DAYTIME RUNNING LIGHTS: THE ATTENTION LIGHT

A literature survey of daytime running lights for motor vehicles and their effect on road safety in the Netherlands

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SUMMARY

In the history of (motorised) traffic, the role of lighting has assumed increasing importance, not only at night but also during daylight hours. Studies in the U.S. and Sweden demonstrated the positive effect of daytime running lights (DRL) on traffic safety. The aim of this study is to investigate whether DRL would be a beneficial measure for the Netherlands.

Lighting in traffic serves three purposes: to see better (yourself) by illuminating the surroundings, to be seen better (yourself) through marking lights and to indicate intention by signalling. The subject of this study, also known in the Netherlands as the "attention light", is a marking light used in the daytime for the purpose of making presence, location, orientation and movement of a vehicle more perceptible to other traffic; it should therefore promote road safety. Current traffic regulations do not allow cars to be equipped with, and to use, special daytime running lights, although the use of low-beam headlights is permitted. The majority of motorcyclists already engage in this practice.

The observations and research results reported in the literature deal with the experiences of fleet-owners and of countries which have made daytime running lights compulsory. These results have, without exception, proved positive for road safety, even though methodological objections can be pointed out for all these studies. Taken overall, a convincing picture is presented: a potential reduction of at least 5% in the overall number of accidents and road victims.
A possible unfavourable side effect for slow traffic cannot be deduced from these studies. This is a relevant question for the Netherlands, which has a large proportion of slow traffic. It seems unlikely that any negative effect will overrule the positive effect attributed to the increased visibility of motor vehicles.
The recommended adaptation is a light fitted in combination with parking lights, similar to the Swedish standard. This light could also serve as an improved side light to replace the use of - often glaring - low-beam head-lights in built-up areas.
The main conclusion is that the introduction of DRL would have a positive effect on road safety in the Netherlands, one that would more than compensate for the costs involved.

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FOREWORD

The use of daytime running lights by motor vehicles (DRL) has been the subject of investigation and measures for many years. Particularly abroad, where favourable results have been reported. This has led to the Netherlands Association for Automobile Insurance (NVVA) to request the SWOV to carry out a literature survey into the effects of DRL.
The purpose of this study was also to assess whether DRL in the Netherlands would have a favourable effect on road safety, and what types of lights could be considered. If the reduction in the number of accidents and victims is similar to that observed in the United States and in Sweden, a significant reduction in the number of victims in the Netherlands can be expected. Special attention should be paid to the specific traffic situation in the Netherlands, with its large proportion of slow traffic.

This study was conducted by Dr. P.H. Polak, of the SWOV Tactical Research Division and published in 1986 as SWOV-report R-86-27. This is a full translation of that report.

1. INTRODUCTION

The use of lights by road users resulted from a need to be mobile at night as well. Vehicle lighting offered a solution to the problem of making the road and other road users clearly visible for the purposes of fast and safe travel at night. Later, public lighting was introduced on a large scale, although vehicles still kept their lights switched on, whether the road was lit or not. For a long time, daytime lighting was not considered an issue. Round about 1960, however, in the USA companies with large car fleets started test, attempting to reduce the number of daytime accidents by means of vehicle lighting. These tests all gave a positive result. The rise of the motorcycle in the USA was coupled to high accident figures, partly attributed to the limited conspicuousness of the motorcycle, a minority in the midst of many automobiles. Motorcycle riders started using their headlights in the daytime, in order to be more noticeable. This was later made compulsory in many USA states and elsewhere. When Sweden made the change from left to right-hand traffic, it was considered necessary to increase the visibility of vehicles - as they would initially come from unexpected directions - by recommending that lights be switched on during the day. Later, Finland and Sweden made daytime running lights compulsory; lights would switch on automatically when the ignition was turned on (if no other lights were operating). Discussions on this subject are in progress in various countries. Canada considers introduction in 1988. In the Netherlands too, introduction of daytime running lights was advocated, while on some roads the road maintenance authority recommended switching on lights in the daytime.

These matters led the NVVA to ask the SWOV to conduct a literature study to investigate whether it would be beneficial to introduce daytime running lights for all motor vehicles in the Netherlands. In agreement with a European directive, legislation is currently in preparation to make low-beam headlights compulsory for two-wheeled motor traffic. This study is therefore based on the assumption that motorcycles and mopeds will be using low-beam headlights in the daytime.

