SWOV Fact sheet

Daytime running lights (DRL)

Summary
In 2008, the Dutch Ministry of Transport announced its intention to run an information campaign to stimulate the use of daytime running lights (DRL). DRL increases the visibility of road users and thus reduces the chance of a crash. DRL's negative consequences, such as a higher fuel consumption and thus larger emissions of harmful materials, can be limited by using special DRL units with energy-saving lamps. Although several scenarios for implementing DRL are possible, the most favourable road safety option for the time being seems to be that in which drivers of existing motor vehicles use the manually dipped headlights in daytime and new cars are equipped with an advanced DRL unit.

Background
DRL involves motor vehicles having their headlights on during hours of daylight. These can be their dipped headlights or a special lighting unit. Having motor vehicle headlights on during the daytime makes motor vehicles more noticeable and saves road crash casualties.
DRL is already compulsory in a number of European countries. Until now this has not yet been the case in the Netherlands. However, it can be seen that many motorists voluntarily switch their headlights on during daylight hours, especially on rural roads and when the visibility is poor. The last time that the use of DRL was measured in the Netherlands was in 1993; 30% of the motorists then had their lights on (Lindeijer & Bijleveld, 1994). In 2008, the Dutch Ministry of Transport announced its intention to promote DRL use with an information campaign.
The EC aims at harmonizing the DRL regulations and the corresponding necessary vehicle requirements. It is important to emphasize the positive effects (saving road crash casualties) and to limit the negative effects (greater fuel consumption) as much as possible. Another point of interest for the EC is whether the road users who do not have their lights on (cyclists and pedestrians) will still be noticed, and whether motorcyclists (who already have their headlight on) are still sufficiently conspicuous. In 2003, the EC commissioned a study of DRL's effects and the implementation strategies, in preparation for a possible DRL implementation. Research institutes in the Netherlands (Netherlands Organization for Applied Scientific Research TNO and SWOV Institute for Road Safety Research) and in Norway (Institute of Transport Economics TØI) have carried out this study. This fact sheet not only deals with the results of this study, but also of studies carried out in the 1990s.

What is DRL's effect?
In-depth crash studies have shown that not having seen the other road user plays a role in 50% of the daytime crashes, and in even 80% of intersection crashes. Theoretical insight and observations explain DRL's effect mainly because of the greater contrast between vehicles and their surroundings; this increases the visibility of vehicles and makes them better identifiable. An additional effect is that vehicles with DRL are estimated to be closer than they really are. This explains why less risk is taken while overtaking and when crossing intersections.
DRL is a way to assist road users in their visual observation task. DRL studies in the 1990s indicated reductions of 10-15% (Elvik, 1996) and 8-22% (Koornstra, 1993) in the numbers of daytime crashes in which two or more road users were involved.
The study commissioned by the EC involved a meta-analysis of 41 studies of the effect for cars and 16 studies of the effect for motorcycles (Elvik et al., 2003). This showed that for cars DRL reduced the number of daytime injury crashes by 3-12%, and for motorcycles by 5-10%. For both results we should mention that the results found per individual study (may) differ greatly. The reduction refers to daytime crashes in which more than one road user was involved. A greater effect on fatal crashes may be estimated. Some of the studies found that the DRL effect declined after some time, and others that it did not decline. No proof was found that the DRL effect depends on the season. The question of how strongly the effect depends on latitude indeed confirmed the previous study of Koornstra et al. (1997), but the relation is now shown to be less strong.
The matter of the extent to which rear lights that are on in the daytime can mask the brake lights, is no longer a problem since the introduction of the third brake light (compulsory in the Netherlands since 1994). In addition, automatic switches have the option of not automatically switching the rear lights on.

