Safety effects of in-car telematics: a checklist

Determining possible adverse effects of telematic systems on the driving task

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Contents

1. Introduction

This report is part of a project instigated by the Transport Research Centre (AVV) of the Dutch Ministry of Transport and Public Works. The project is aimed at investigating the effects on road safety of various applications of telematics intended to support the driver.
Apart from AVV, who has commissioned the project and participates in some of the work, the project is carried out by three institutes:
- TNO Human Factors Research Institute.
- Traffic Research Centre of the University of Groningen (TRC).
- SWOV Institute for Road Safety Research.

During the first two stages of this project the safety effects of single Advanced Transport Telematics (ATT) systems have been investigated in both a number of theoretical studies and a series of experiments. The overall aim of this research is to provide policy makers with a well-based tool to assess the safety-effects of existing and new telematic systems in road vehicles. The project must result in a set of guidelines and methods to identify potential safety hazards that single or multiple applications of these ATT systems may produce.

The general setup of this project contains three or four stages:
- At first a checklist is defined that summarises available knowledge on known safety effects and diagnoses which part or function of a given ATT device may prove unsafe or doubtful.
- The second step is the definition of standard procedures for laboratory testing to produce a verdict on the ATT device or parts of the device for which the checklist was inconclusive.
- The third step determines if and what modifications of the ATT application will be necessary.

However, the overall results of the project so far show that existing knowledge still only provides fragmented knowledge and not a clear, comprehensive picture. Therefore, as long as this situation remains, the second step of the scheme (laboratory testing) should be complemented by another possible testing method: full field testing.
During the second stage of the project, a first concept of the checklist was introduced. This checklist mainly considers overload and underload as sources of possible adverse effects of ATT and also the possible effects of interference of two systems that operate simultaneously.
In the current report an attempt is made to reorder this checklist according to the aspects of visual- , mental - and physical task load and also to assemble basic material necessary to extend the checklist with aspects of counter-productive behavioural adaptation. To that end, an expert meeting was organised to obtain directives on which way to go with counterproductive behavioural adaptation. The results of this meeting were twofold:
- a structuring matrix, based upon characteristics of ATT applications and characteristics of the traffic environment;
- a list of psychological mechanisms relevant to behavioural adaptation.

Subsequently, it has been attempted to interpret relations between the items of the latter list with the aid of a general model: the model of situation awareness. According to this model it is concluded that schemata (models of the relation between surrounding phenomena), scripts ('automated' sequences of actions) and the ways these are generated or changed, play an important role in behavioural adaptation. The paper concludes with a recommendation for a three-step procedure to obtain a checklist on counter-productive behavioural adaptation:

- analyse the contents of schemata and scripts and determine common characteristics;
- determine which characteristics are indispensable for safe driving behaviour;
- determine which of the characteristics may be influenced by ATT applications and in which way.

2. The revised checklist

2.1. General remarks

The following checklist is completely derived from the checklist reported in a former report of Heijer (1997) and has the same structure, that is: the list consists of a series of questions that signal a *possible problem* with a *confirmative answer*.
It should be emphasised that such a confirmative answer to any *single* question does not necessarily imply that the ATT device is unsafe: at most, it signals a point of extra attention. If the application of the checklists leads to many such points however, serious doubt about the safety of the device should be raised and further investigation is indicated.

This applies particularly *to underload* checking: the questions often refer to functions that, if carried out with 100% reliability, by itself constitute a relief of the driver's task rather than a threat. However, a driving task from which *too many* elements are taken from the driver's direct control (putting the driver in a supervisory role for those aspects) does not provide sufficient stimuli to keep the driver alert in prolonged driving.

2.2. Visual taskload

Overload checking

- Do any visual messages require more than three glances of at most one second?
- Can visual messages be seen well in extreme lighting conditions (at night, in heavy sun) => is there *no* automatic adaptation to external lighting conditions?
- Does any visual display *fail* to comply with any of the legibility conditions:
- viewing distance 70-75 cm;
- character height 6,4 mm or larger;
- minimum 5x7 matrix per character;
- character width-height ratio 0,7-0,8;
- horizontal character spacing 75% of character width;
- vertical spacing 35%-100% of character height;
- use only simple fonts without serifs and italics;
- do not only use capitals on messages longer than three words

Underload checking

- Does the system take care of obstacle detection?
- Does the system take care of signal input?

2.3. Mental taskload

Overload checking

- Are any messages exclusively system-paced an short-lived and can not be repeated or switched off at drivers request?
- Do any messages require extended decision making?
- Are any messages confusing or ambiguous?