2. LIGHTS IN TRAFFIC

2.1. Concept description

Unfortunately, there is no generally accepted terminology in relation to lighting which makes a clear distinction, for our purposes, between the fitted "lamp" and the light it emits, for example. A terminology describing the function of lights is also lacking. We will use the following terminology in this report: a "lamp" (e.g. headlamp, fog lamp) is fitted to or on a vehicle (or road user). If it is switched on, that vehicle carries a "light" (headlight, fog light). In addition, the terminology of the traffic code will be used as much as possible.

Lights on vehicles serve one of three purposes:
- illumination;
- marking;
- signalling.

Illumination
This serves to improve the visibility of the surroundings. In circumstances where there is insufficient natural or artificial light, the driver of a vehicle must use lighting to make his driving environment sufficiently visible. This includes:
- headlights (high-beam and low-beam headlights);
- front fog lights;
- adjustable spotlights;
- some reversing lights.

In contrast to the function of improving visibility for the driver, the following lights help to make the road user more conspicuous.

Marking
Marking lights are intended to allow or promote the detection and recognition of a vehicle. They also offer information about location, orientation and direction of movement of the vehicle. The weaker the external lighting becomes and the greater the distance at which the vehicle must (should) be visible, the more such lights become essential.

They include:
- parking lights;
- rear lights;
- rear fog lights;
- contour lights (marker lights (U.K.)/clearance lights (USA);
- number plate lighting.

The differentation between illumination and marking is not absolute: illumination lights also mark the vehicle. The low-beam headlight, originally intended to provide illuminating "passing light" without blinding others, is now used as a marking light, particularly in the built-up areas.
The subject of this study, daytime running lights, also belongs to this category. A feature of this group of lamps is that they burn for longer periods of time, the duration being equivalent to the length of the journey. Functionally, these lights supplement the information provided by the vehicle itself at optimal visibility. The marking function is enhanced by the various (retro)reflectors found on vehicles.

Signalling

This relates to lamps which burn temporarily or blink for some time indicating that the vehicle is conducting, or is about to conduct, a certain manoeuvre. These include:
- brake lights;
- direction indicators;
- warning lights;
- headlight in flashing mode ("Lichthupe");
- some reversing lights;
- flashing lights (only for special vehicles and purposes).

These lights give coded information.

Daytime running lights (DRL) can now be defined as marking lights used in the daytime. The concept of 'daytime' is further understood to mean in this study: the times and conditions when current legal regulations do not prescribe lighting.

Daytime running lights are is known under various names: "motorvoertuig-verlichting overdag (MVO) of attentielicht (attention light)" in the

Netherlands, "varselljus" in Sweden, "kjørelys" in Norway and "feux de jour" in France and Canada.

2.2. The driving task

The functional aspects of traffic participation (also known as the driving task) can be divided into various levels. For our purpose it primarily concerns the performance of manoeuvres required to follow a particular course, but more specifically the response to disruptions such as crossing traffic. The situations relevant to our problem are those where encounters with other road users (could) take place, particularly with motor vehicles. A road user only can respond adequately, i.e. safely and efficiently to such encounters if he or she is:

- aware of the presence and nature of other road users;
- informed about the location, orientation and speed of these road users; and if possible
- aware of the manoeuvre that the road user(s) intend(s) to carry out.

This information is gathered both actively and passively. For active observation, visibility is relevant: the extent to which something, in a given context, can be observed, given that the nature and position of the object to be observed are known to the observer in advance. For passive observation, conspicuousness is of greater importance: conspicuousness is the extent to which something in a given context can be noticed timely, when presence and location were not previously known to the observer (IWACC, 1984). In road traffic, both aspects of observation are of great importance: the busier the traffic, the more important passive observation will become. In general, an approaching road user will first enter the peripheral field of vision and be noticed if he is sufficiently conspicuous, after which he may be more closely observed in the central field of vision. An important characteristic of our peripheral field of vision is that few details can be observed - this is the province of the central field of vision. The extremely large peripheral field of vision, on the other hand, is well adapted to the detection of movement.

If some moving object is to be observed peripherally, it must have a certain degree of contrast with respect to its surroundings (Rumar, 1981). The alternating natural lighting and the great diversity in the form and colour of motor vehicles often results in a lack of adequate contrast. Older traffic participants have particular difficulty and they are furthermore hampered by a narrower peripheral field of vision (Robinson, 1985). Aside from the contrast factor, the conspicuousness of an object is dependent on its size, shape, colour and brightness. If we accept that the colour of a car is optional, while an increase in size is not permitted or undesirable, only a greater contrast with the surroundings remains to enhance conspicuousness in the daytime: daytime running lights. Much research has been done into the effect of lights fitted to objects, i.e. their degree of conspicuousness (see Attwood, 1981 for an overview). The result showed that lights which do not glare at night are still sufficiently powerful to make a significant contribution to conspicuousness and recognisability in the daytime.