How visible are the other road users?
It is sometimes suggested that road users who do not have their lights on in daytime are visually 'pushed aside' by DRL vehicles, i.e. the masking effect. The EC also commissioned this to be studied. TNO carried out a laboratory experiment (Brouwer et al., 2004) in which subjects were shown slides with pictures of traffic situations in daylight circumstances. The slides contained a car with or without DRL and another road user: a pedestrian, a cyclist, or a motorcyclist with or without lights. The subjects were instructed to determine as quickly as possible if there was another road user present. The time needed to do this was registered.
The results were that subjects were able to identify the traffic situation of cars with DRL more accurately and quicker than that of cars without DRL. No indications were found of a lesser conspicuousness of vulnerable road users when near a car with DRL. On the contrary, results pointed in the opposite direction: road users without lighting in fact profited from DRL. It is also an advantage that vulnerable road users can see cars with DRL sooner than cars without DRL.
The meta-analysis of Elvik et al. (2003) concludes - although with some reservation - that DRL probably reduces the number of car crashes involving cyclists and pedestrians. A recent study carried out by the Austrian Epigus Institut (Pfleger, 2007) concludes that, based on study of road users' observation behaviour, DRL has no benefit in good weather, but is an advantage in bad weather. In rare cases DRL could be responsible for obscuring persons and vehicles
Motorcyclists in the Netherlands, who nearly all have their headlight on during daytime, sometimes express the fear that their conspicuousness lessens if cars also have their lights on during daytime. The TNO laboratory experiment (Brouwer et al., 2004) showed that the subjects saw both motorcycles with their lights off and motorcycles with their lights on sooner if cars also had DRL. However, motorcycles with DRL were spotted faster. Wildervanck (1994) already explained this phenomenon. By having his headlight on a motorcyclist separates himself from the static surroundings and thus is noticeable as a moving vehicle. And that is what it continues to be, even if the surrounding vehicles also have their lights on.

Does DRL have any disadvantages?
DRL has disadvantages. If the lamps are lit, the dynamo is switched on and more fuel is used. Although the extra consumption is the same per car, the relative differences are large. A fuel efficient car using 6.7 litres per 100 km (1:15) with DRL has an extra consumption of 3%, a 10 litres per 100 km (1:10) car uses 2% more, and a lorry of 33 litres per 100 km uses 1% more (ETSC, 2003). A larger fuel consumption causes a greater emission of harmful materials that produce air pollution. The CO_2 emissions of car traffic increase by 0.6-1.4% (Elvik et al., 2003). Saving fuel and reducing CO_2 emissions can be achieved by using special DRL lamps. Instead of 2x55W lamps for the dipped lights 2x21W can be used (a reduction of 62%). LED lamps of only a few Watts lead to an even higher reduction. In addition automatic switches can turn off unnecessary lighting (e.g. the rear lights).
Another disadvantage of DRL is that headlamps burn out more often, because they are switched on longer. This problem is small if LED lamps are used. Batteries can also run down if one forgets to turn the lights off. This can be solved by mounting a bleeper or an automatic DRL switch (after turning off the engine the dipped lights go out). Both can be installed in existing cars (Schoon, 1991).
There is also the matter of whether blinding occurs. Blinding has been researched extensively (Koornstra et al., 1997; Hagenzieker, 1990). The degrees of blinding vary from a nuisance to complete blinding. DRL can cause daytime blinding (especially nuisance) when the light intensity of the dipped light is too high and the surrounding lighting is at a relatively low level (also at sunset). The too intense dipped lights are due to incorrect adjustment. In fact this is not a DRL problem; the blinding is more severe at night time. Nowadays dipped lights are quite well adjusted because of the MOT and built-in systems that ensure an automatic adjustment of headlights. Blinding does not occur with lamps that have been specially developed for DRL purposes.

What are the options for implementing DRL?
The EC requested that various options for DRL introduction in the EU be listed (Commandeur et al., 2003). These are:
1. only a behavioural measure with manual operation of dipped lights;
2. same as 1, but with a compulsory automatic DRL switch for *new cars*;

3. same as 1, but with a compulsory advanced DRL unit for *new cars*;
4. a compulsory automatic DRL switch for all *new cars*; 'old' cars without this facility do not have to use DRL;
5. same as 4, but with a compulsory advanced DRL unit.

Do the DRL effects compensate for the costs?
The Norwegian TØI research institute conducted a cost-benefit study of the five above-mentioned options (Elvik et al., 2003). This compared the positive effects, expressed in casualty reduction, with the DRL costs (environmental damage, fuel consumption, etc.). The calculations showed that the benefits by far exceeded the costs for all options. The scores were:
- high: option 1with a benefit-cost ratio of 2.0;
- middle: options 2, 3, and 5 with a benefit-cost ratio of 1.7, 1.7, and 1.6 respectively;
- low: option 4with a benefit-cost ratio of 1.4.