- Is control of the system context dependent => are there multi level menus?
- Do any verbal messages not comply to:
- the use of commonly familiar words only;
- a limited set of phrases.
- Are any haptic messages confusing or ambiguous; is the sensory message always distinguishable from random environmental inputs?

2.4. Physical task load

Overload checking
- Is sometimes immediate manual control required (e.g. deactivating an alarm)?
- Is the loudness of the message outside the limits:
- 15-25 dB over background noise;
- never over 115 dB;
- Are the alarms used outside the following specifications:
- frequency range 500-2000Hz
- repetition rate 1-8 1/sec
- non-speech messages only
- Are some controls difficult to reach or to handle?
- Are some controls difficult to identify?
- Do some controls require visual feedback to operate (e.g touch screens) underload checking?
- Does the system take over pedal control?
- Does the system take over part of manual control?
- Does the system stimulate driving at night?
- Does the system tempt the driver to abandon resting?
- Does the system affect behaviour when the driver is in a unfavourable state (fatigue, drugs)?

Counterproductive adaptation checking
- Is the device explicitly designed and presented as contributing to safer driving?
- Is the device explicitly presented as something that watches over you?
- Is the effect of the device continuously present in the driver's task environment?

2.5. Consequences of simultaneous application of multiple ATT systems

In the previous report, a checklist was conceived to check for the consequences of multiple, possibly interfering, ATT systems. This checklist has been slightly modified to comply with the general idea of the checklist procedure: producing 'warning flags' rather than outright acceptation or rejection of the applications under scrutiny. Because the interaction between various aspects of two simultaneously operating systems leads to a number of subsequent 'if-then' decisions, the list is presented in the form of a flow chart rather than as a sequential checklist:

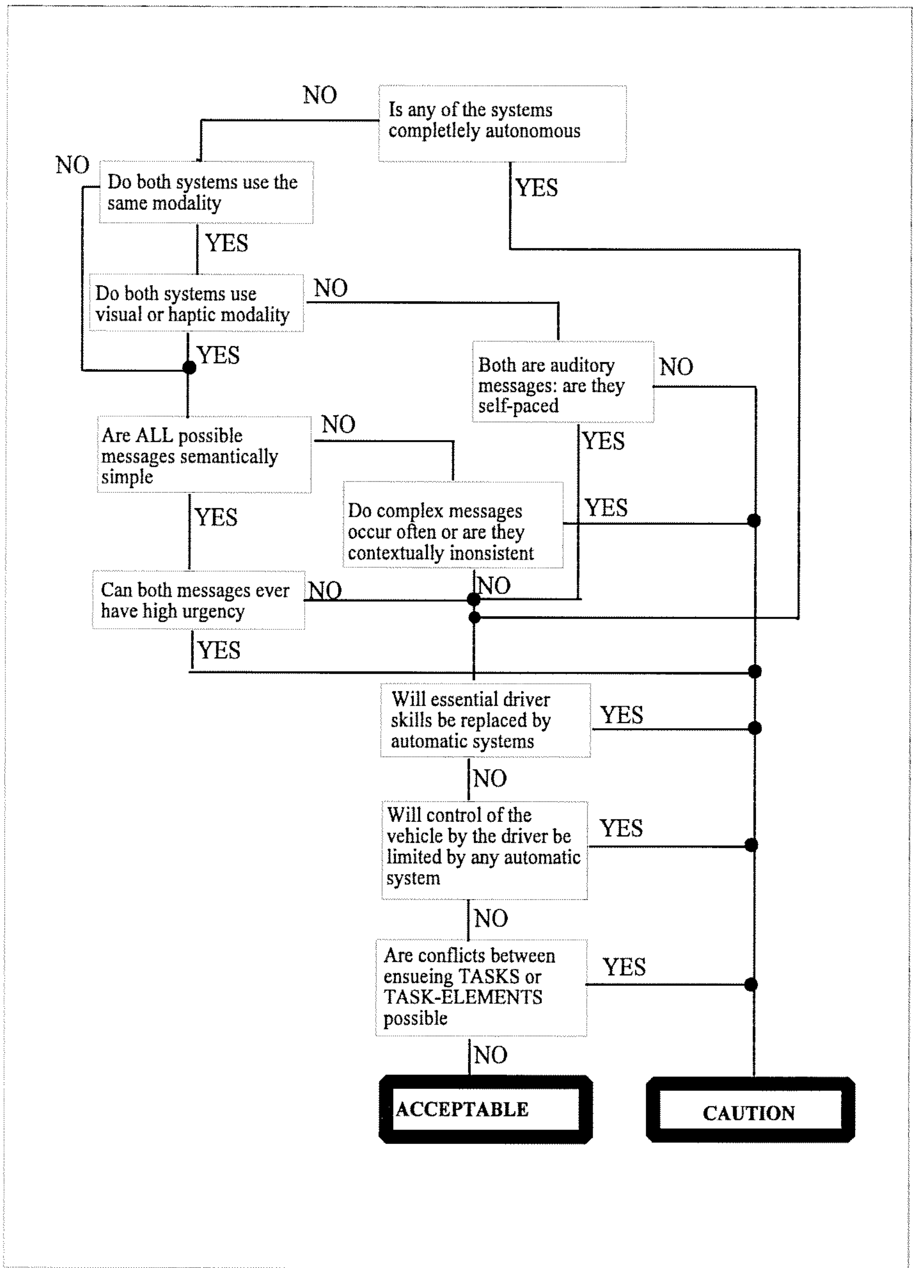

Figure 1. *Checklist for the assessment of interference of two systems.*

3. Counterproductive behavioural adaptation

3.1. Introduction

One of the possible effects of telematic modification of the driving task is long term behavioural adaptation. Some forms of this adaptation may be detrimental to traffic safety and therefore have to be considered in this study. A previous literature search proved that only the most superficial criteria for counterproductive adaptation are reported. As a consequence this small, scale study will not produce an actual checklist on this item but only an inventory of possible components and their mutual relations. In order to prepare such an inventory, an expert meeting was instigated to provide a first basis from psychological principles. Furthermore an attempt is made to combine insights from the field of man-machine systems to obtain more detailed descriptions of possible adaptation mechanisms.

3.2. Results of the expert meeting

3.2.1. *Proceedings*

The expert meeting has been reported more extensively in a separate report; here it suffices to introduce the most significant results from that meeting. The first action of the meeting was to establish general types of mechanisms for behavioural adaptation: the human part of the process.

The second action was an inventory of external influences: the characteristics of ATT applications that may play a role in behavioural adaption.

The third action was dubbed "ordering principles" but actually mainly addressed an extension of the external influences by introducing short- and long-term aspects of the traffic environment.

The meeting decided that a possible application of these three steps to obtain insight in long term behavioural effects would be the following sequence:
- start with the functional definition of one or more concrete ATT systems according to action 2;
- make an inventory according to action 3 of possible effects on the traffic environment that can be induced by the intended effects of the ATT systems (concentrate on the last two levels: interaction between road users and individual driving task);
- determine which of the behavioural characteristics listed in action 1 correspond closest to those found in the previous step and try to establish their long term implications.

The fourth action the meeting took was instigated by the question whether the behavioural principles listed in action 1 were really complete. It was decided that these principles could perhaps be derived from the capita in fundamental publications of psychology. These capita would than be ranked by the members of the meeting with respect to relevancy for counter-productive behavioural adaptation.

3.2.2. *Considerations*

The first three actions produced three main themes: individual behavioural determinants, ATT system characteristics and road/traffic characteristics. These three themes can be interpreted as three independent dimensions, forming a three-dimensional space or matrix in which the phenomena of long term adaptation can be described. This spatial or matrix model must be used with care however because even *within* a single 'dimension' the listed characteristics are often separate but interdependent entities. This is especially true for the dimension of behavioural mechanisms. For this reason, instead of stepping through all the separately listed items of the behavioural dimension, it is proposed to organise the third step of the procedure according to modelling considerations that explore the possible causal relations between the items.

3.2.3. *Results of the meeting: general dimensions*

The members of the meeting produced the following description of the three dimensions mentioned before:

Dimension 1: characteristics and behavioural mechanisms of the individual driver

- Short term learning (cognitive and procedural, affected by reward/punishment).
- Adaptation effects with components:
  - unintended consequences;
  - deliberate misuse;
  - long term learning effects.
- Changes in traffic-interactions (reduction of predictability of traffic behaviour due to unusual behaviour induced by ATT).
- Loss of motoric of cognitive skills.
- Habit forming/dependency on characteristics of specific system/design.

Dimension 2: characteristics of ATT systems and their interfaces with the driver

- Type of telematic system:
  - advisory;
  - suggesting/supervising;
  - controlling or autonomous.
- Reliability of the system.
- The internal consistency of operation of the system.
- Relevancy of the functionality of the system (for driver and road authority).
- Nature and frequency of the feedback the system provides.