2.3. Daytime running lights

The notion that it would be safer to also use lights during daytime hours stems from the early 1960s. The earliest reference to daytime running lights dates from 1964 (Allen & Clark, 1964). They stated the idea was initiated in Texas as a road safety campaign, under the motto: "Drive Lighted and Live". From 1961, campaigns were held in the USA, sponsored particularly by bus companies such as Greyhound. After that, the emphasis came to lie more on motorcycles. Around 1970, the idea caught on in the Scandinavian countries. In Sweden, an interim recommendation for daytime running lights was in practice during and after the transition to right lane traffic in 1967; studies would later show that the degree of compliance with the recommendation was not great (Rumar, 1981): under clear weather conditions, only 2% followed this advice. The Swedish police have used low-beam headlights in the daytime since 1967, the Swedish army following suit in 1969. In the Netherlands, certain roads through forests have since 1977 carried the advice to motorists to switch on their lights. In an article in the Dutch magazine "Verkeerskunde" we first come across the term "attention light" (Zoete, 1977).
The effect of a measure (such as the introduction of daytime running lights) would have on road safety can be approached from two angles: a theoretical one, where existing knowledge about factors influencing the traffic process can help - through reasoning and inference - to deduce a particular relationship between the measure and traffic safety; secondly,

an empirical approach, which evaluates the actual effect of a measure following its introduction. In practice, these methods should complement each other. Generally speaking, it can be said that, when applied to the traffic process, both methods are associated with great methodological difficulties. This is particularly true when determining the effect of daytime running lights. It is uncertain what proportion of all accidents is (in part) due to road users not seeing each other, at least to an in-sufficient extent (Henderson et al., 1983). It is also un-certain to what degree the conspicuousness of road users was inadequate in these cases. This lack of knowledge is evident at both a theoretical and an empirical level. However, none would dispute that visual information represents by far the greatest and most important part of all information needed by a driver to perform his driving task (this is true for pedes-trians too, of course).

Therefore, it is generally considered necessary for both the road and whatever may be on or alongside it, including other road users, to be clearly visible. The visibility of a relevant object depends on the extent to which it can distinguish itself from other objects and the background - by brightness contrast, colour contrast or a combination of these. Often, natural daylight provides sufficient illumination for relevant objects (Schreuder, 1985) to be clearly visible. In some circumstances, this visi-bility is not optimal, while certain combinations of surrounding lighting, (traffic) environment, shape, size and colour(s) of the object could lead to extremely poor visibility. A notoriously unfavourable situation is a low sun and subsequent glare, combined with dark vehicles against a dark background.

The common version of daytime running lights comprise two white lights at the front of the car, for motorcycles usually one light. They should be fitted such that the light is clearly visible from the front to the sides, with a sufficient light intensity in all directions. The Swedish standard shown in Table 6 serves as example. Such a lamp is easy to make, by placing an additional 21 watt filament in a standard parking light (normal-ly 5 watt). If it is wired such that it will burn as soon as the ignition is turned on, we speak of an automatic daytime running light. In this way, the driver does not need to perform any additional operation, thus encouraging uniformity and enhancing the degree of compliance. Usually, this type of daytime running lights is found in combination with burning rear lights. According to an American study (Cantilli, 1970), this reduces the risk of head-tail collisions. When the headlights are switched on, the automatic daytime running lights will extinguish.

2.4. Regulations in the Netherlands

Regulations relevant to lights in Dutch traffic are rather complex. Aside from domestic rules, the are various important, even binding, international rules.

The Road Traffic Act (W.V.W.) of 1935

This forms the basis of the system. It states that many matters must be controlled through regulation; lighting is not explicitly referred to.

The Road Traffic Regulation (W.V.R.) of 1950

This includes the equipping requirements for vehicles. Article 13.3 states that a vehicle "from one half hour after sunset to one half hour before sunrise, furthermore during twilight and during the daytime, when circumstances, particularly those of a meteorological nature, provide insufficient daylight to allow others to observe the presence of the vehicle", must satisfy the requirements concerning lighting as set out in Chapter IV of this Regulation. Articles 65-85 of this chapter deal with these requirements. Aside from compulsory lamps, various lamps are discussed which, although not compulsory, must meet certain conditions if fitted to the vehicle. Daytime running lights or the attention light are not mentioned. In the last paragraph (34) of the table with Article 84, it is stated that vehicles should not display a greater number of lights (or reflectors) than are permitted or prescribed by, or in accordance with, this Regulation.

