td>
<td>1.5s</td>
</tr>
<tr>
<td>Lit vehicle under repair at night</td>
<td>1.5s</td>
</tr>
<tr>
<td>Parked Police Vehicle</td>
<td>2.8s</td>
</tr>
<tr>
<td>Amphotometer: Beaconsfield</td>
<td>3.4s</td>
</tr>
<tr>
<td>Amphotometer: Dandenong North</td>
<td>3.6s</td>
</tr>
<tr>
<td>Amphotometer: Gisborne</td>
<td>3.6s</td>
</tr>
<tr>
<td>Amphotometer: Tynong</td>
<td>2.54s</td>
</tr>
<tr>
<td>Railway crossing: Night (General Population)</td>
<td>1.50s</td>
</tr>
<tr>
<td>Railway crossing: Night (Rally drivers)</td>
<td>1.50s</td>
</tr>
<tr>
<td>Railway crossing: Day</td>
<td>2.53s</td>
</tr>
<tr>
<td>Car following</td>
<td>1.26s</td>
</tr>
</tbody>
</table>
Watts, G.R.
The evaluation of conspicuity aids for cyclists and motor cyclists
Transport and Road Research Laboratory, Vehicle Safety Division
Crowthorne, England, 1980
in: Oborne, D.J. & Levis, J.A.
Human factors in transport research - volume 1.

Summary
The paper reviews test methods that have been used to evaluate
conspicuity aids for cyclists and motor cyclists. Results are given
for daylight tests on a number of clothing items and vehicle
attachments using a peripheral detection task.

A survey of published literature had revealed six methods for the
evaluation of the effectiveness of conspicuity aids and materials.
The first method is the registration of the detection and recognition
time. The time taken from the presentation of an object to its
detection is often used as a measure of conspicuity.
The second method uses subjective assessment. In this method subjects
make absolute or comparative judgements, usually while looking
directly at objects. Paired comparisons, magnitude estimations and
category rating scale techniques have been used.
Recall of a test object is the third evaluation method. In this test,
subjects are asked whether they recall having seen a specific object.
For a quick evaluation of visibility a visibility meter can be used.
With detection distance measurements, it is possible to determine the
distance at which an object can be detected.
Finally, accident studies can be used to validate the results of
experimental work.

It was decided to use peripheral detection technique to evaluate cycle
clothing and attachments, because the experimental conditions
resembled a common cycle accident situation.
Tested were the conspicuity effects of a fluorescent orange flag, a
fluorescent yellow panel, a fluorescent orange helmet, a fluorescent
orange waistcoat, a fluorescent yellow waistcoat, a fluorescent orange
jacket, a non-fluorescent yellow jacket, and a non-fluorescent dark
blue jacket.

The results pointed out that against a dark background, the yellow
jacket and the fluorescent orange helmet resulted in significant
larger detection distances. Against a light background no significant
effect was found.
Additional luminance measurements showed that the head and shoulder
were respectively 7 and 5 times brighter than the front of the jacket. Therefore fluorescent materials should preferably be placed on the head or shoulders of cyclists and motor cyclists.

Value of the report
The results of this report are hardly of any value to this literature study. The described validation of experiments through accident studies is difficult as the number of accidents is limited and often too little information is known. More important are the described evaluation methods for conspicuity, which may be helpful when starting up testing programmes.

Subjects
7.3 The interpretation time for each of the route guiding pictogrammes
Summary
In the report a systematic account is given of the possible applications of electronic aid in road traffic, the current applications and the gaps or areas where improvement could be made. The emphasis is laid on the role electronics can play in improving road safety.

Data on the travel behaviour (destination, trip motive, route, flow, speed, density, and the like) are momentarily obtained from periodic surveys among samples of the population or by monitoring roads. For the collection of data various countries are planning to make their network denser and collect more data automatically. The author questions this trend and favours a more economic way of collecting data. He thinks it better to collect only a limited quantity of absolute necessary basic data permanently and to collect other data from ad hoc samples. The best way of passing on information to drivers seems the radio traffic service with more or less coded messages that can be decoded by the receiving radio system. Travel behaviour could be influenced directly through electronic vehicle identification. Thus a certain category of vehicles could e.g. be denied access to certain areas.

At the level of traffic behaviour, electronics could help the authorities to distribute and guide traffic flows and detect hazards (traffic control) and to help individual road users through information on routes, recommended speeds, the state of the road surface and so on (assisting road users). Momentarily, many different systems are being developed. However, hardly any of the traffic control systems have been evaluated on their effects, particular on road safety. The majority of road user assistance systems are still in their experimental stage. The advantages and disadvantages of aural and visual presentation of information have still to be investigated. Two-way communication systems provide more scope for individualisations as compared with the one-way systems.

The manoeuvring behaviour can be assisted through electronic devices which can even take over certain tasks. The applications of systems that already exist or are being developed,
are in the field of cruise control, lateral position control, longitudinal guidance, collision avoidance, anti-locking, steering wheel movement control and general vehicle monitoring and warning. The possibilities of taking over the driver's tasks should be considered further. Special attention should be paid to possible risk compensating behaviour and the possibilities of correcting malfunctions.

During an accident, electronic devices can activate a mechanismus that protects vehicle occupants. After a crash electronic aids can be used for communication to alert emergency services. This aid can be enlarged in the near future. Electronics can also be used for supervising assistance.

Often the incorporation of electronics causes some problems. Herefore are three reasons. First, input data can not always be measured sufficiently reliable.
Second, for data processing, which includes a good weighing and decision making, a thorough knowledge is required of the traffic and the way in which intelligent systems transform input into output. Furthermore, in order to avoid incorrect decisions, allowance has to be made for exceptions.
Third, the output has to be processed in some form for further use. If the system is not human, an other system has to be activated. This does not necessarily have to be an electronic system, although mechanical systems have the disadvantage of being much slower and less reliable as compared with electronical ones.
If the user is human, allowance has to be made for the specific problems humans have when processing information: problems of capacity, of discrimination and interpretation and of motivation.

Problems of capacity
The human brain has only limited space available for data processing, thus humans are inclined to choose all sorts of suboptimal solutions. This can be overcome by representing the problem in the optimum way and applying a suitable but complex decision rule.

Problems of discrimination and interpretation
Perceptual quantities which hardly differ can cause problems of discrimination. If the information is relevant to several traffic processes, a problem of interpretation can occur.

Problems of motivation
Information which is not confirmed by the user's experience can result in the road user ceasing to obey instructions and recommendations.
Distinction must be made between tasks performed consciously and tasks performed perceptually-motorically. In the latter case, information designed for consciously processing makes less sense.

Value of the report
The application of electronics in road traffic is dealt with so generally that the value of the report for this literature study is only very moderate. The remarks on the limitations of the human brain might be of some help.

Subjects
4.1 The distraction of drivers from their driving task by the presentation of aural route guiding information (general)
4.2 The distraction of drivers from their driving task by the presentation of visual route guiding information (general)
11.1 The possibility to use traffic safety criteria. The possibility and desirability of accountance for external circumstances (general)
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