Dimension 3: characteristics of the traffic environment

- Behavioural aspects (dimension 1).
- System characteristics (dimension 2).
- Traffic characteristics in terms of:
  - effects on mobility;
  - effects on the traffic flow;
  - effects on interactions of traffic participants;
  - effects on the individual driving task, traditionally distinguishing: strategic, tactical and operational level.

3.2.4. *Results of the meeting: elaboration of behavioural topics and ranking*

According to action 4 of the meeting, the list for the first dimension has been extended along the lines of textbook capita. This produced the following topics:

- Attention.
- Adaptation/compensation.
- Attitude with respect to:
  - mobility;
  - choice of vehicle;
  - choice of speed;
  - violation.
- Attribution (in the sense of assigning causes of events to personal or situational characteristics).
- Decision making.
- Reward or punishment/convictions.
- Observation/detection:
  - visual;
  - recognition of danger.
- Emotional state.
- Experience.
- Errors, recuperation and misuse.
- Acting- protocols, schemes.
- Learning (long- and short term /aptitudes and cognition).
- Motivation (safety versus other motives).
- (Moral) values.
- Sensation seeking.
- Role behaviour.
- Social skills, social interaction.
- Perceptive- cognitive- and motor skills.
- Fatigue.
- Expectations.
- Workload.

Prioritising of these factors according to their relative importance for counterproductive behavioural adaptation by the members of the meeting resulted in a wide range of different opinions; too wide a range in fact to be useful for a modelling approach.
For this reason, it is attempted to adopt an existing model to define structural relationships between (as many as possible) items in the list along with characteristics of the other two dimensions and the driving task of the individual driver. This model must make it easier to infer mechanisms of long term adaptation, which can then be judged on their (counter)-productivity.

3.3. **Modelling relationships between the topics**

3.3.1. *The driving task*

The model that is proposed here as a general framework for the evaluation of psychological factors is strictly descriptive and derived from ideas both from cognitive psychology and from the field of man-machine systems: the models of Situation Awareness as proposed by Endsley (1988a; 1988b).

The model has been developed to study the behaviour of aeroplane (fighter)pilots and air traffic controllers. It does not contain any details of the specific tasks or functions of these operators however: it is constructed from existing theories and models regarding general human behaviour in controlling tasks. The model is therefore believed to be valid in similar, highly constrained, man-machine tasks like the driving task. The only addition to the model specified by Endsley is, that the general specification 'environment' with which the human operator interacts has been divided into 'vehicle' and 'traffic system'.
Figure 2 depicts this basic framework.