The Regulation for Traffic Rules and Traffic Signs (R.V.V.) of 1966

This describes a code of behaviour. Which lamps must or may be lit, and under what conditions? Relevant to this study is the statement that non-glaring lighting may always be used, also in the daytime (i.e. aside from those periods and circumstances as described in Article 13.3). In other words, in the daytime all permitted marking lights may be used, including low-beam headlights. Special attention lights probably do not fall under this category. Furthermore, the term twilight is not further defined.

So-called civil twilight, related to the movement of the sun, lasts about 40 minutes on average (maximally 50 minutes and minimally 30 minutes, approx.). Evidently the concept of twilight as stated in the Act differs from this civilian twilight, as meteorological conditions are not taken into account in this instance. During twilight and during special daytime conditions (as described in the regulation), the use of lighting by motor vehicles is certainly not uniform.

International agreements

In order to promote the free traffic of persons and goods, the Netherlands is party to a number of international agreements. The most extensive is one resulting from the Netherlands' membership to the United Nations. Under the banner of the UN, a number of treaties have been realised to regulate international road traffic. These types of regulation override domestic rules. The most important is the Vienna treaty on road traffic of 1968, with appendices. This treaty has helped to further define the European road traffic system as a whole. The Netherlands has collaborated in its development and continuation, although it has not yet ratified the treaty. This is due to the different priority rule for slow traffic in the Netherlands, causing the rules of the UN Economic Committee for Europe (ECE) to have no formal legal force in the Netherlands. These rules, which are valid for a large part of Europe, including part of the Eastern bloc, are identical to those drawn up in an EC context; however, the latter do have legal force in the Netherlands and are based on the Treaty for the foundation of the European Economic Community. The EC issues 'directives' (for lighting of motor vehicles this is Directive 76/756/EC). In practice, all motor vehicles imported into, or manufactured in the Netherlands must satisfy this directive. Daytime running lamps or attention lamps are not mentioned in this directive, either. Therefore, Swedish cars destined for the European market must first have their prescribed daytime running lights disconnected - these burn automatically when the ignition is on and other lights are off.

3. THE EFFECT OF DAYTIME RUNNING LIGHTS

3.1. The relevant traffic situation

The purpose of daytime running lights is to promote traffic safety during the day by improving the conspicuousness of cars. Anyone using this light becomes more noticeable to other road users. This implies that the relevant traffic situation is one of a daytime encounter between two or more traffic participants, including at least one motor vehicle. The unusual aspect of daytime running lights is that some road users employ it particularly for their own benefit, while others do it more for the safety of other traffic. By using daytime running lights, a lorry - which is heavy and not very vulnerable - reduces risk to others much more than he reduces risk to himself. After all, the consequences of an accident are more serious for those others than for himself. It is a different matter for a vulnerable traffic participant such as the motorcyclist. He uses lights in the daytime (in some places for years already) out of self-interest: he wants to be more conspicuous, for fear other traffic will not see him. For cars, the main purpose is to be more conspicuous to other cars and to more vulnerable road users; a relatively less important aim is to be better visible to heavier traffic. It becomes more complex when traffic is so busy that most encounters involve more than two traffic participants. The effect of using daytime running lights also becomes more complex: with an encounter between two traffic participants, daytime running lights never have a negative effect, but if there is question of several traffic participants, this might be the case. In those situations, one could speak of a "conspicuousness race": for example, if cars become more conspicuous this is on the one hand beneficial to motorcycles, as cars will be more perceptible; on the other hand, it would be unfavourable if these motorcycles became less conspicuous in the midst of these more dominant cars. In any case, the relative size of both effects is very much dependent on many aspects of the traffic situation. This might also be true for slow participants in very busy traffic; again, though they might benefit from being better able to observe fast traffic, they may be disadvantaged by the fact that they become less conspicuous themselves. Study has not shown whether in such cases there is indeed question of deleterious effects associated with daytime running lights. It may be remarked that if these negative effects are really present, they would be even more evident at night. Any relative decline in the visibility of pedestrians and cyclists as a result of motorists' use of daytime running lights becomes negligible when compared to their situation at night, when the dominance of motor vehicles with low-beam headlights becomes even more apparent.

3.2. Experiences and study results

Experiences relevant to the attention light for cars can be divided into two categories:

- experiences of fleet-owners
- experiences in states which have made daytime running lights compulsory.

The studies amongst fleet-owners represent the largest number; apart from one Canadian study, they were all conducted in the USA. The oldest study is one dating from 1965 and relates to vehicles of the New York Port Authority (Cantilli, 1965); the most recent study concerns 2000 motor vehicles from three car fleets (Stein, 1984). These studies were all organised in a similar vein: part of the car fleet used daytime running lights and after a period of a year, for example, the accident figures for this group were compared with a control group or with the same group statistics from the previous year. Methodologically speaking, the first setup is preferable in comparison with the second one, because as a rule, autonomous changes in time also take place; these may have an effect on the number of accidents recorded. As the average number of daytime accidents per vehicle per year is small, accident statistics from these studies are proportionately small. This means that even a reduction in the order of 20% is not statistically significant in many cases. This problem would be solved by including a sufficiently large population of vehicles in the study. Another objection to this type of study relates to the possibility to make generalisations: the composition of the "fleet" is always different from the total number of cars on the road nationwide. Furthermore, in the situation studied only a small proportion of all vehicles nationwide are fitted with daytime running lamps, therefore one cannot simply relate this to a situation where the regulation is compulsory for all vehicles. It is likely, therefore, that the effects measured probably represent an upper limit. It is not known whether a drivers awareness of the fact that he is using daytime running lights influences his driving behaviour, and therefore the number of accidents. All studies demonstrated a considerable reduction in the number of multiple daytime accidents, ranging from 7% to over 30%. Often all accidents were included in the study, even those with material damage only. The available data did not permit any conclusions to be drawn as to whether accident reductions attributed to the use of daytime running lights differed as a function of the severity of the accident.

Until today, only two countries have made daytime running lights compulsory: Finland and Sweden. Reports have been published on both (Andersson et al, 1976 and Andersson & Nilsson, 1981). The great methodological problem relates to the fact that it concerns before and after studies. A more or less subtle statistical analysis is conducted on the basis of available data about accidents and the percentage of vehicles observed using daytime running lights. The studies cover a period commencing several years prior to the introduction of the regulation and continuing for several years after that date. Here, too, introduction of the compulsory daytime running lights was not the only change. As a consequence, the results again are at best barely statistically significant, although they do all show a reduction in the number of accidents.
The results for both categories of experience are given in Table 1, representing an extension to a table produced by Henderson et al. (1983). Where a reduction is indicated, a reduction percentage for the number of multiple daytime accidents - involving at least one motor vehicle - is implied, i.e. for the accident category relevant to this area of study.

The general picture is clearly a favourable - though often not statistically significant - outcome for each study, averaging from a reduction of 7.2% to 32% in the relevant accident categories. Taken overall, one can speak of a most significant result. The probability that over 8 independent studies all show a reduction is very small.

As far back as 1972, the Dutch army were advised, at their request, to use daytime running lights on their military vehicles (Riemersma, 1972). Of course, this concerned a most unusual group of vehicles.

In a consultative document for the State Automobile Centre (Roszbach, 1974), SWOV recommended the continuous use of daytime running lights.

However, this should affect all vehicle categories, so that the increased safety of one group will not be at the expense of other groups - unless the measure were to relate to categories that represent a particular danger.

At several locations in the Netherlands, the use of DRL is presently recommended by means of a sign to "Switch on your lights":
- on a road in Enschede (since 1977);
- on two roads near Lelystad (RW 310 and 311 since 1978);
- in some tunnels (e.g. Schiphol airport tunnel since 1982).

According to the figures from the Department of Public Works, the degree of compliance with the recommendation (both in the tunnels and near Lelystad) is only moderate: from a minimum of 2% under fine weather conditions to 96% at morning peak time in the rain; the average compliance is less than 70%. The influence on traffic safety is impossible to establish, due to the small number of accidents and the great variation in traffic density on these roads. The municipal police of Enschede confirms this conclusion.

3.3. Estimated effect for the Netherlands

In order to understand what sort of accident in the Netherlands might be affected by the daytime running lights, the 1984 traffic victims (dead and injured) were subdivided according to the relevant characteristics indicated in Table 2.

It is notable that the victims recorded for the circumstances relevant to this study (i.e. in the daytime and involving at least one motor vehicle) comprise almost half of all traffic victims.
These 25,661 victims can be further subdivided according to severity and compared with the other victims; see Table 3 for this data.

If we relate the reduction statistics from abroad to the situation in the Netherlands, we can gain an impression of the likely effect should daytime running lights be introduced in the Netherlands also. As the reduction factors are fairly uncertain when examined individually - which is even more the case for specific effects, subdivided according to severity, season, building density and type of road user - it was decided to work with a global reduction factor. Taking into account that the reduction factors listed for Finland and Sweden in Table 1 (25% and 11%) were found following a rise in the use of daytime running lights from approx. 50% to almost 100%, while for Finland the compulsory use of lights only applied in winter and outside the built up area, a study of the literature provides an average reduction factor of 20% for daytime accidents involving at least one motor vehicle. The calculation model for the Dutch situation - with relatively many densely urbanised areas and a somewhat more southern latitude - gave a hypothetical reduction of 10%. By multiplying the cells of Table 3 with the reduction factor we arrive at Table 4, resulting in overall reduction percentages of 4% to 5%.