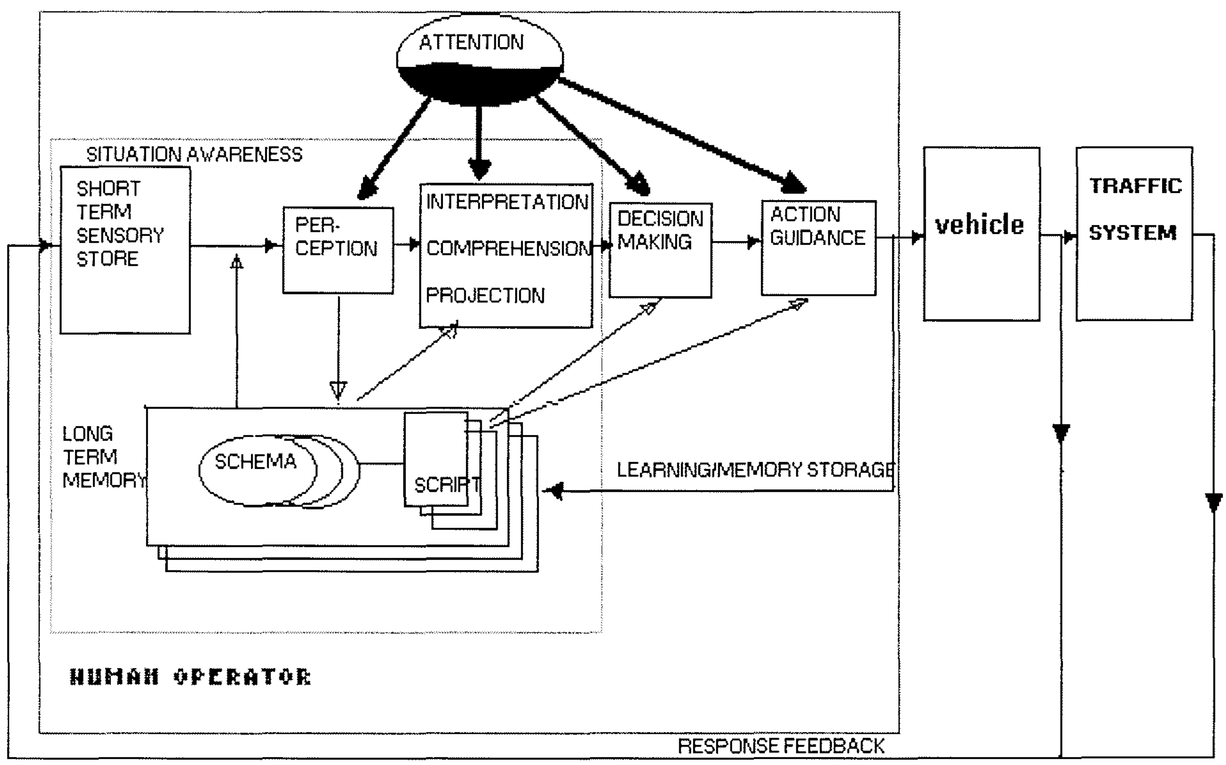

Figure 2. *Situation Awareness diagram, adapted from Endsley (1988).*

The main virtue of the diagram in our context is that it depicts the interactions between a number of functions and will allow us to consider the influence of short term changes and long term modification of those functions.
In order to do so, we will now consider the separate blocks of the diagram and mainly focus on those terms that influence long term adaptation.

3.3.1.1. *Short term sensory store*

This part of the diagram relates to a function of the human operator where all data of sensory input is supposed to be temporarily stored in an unstructured way. How this hypothesised function can be influenced by psychological factors is unclear from Endsley's description. This influence could be relevant if the effect would be a partial loss of data, but since there is no insight in possible conditions that may cause such a loss, this function cannot contribute to the assessment of long term adaptation (at least for now).

3.3.1.2. *Perception*

Perception plays a crucial role in the process of virtually any man-machine task. As is indicated in the diagram, perception is not considered a 'passive' observation of the surrounding system, but must rather be considered an interactive process (Neisser, 1976) between long-term memory concepts (schemata) regarding the surrounding process and observation of the actual process. Thus, starting at an arbitrary point in the iterative process, a preconception about the traffic process first determines the type and priority of traffic parameters that will be observed and the actual observations may in turn lead to different priorities, the choice of different parameters or a more appropriate traffic concept (different schema), thereby producing an altogether new set of parameters and priorities, etc.
Long term learning processes that may be induced by telematics thus may affect both the types and priorities of characteristics in the surroundings and the idea about their relationship. If we only consider possible adverse effects they can be termed as follows:
If these learning processes change schemata in such a way that important characteristics in the environment receive less or no attention, then this must be considered adverse adaptation.
(As an example: an important characteristic can be the distance to a vehicle in front).

3.3.1.3. *Interpretation, comprehension, projection*

These three items will partly be considered separately since they represent mechanisms that may be affected differently by telematic functions.

Interpretation and comprehension
The schemata from long term memory are supposed to contain a series of characteristics present in the environment and a concept about their causal relationship. Together they constitute a *model of the traffic state and state changes*. Such a model contains at least different parts for:
- Own behaviour: based on both formal (external) and informal (self generated) rules and preferences.
- Behavioural goals. These goals contain short term goals for the tasks at hand, but also long term goals that determine a.o. preferences for certain types of schemata and scripts (aggressive- , defensive- or sporting driving etc.).
- Behaviour of the own vehicle, including external conditions for operation.
- Generalised behaviour of other traffic participants in the direct vicinity.
- Generalised traffic state in a wider vicinity; intermediate term expectations.

The model underlies the interpretation and comprehension that is: it is attempted to relate actual parameter values and changes in the environment according to the relations defined by the model. The model is thought to be constructed in such a way that interpretation and comprehension are swift enough for adequate responses in most traffic conditions.

States or state-changes that cannot be interpreted along the pathways of the model will generate incomprehension at first, followed by either confusion or remedial actions. The remedial action often consists of starting a process to select an alternative schema or script that better fits the perceived state and state changes.
In any case, incomprehension at least results in longer processing times and hence the possibility of tardy or inadequate responses.

Projection
The term 'projection' can also be interpreted as 'anticipation' or 'prediction': it refers to the use of the model or schema to construct an expected state of the traffic in the near future. That this anticipation is necessary can be understood by the following reasoning.

However fast the internal model may operate, it requires a certain amount of operation time. The same goes for all other steps of the diagram inside the block labelled 'human operator'. This leads in effect to a certain time lag between observation and action: the reaction time. This time lag, as in all feedback systems, may cause instability which in traffic soon translates into accidents. There are several ways to compensate for this time lag.
The first is, to adopt a driving strategy that provides sufficient headway to compensate for the timelag: a purely reactive type of control. In this case, in order to avoid unpractically large headways, the time lag can be minimised by concentrating on very few control parameters (e.g. only the gap with a vehicle in front).
Since this mode does not involve elaborate processing it is supposed to generate a relatively low task load. Threats to safety in this mode will therefore not primarily arise from overload, but from the inherent limitations in stability of this controlling behaviour.

The second way to compensate for the time lag is to base decisions and actions on a *predicted* traffic state rather than on a directly observed state. The generation of this predicted state, using all the elements in the afore going model, is the aim of the projection function.
This mode of operation allows a larger number of control variables to be considered and a more complex driving strategy. Even if the processing time is larger, this can still lead to stable control behaviour because the prediction time can be adjusted at the same time (within reason of course). Moreover, if the predictions are slightly wrong, there is usually enough time to detect the error and to compensate.
Where this control mode is more stable than reactive behaviour from a systematic point of view, it involves much more processing and can therefore cause a higher task load. However, it should be pointed out that a linear relationship between task complexity and task load does not necessarily exist.

Effects of long term adaptation on interpretation, comprehension and projection
There are many 'handles' to this part of the diagram with respect to long term adaptation. Many of these handles are related to changes in the models that result from long term adaptation and in this way also change interpretation, comprehension and projection. In the context of this limited research it is impossible to produce an exhaustive list of possible modifications and effects. The following list of changes to components of

the model must therefore be treated as a series of examples rather than as an exhaustive collection.

Changes to the model of own behaviour
ATT applications may selectively change the emphasis or significance of certain external rules, leading to a change in the internal rules or types of goals.
Whether this change will have counterproductive implications for behaviour is determined by the particular functions of the ATT application, possibilities for compensation, social acceptance etc.
As an example: devices that provide early warning for radar emissions (police speed checks) may lead to an adaptation to higher (illegal) speed levels.

Changes to the model of own vehicle
ATT applications that modify the responses of the vehicle to control actions eventually will lead to changes in the model, or, the expected behaviour of the vehicle.
If the actual changes are effective only in rare events, learning the nature of the changes will be slow and the model can become imprecise, with possible adverse consequences. This may e.g. be the case with Anti Blocking Systems for emergency braking.
Conversely, a different detrimental effect can arise from changes that only *fail* in rare cases but have become expected.
As an example: devices that automatically monitor and regulate the time gap between vehicles (AICC) will induce reliance on this monitor function; if the automatic function fails sporadically, and constant monitoring of this gap has been removed from the behavioural patterns of the driver, an accident may occur.

Whether or not certain modifications of vehicle responses lead to counter-productive adaptation depends also on the personal long term goals. Particularly in the case that a driver adheres to aggressive personal goals (e.g. high speeds), certain modifications can lead to reinforcement of this aggressive behaviour. Conversely, a more moderately inclined driver can possibly use the same modification to more benign effect. This reasoning leads to the conclusion that long term adaptation will differ from one individual to the other, thus making the estimation of long term effects even more complex. At least we will have to consider different effect between general groups of drivers.

Changes to the model of behaviour of other road users
Both previous parts probably also play a role in the construction of the models for prediction of the behaviour of other road users. ATT applications that modify the outwardly observable behaviour to such an extent that it does not completely fit, any of these models may cause the prediction to fail. Especially in case of a mixed population of equipped and non-equipped drivers, problems with the predictions may arise when determining which driver will display which (equipped/unequipped) behaviour. This may lead to an increase of prediction errors and ultimately to more accidents.
The latter is actually a case of established benign adaptation that is rendered counterproductive by the ATT application.
As an example: certain concepts of AICC that control the time gaps between vehicles have shown more frequent braking (when compared to the human driver). Since other drivers are alerted by the changes in speed, but can not

easily appreciate the reason (which is: only increasing the gap) such a system may more frequently lead to a general disturbance in the traffic stream.

Changes in the representation of the general traffic situation
ATT applications may permanently affect the representation of the general traffic situation adversely. This can be caused by focussing attention on traffic aspects that are not currently the most important aspects.