3.4. Gaps in our knowledge

In short, we can state that it is uncertain whether, and to what extent, making a certain class of road user more conspicuous will result in other classes of road user becoming less conspicuous. Furthermore, it is not known whether being less conspicuous would also cause that group to become more vulnerable. The first relationship can in principle be tested by laboratory study, using simulated traffic situations to investigate whether fitting lights to objects will make other objects less conspicuous.
As is always the case, it will be much harder to establish a relationship between any diminished conspicuousness and safety on the road.

3.5. Disadvantages

Various potential negative effects of the use of daytime running lights are conceivable. The effect might only be temporary, due to habituation. However, the nature of our innate visionsystem pleads against that argument. In that case, this should also be true for all marking and signalling lights already in use.
This last argument is also true for the objection that cars with no daytime running lights will be worse off than before. If motorcycles continue to ride with low-beam headlights in the daytime, there is no danger of them becoming less conspicuous with respect to cars. Based on the principle that cars are equipped with separate "attention lights", lights for use at night will not wear out more rapidly and become less safe. Furthermore, none of the hypothesised disadvantages has ever been confirmed by the study results to date.

4. REALISATION AND INTRODUCTION

4.1. Types of lights

The attention light for cars has been realised in various ways, while other types have also been proposed:

a) (European) low-beam headlights;
b) dimmed high beam;
c) dimmed dipped headlights;
d) side light (parking light);
e) improved side light;
f) indicator lights (all four);
g) special "attention lights" fitted separately.

Whatever type selected, automatic switching implies that changes in wiring and switching mechanisms are necessary. For types a) and d), no additional equipment to the vehicle is necessary if switching continues to be on a manual basis. For types e) and g), existing lamps will need to be altered or new ones added. For b), c), e), f) and g) the wiring of the vehicle must be adapted. In principle, all types lend themselves to adaptation of vehicles already on the road.
For the sake of completeness, we also refer to a recently proposed version (Jenkins & Wigan, 1985), where motorcycles drive with (intensity) modulated headlights during the daytime. Power consumption and additional costs vary considerably between the different types. Canadian cost calculations (Transport Canada, 1985) are shown in Table 5, where the discounted value of the purchase price and all subsequent associated costs have been taken into account.
This table includes the extra costs of the new car, the cost of (more frequent) bulb replacement and the increased fuel consumption. According to Canadian calculations, the benefits outweigh all costs associated with separate daytime lights if even a 2% reduction in the total number of victims is achieved, i.e. 4% of DRL-related cases.

The functional requirements set for the attention light in Sweden have been described by a norm (SIS, 1978). In brief (Rumar, 1981), it is based on indicating a minimal brightness for the various directions given in Table 6, on the proviso that the intensity may be no greater than 800 candela in any direction. The luminous area must be at least 40 cm^2, the colour white or yellow.

The low-beam headlight does not satisfy the norm because it is glaring in some circumstances. Low-beam headlights, dimmed high beam and dimmed dipped headlights all have the wrong direction dependence, while side lights are too weak and indicator lights have the wrong colour, so that information allowing the observer to distinguish the front and rear end of a vehicle is not available. The improved side light and the special "attention light" are the two remaining options.
The improved side light is relatively easily achieved by replacing the normal side light bulb (5 watt) with one having a second filament of greater wattage. This solution was chosen by Swedish car manufacturers. The advantage is that the geometry of the reflector and lens cap of the side light must meet similar requirements to the attention light. Separate lamps serving as special "attention lights" can serve to equip existing cars. In order to equip cars on the road with "attention lights" quickly and easily (Teague et al., 1980), it is proposed to fit a simple electrical relay which will automatically switch on the low-beam headlights.

4.2 The new-style side light

The lighting to be used by motor vehicles at night, in the presence of adequate public lighting (particularly inside the built-up area), has been the subject of discussion for years in the Netherlands. In principle, only marking lights are needed under such conditions. While side lights were formerly used under such conditions, later this was considered insufficient and low-beam headlights were prescribed. However, the use of low-beam headlights under these condition is not always ideal, as they can blind others, while the difference in conspicuousness between fast and slow traffic is most unfavourable, due to the weak lights used by slow traffic. SWOV proposed (SWOV, 1969) a new type of side light which is stronger that the present one but does not blind oncoming traffic. The specification for this new "city" light strongly resembles the specification for the attention light. The introduction of an attention light or the new-style side light requires the same modification. The introduction of the new-style side light would only require another switch setting on cars. This would not be necessary if the new side light is introduced simultaneously with, or subsequent to, the attention light. Diagrammatic representation:

Situations	Switch positions	Function
Current	Off	No light
	Parking	Side (parking) light
	Night	High-beam or low-beam headlight
Following introduction of the attention light	Day	Attention light
	Parking	Side (parking) light
	Night	High-beam or low-beam headlight
Following introduction of the new style side light	Day	No light
	Parking	Side (parking) light
	Night in b.u.a.	Side light new style
	Night outside b.u.a.	High-beam or low-beam headlight
Following introduction of both lights	Day or night in b.u.a.	Attention light
	Parking	Side (parking) light
	Night outside b.u.a.	High-beam or low-beam headlight

An additional advantage of the attention light, provided it is switched on automatically, is that the motorist does not forget to drive without light. If the new-style side light is also introduced, motorists will usually drive with the correct lighting. If there is no public lighting, the absence of correct lighting, i.e. low-beam headlights or high beam, will be quickly noticed.

4.3. Introduction options

Far-reaching changes to the equipping requirements for vehicles and to the code of behaviour for traffic participants are complicated matters, and the situation beyond the country's own borders must not be ignored. At present, it does not look as though other EC countries are willing to amend their regulations in favour of daytime running lights. A request from Sweden and Finland to determine an ECE standard for this light received no response from other European countries. On the other hand, there is room for domestic deviations from the European norms in this regard. For example, in the Netherlands slow traffic approaching from the right does not have right of way, in contrast to almost all other countries in the world. All cars exported to Scandinavian countries must have daytime running lights. Canada is considering introduction, without waiting on the results of discussions held in the USA. In the Netherlands, a number of amendments to the traffic code are in preparation and will be introduced in several years' time. The introduction of the attention light, whether or not combined with the new-style side light, could be included in this process.

5. CONCLUSIONS AND RECOMMENDATIONS

This literature study has investigated whether, and if so to what extent, the introduction of daytime running lights would have a favourable effect on road safety in the Netherlands. For two-wheeled motor vehicles, this question has already been answered in the affirmative: in many countries - and soon in the Netherlands - motorcycles and mopeds are already obliged to use low-beam headlights during the day. In fact, most motorcyles are already using DRL on a voluntary basis. This is not the case for four-wheeled motor vehicles: even when expressly requested by a sign to "Switch on your lights", considerably less than half the number of drivers comply. From the beginning of the 1960s, the question was put and examined whether it was useful and feasible to make (motor) vehicles more conspicuous in the daytime, by making them contrast more with their surroundings. Tests were carried out on cars using DRL, with positive results. Laboratory situations were also used to study the detection of approaching objects and whether the fitting of marking lights improved their conspicuousness: this proved to be the case. Two countries, Finland and Sweden, made daytime running lights compulsory and subsequently reported positive results. In summary, one can conclude that the detection of the presence and movement of approaching vehicles can also be considerably improved in the daytime by fitting such vehicles with marking lights, i.e. daytime running lights. Studies into the effect of daytime running lights on road safety (all deriving from abroad) are, without exception, positive. Although the individual results are not, or hardly, statistically significant and the studies show - unavoidable - methodological shortcomings, when taken overall they do indicate that daytime running lights causes a significant reduction in accident probability. For an entire country, this reduction (nationally distributed over a full year) lies between 10% and 20% for daytime multiple accidents involving at least one motor vehicle. Although the costs involved are not negligible, it has been calculated that even with a reduction of at least 4% the benefits, in financial terms, will outweigh the costs. Disadvantages have never been observed, but could play a role in the specific Dutch situation: a large proportion of slow traffic and extensive urbanisation do not permit the Netherlands to be directly compared with the areas studied. There may be question of a conspicuousness race, whereby pedestrians and cyclists could be at a disadvantage because they become less visible next to the (more conspicuous) motor vehicles. Clearly, if such an effect would truly be the case, this would reflect most unfavourably on the nighttime situation, when unmarked or poorly marked cyclists and pedestrians come off extremely poorly with respect to motor vehicles, equipped as they are with - often glaring - low-beam headlights. The negative consequences of a conspicuousness race have not yet become apparent from empirical study; it is purely a theoretical concept. Furthermore, this negative effect should then be greater than the positive effect associated with the improved conspicuousness of fast traffic for slow traffic, to dispense with the proposal to introduce DRL.