3.3.1.4. *Decision making*

The previous stages in the diagram produce an assessment of the state of the traffic context and projection of the own position in this state, together with a desired position. Decision making addresses the process of choosing an action or a series of actions from a repertoire of scripts, that will most likely (according to a subjective judgement) produce the desired state.
This part of the diagram can be affected by long term adaptation by modifications to the repertoire of scripts (automated sequences of actions) and by changes in the criteria to apply certain scripts. This will often be induced by changes in the previous stages. For instance: changes in vehicle behaviour due to ATT systems translate into changes in the model of the own vehicle (possibly also into changes of the perception of the role of driver). This may lead to permanent changes in some scripts or cause certain scripts to fall into disuse.
Such changes can be considered counterproductive if they involve the loss of skills that may still (rarely) be necessary.
This effect is somewhat similar to that of underload; however, in the case of underload, skills are not lost: they do still exist but are not invoked or invoked too late because of lack of attention or arousal.

3.3.1.5. *Action guidance*

This part of the diagram represents a form of supervisory feedback control on the execution of scripts, for instance the monitoring of control limits. Such functions can be partially taken over by automatic systems, which, in the long run, may imply a similar loss of skills as mentioned in the previous paragraph.

3.3.1.6. *Long term memory processes*

With this term a series of processes is indicated that somehow build, change or erase memory structures. Insofar as we understand these processes the most important one for long term adaptation is commonly referred to as learning. The expert group has distinguished cognitive and procedural learning, which in the context of the framework can be translated as:
- procedural learning: the formation of the scripts.
- cognitive learning: the construction of the schemata.

Learning and forgetting are considered the basic ingredients of long term behavioural adaptation since it determines the way the schemata and scripts are constructed; these long term memory processes underlie all changes dealt with in the previous paragraphs.
In the diagram, learning is simply associated with feedback of the state of the environment and is not specified further. In this, the diagram is probably too simple: the influence from the environment mostly enters by way of the

perception and not directly. As a result, long term memory processes and perception are closely coupled, which complicates these matters considerably. We now have the following cycle: perception is influenced by schemata, the formation of schemata and scripts depend on long term memory processes and the long term memory processes are directed for an important part by perception.
This cycle has implications for long term adaptation. One of the consequences can be, that people will much sooner adapt to changes (by ATT devices) in characteristics that are frequently sampled in the perception-routine of a schema than to changes in characteristics that are less frequently sampled or excluded. So the adaptation on the individual level will partly be directed by idiosyncrasies in the schemata, which means that we can only predict adaptation reasonably on common factors. Some of these factors are part of the list produced by the expert group.
Again as examples rather than as an exhaustive summary such phenomena may be:

- consistently and frequently occurring related events of various nature: events that occur rarely can hardly be learned by experience, but can be adapted to by:
- inference by functional parallels or analogues or;
- attribution.

Furthermore part of the control of traffic behaviour depends on:

- rewards and punishments.

A more consistent review of current knowledge on how, why and under which conditions memory structures are conceived or forgotten will be fundamental to the construction of a theory on counterproductive behavioural adaptation (and hence a checklist).

3.3.1.7. *Attention*

In the diagram, Endsley (1988) has depicted attention as a limited resource (a reservoir) that may be distributed in varying amounts over the functional 'blocks' in the diagram. Depending on the relative amount of attention received, the particular function is performed more or less intensively. Whether or not this concept of a limited resource is considered completely valid, it can be stated that the *time* available for the performance of all functions is certainly limited by the dynamic characteristics of the tasks that have to be performed. Many of the tasks involve both decision making and some sort of motoric action within limited time intervals. Under those conditions it seems reasonable to assume that the amount of attention received by any of the tasks will be (more or less) reflected in the fraction of the available time spent on the task. Thus the function of attention in the diagram in this type of man-machine systems can be interpreted as the relative distribution of time over the different functions within the (variable) time-interval between actions or decisions demanded by the current (sub)task. In this interpretation, distractions are seen as tasks irrelevant to the main tasks, limiting the time available for relevant tasks.
Long term behavioural adaptation on this level can work in two ways: by changing the relative time allotted each functional block and by inserting or deleting subtasks. In the first case, change of relative time, the effect can be considered counterproductive if time is withdrawn from a function that already needed all time available.

The effect of the second case, inserting or deleting subtasks, will generally result in changes in the task load and therefore be assessed under that chapter.

3.3.1.8. *Other factors*

All previous parts concern the operation of a more or less rationally constructed driver model. The emotional state of the individual is an example of a factor that can severely influence the operation of one or more of the rational functions. Long term counterproductive adaptation in this case means that certain actions of ATT devices permanently and consistently evoke emotions that lead to undesired changes in individual behaviour.
A similar reasoning can be constructed for the influence of motivation and convictions since long term changes of these parameters are often linked to emotions.