It is advisable to investigate whether in certain traffic situations the increased conspicuousness of certain groups of traffic participants would be at the expense of the conspicuousness of other road users. If this effect were indeed present, this should lead in the first place to a reappraisal of motor vehicle lighting at night.
The use of DRL by only a proportion of drivers is probably damaging for those not using lights, so a 100% compliance should be the aim.
Furthermore, the advantage motorcyclists now enjoy with the use of low-beam headlights in the daytime could be partially lost.

The principal conclusion drawn from the literature study is that - despite the limitations described - it is likely that the introduction of daytime running lights, i.c. the attention light, in the Netherlands will lead to a reduction in the number of traffic victims, one that will more than compensate for the financial costs involved. Therefore, it is recommended to consider introduction, to again broach the subject in an international context and to investigate any possible negative consequences.
As every attempt should be made to achieve the most uniform situation possible - night or day - it is recommended to consider daytime running lights in conjunction with the improved side light; the latter could replace the low-beam headlight inside built-up areas.

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TABLES 1 TO 6

Table 1. Comparative fleet-owner studies and before-and-after studies in countries with compulsory DRL, with type of study and reduction.

Table 2. 1984 distribution in the number of casualties (dead and injured) according to light conditions and accident type, with percentage totals, for the Netherlands.

Table 3. 1984 distribution in the number of casualties of daytime accidents involving at least one motor vehicle and other accidents, according to severity, with vertical percentages, for the Netherlands.

Table 4. Hypothetical reduction in the number of casualties at 100% DRL compliance.

Table 5. Discounted costs in Can.$ over the life of a car (Source: Transport Canada, 1985).

Table 6. Minimum light intensity in candela as a function of the angle in degrees, between straight ahead and the direction of view.

Comparative studies			
Cantilli (1965, 1970)	238 modified vehicles compared with control group		-18%
Allen & Clark (1964) (Greyhound Bus)	1 year 24 hours lights on compared with previous year	USA Canada	-12% -24%
Attwood (1981) (AT&T LongLines)	1 year 24 hours lights on compared with previous year	Average	-32%
Attwood (1981) (Checker Cab)	Taxicabs with 24 hours lights compared with other taxicabs		-7.2%
Stein (1984)	Over 2000 vehicles with automatic attention lights compared with control group		-22%
Before-and-after studies in countries with DRL-obligation			
Finland (Andersson et al, 1976)	Before and after DRL-obligation in winter outside built-up areas		± -25%
Sweden (Andersson & Nilsson, 1981)	Before and after DRL-obligation universally applicable times		-11%

Table 1. Comparative fleet-owner studies and before-and-after studies in countries with compulsory DRL, with type of study and reduction percentage.

Casualties	Daylight	Twilight/ Dusk	Total
Accidents with at least one motor vehicle	25661 (49.1%)	8917 (17.1%)	34578 (66.2%)
Other accidents	10934 (20.9%)	6779 (13.0%)	17713 (33.9%)
Total	36595 (70.0%)	15696 (30.1%)	52291 (100%)

Table 2. 1984 distribution in the number of casualties (dead and injured) according to light conditions and type of accident, with percentage totals, for the Netherlands.

Accidents	Dead	Hospital admissions	Other injured	Total
Daytime with at least one motor vehicle	692 (42.8%)	7315 (46.8%)	17654 (50.4%)	25661
Other	923 (57.2%)	8315 (53.2%)	17392 (49.6%)	26630
Total	1615 (100%)	15630 (100%)	35046 (100%)	52291

Table 3. 1984 distribution in the number of casualties of daytime accidents involving at least one motor vehicle and other accidents, according to severity, with vertical percentages, for the Netherlands.

Casualties	Dead	Hospital admissions	Other injured	Total
Daytime accidents with at least one motor vehicle	69	732	1765	2566
Other accidents	--	--	--	--
Percentage of total	-4.3%	-4.7%	-5.0%	-4.9%

Table 4. Hypothetical reduction in the number of casualties at 100% DRL compliance.

a) dipped headlight	326
b) dimmed high beam	109
c) dimmed-dipped headlight	157
d) improved parking (side) light	71
e) indicator lights	59
f) special "attention lamps"	69

Table 5. Discounted cost in Can. $ over the life of a car (Source: Transport Canada, 1985).

Position		Left (-)		Middle			Right (+)	
		-20°	-10°	- 5°	0°	+5°	+10°	+20°
Higher	+10°	-	-	-	-	-	-	-
	+5°	30	60	-	210	-	60	30
Middle	0°	-	105	270	300	270	105	-
	-5°	30	60	-	210	-	60	30
Lower	-10°	-	-	60	-	60	-	-

Table 6. Minimum light intensity in candela as a function of the angle in degrees, between straight ahead and the direction of view.