3.3.2. *External parameters affecting the driving task*

External parameters in this context are those parameters that represent generalised influences from the environment e.g. formal traffic rules and regulations and actions and generally accepted but informal behavioural rules. Telematic applications can be accompanied by specific changes in formal rules and may also change the informal rules by evoking large scale responses in the populations. The following paragraphs treat some of these changes, again more as examples of what is possible than as an exhaustive list.

3.3.2.1. *Attitudes*

There are several topics in the list that may be subject to long term adaptation. For instance attitudes with respect to driving behaviour and driving in general may change under the influence of telematic support. Adverse effects in exposure to danger that could result from an increase in driving ease and comfort are e.g. that a higher speed is chosen or that the car will be used more frequently. This kind of effect also depends on the nature of the telematic system: if the support only functions on motorways and not on rural roads and inside build-up zones the adverse effect may be smaller than when the support always works.

3.3.2.2. *Attribution*

Attributions may change under the influence of (repeatedly) observed or inferred causalities. The effects of changes in the individual behaviour of a large group of drivers or vehicles has already been treated in the previous chapters. However, attribution also concerns the actions of other actors that are important to driving: road authorities, police, judicial system, public opinion. Application of telematics can *actually* change the actions, preferences, attitudes of these actors more or less permanently which may lead to changes in attribution that are not necessarily counterproductive. There may also be *inferred* changes in action that may lead to counter-productive behaviour: e.g. the reasoning that such a large part of the population is equipped with speed limiters that police speed checks will be rare, thus providing more room for individual speeding.

3.3.2.3. *Rewards, punishments and emotional responses*

ATT applications that automatically dole out rewards or punishments may evoke an emotional response that in turn leads to permanent resetting of attitudes or goals. Again, these adaptations can be benign as well as counterproductive. An example of the latter is the estimated counter-productive response to road pricing on main routes, where a shift of a large amount of traffic to lower order, much more dangerous, roads is expected.

3.4. **In conclusion**

3.4.1. *General conclusion*

Counterproductive adaptation of behaviour proves to be a multi-faceted problem. Experts deem many known psychological mechanisms relevant to this adaptation. As a consequence there is a large number of possible ways in which driving behaviour can be permanently affected and whether or not this behavioural adaptation is deemed counterproductive partly depends on changeable values of society. In this chapter we have tried, partly by way of a structuring model, partly by example to provide some handholds on this problem. Predicting counterproductive adaptation is a problem that is in no way solved however: the scope of this study has precluded any thorough investigation or proof of the presented mechanisms.

3.4.2. *Consequences for a checklist*

The model used here mainly provides the insight that schemata and scripts play a central role in man-machine systems: they direct all other processes like perception, decision making and acting. Long term behavioural adaptation in terms of this model therefore focuses on changes in these schemata and scripts and changes in the repertoire of alternative schemata and scripts. These changes are brought about by long term memory processes, mainly learning and forgetting, processes that themselves are probably influenced by the nature of the schemata.

A possible first approach to a theory and a checklist can make use of the possible coupling between schemata, scripts and perception. First, we can try to determine common elements in the schemata and scripts that road users employ. Subsequently, we can use these common characteristics to derive 'basically necessary' knowledge and skills that should not be impaired by adaptation as a template to define counter productivity. Finally we can try to categorise the influence of ATT devices according to:

- which of the common elements is affected and how (supported, enhanced, substituted, changed etc.), to establish the nature of the effect
- does the effect occur rarely, frequently or continuously, to establish the possible severity of the effect.

These three steps should at least lead to a more elaborate set of checks than is currently available, but completeness cannot be claimed.

Literature

Endsley, M.R. (1988a). *Design and evaluation for situation awareness enhancement.* In: Proceedings of the Human Factor Society 32nd Annual Meeting, pp. 97-101. Human Factors and Ergonomics Society, Santa Monica, California.

Endsley, M.R. (1988b) *Situation Awareness Global Assessment Technique (SAGAT)*. In: Proceedings of the National Aerospace and Electronics Conference, pp. 789-795. IEEE, New York.

Heijer, T. (1997). *A safety checklist for ATT devices.* R-97-19. SWOV Institute for Road Safety Research, Leidschendam.

Knippenberg, C.W.F., Rothengatter, J.A. & Michon, J.A. (1989). *Handboek Sociale Verkeerskunde*. Van Gorcum, Assen.

Neisser, U. (1976). *Cognition and Reality.* W.H. Freeman and Co.