The benefit-cost ratios were calculated for twelve European countries over a period of twelve years. This was not done for Denmark, Finland and Sweden because these countries already have compulsory DRL. As an example we present here the calculation of option 3 in absolute figures (cost level 2003). The reduction of deaths and injured expressed in money amounts to € 49 billion, and the environmental damage amounts to € 10 billion. This is a benefit of € 39 billion. The total costs of advanced DRL units, extra fuel consumption, and lamps wearing out amounts to € 23 billion. This results in a ratio of 1.7. Option 3 was calculated for specific DRL lamps that use less energy than dipped lights. If a calculation had been made for LED lamps, the benefit-cost ratio of option 3 would have come up best.

What are the assumptions for the DRL cost-benefit analysis and casualty reduction?
Based on the results of the meta-study of crashes the following assumptions for the effectiveness of DRL have been made for the cost-benefit analyses. The effectiveness in reducing the number of daytime multiple crashes is:
- fatal crashes: a reduction of 15%;
- severe injury crashes: a reduction of 10%;
- slight injury crashes: a reduction of 5%;
- Property Damage Only crashes: a reduction of 0%.

The actual DRL use in the twelve countries was assumed to be 10%. If making DRL compulsory increases the use to 90%, the estimation is that it can save 2,400 deaths, 17,000 severely injured and 51,000 slightly injured annually. These numbers are based on the number of casualties in 2000.
We can make the same assumptions for the Netherlands, but the current DRL use must be estimated higher than 10%. Because there are no recent measurements the estimate will be set at 30%, based on previous measurements. Compulsory DRL in the Netherlands would then result in an annual reduction of approximately 35 deaths and 500 in-patients. These numbers are based on the number of casualties in 2006.

How advanced is DRL's implementation?
In a number of countries DRL has been introduced in stages, for example by first encouraging voluntary use or by gradually making it compulsory (e.g. only on rural roads). Such a gradual introduction can help remove opposition, as was shown by a SWOV study for the EC. The opposition to DRL diminished rapidly after introduction and the acceptance was generally high. This was irrespective of whether it was a vehicle or a behavioural measure.
At present, fourteen European countries already have some kind of compulsory DRL for cars. In Denmark, Estonia, Finland, Latvia, Norway, Slovenia, the Czech Republic, and Sweden it is compulsory all year round, and on all roads. In Lithuania, Poland and Slovakia it is compulsory on all roads during the winter months. In Hungary and Italy it is compulsory on rural roads all year round. In Portugal, DRL is compulsory all year round on roads for which this is indicated. In Austria[1] compulsory DRL has been abolished as of 1 January 2008.
In Belgium and Spain dipped lights are compulsory for motorcycles during daytime hours. In Switzerland DRL is recommended. The non-European country Israel has chosen compulsory DRL during the winter months on rural roads.

[1] In Austria, DRL was abolished as of 1 January 2008; it had been compulsory from 2006 (also see SWOV position *Daytime running lights is safer*)

In countries where it is compulsory the driver must switch on the dipped lights manually (a behavioural measure). Only Canada has chosen for a vehicle measure; cars must be equipped with an automatic DRL switch. Swedish car manufacturers have also adopted this system. This means that in the Scandinavian countries where DRL is compulsory always and everywhere, many cars are equipped with automatic DRL switches. Also the Volvos and Saabs which are imported in the Netherlands are equipped with these switches.
In 2003, a SWOV inventory in 25 European countries showed that five other countries have plans directed towards compulsion, varying from a behavioural measure during winter months to an extensive technical measure. This last one is a French idea of an advanced DRL unit with lamps that have a light intensity between that of dipped lights and parking lights, and with a light sensor that ensures that the dipped lights (and other switched off lamps) are automatically switched on at sunset (Robert, 2000). The Dutch Ministry of Transport has expressed itself to be in favour of this system for the Netherlands. In 2003 France has already made a modest start by recommending manually operated DRL on rural roads (CNSR, 2003).

In Europe there is concern about the negative environmental effects of DRL. This argues in favour of advanced DRL units with energy saving lamps. LED lamps would even result in environmental benefits for countries that currently have a high DRL use.

In August 2006, The EC put out a questionnaire on which both organisations and individuals, within as well as outside the EU, could give their opinion about DRL. In December 2006, the following results were published (*Table 1*)

Respondent	In favour of DRL		System		
	Ja	Nee	In favour of option 3[1]	In favour of option 5[2]	Unknown/other
Ministries	83%	17%	60%	30%	10%
Companies, e.g. research	87%	13%	72%	7%	21%
Associations, clubs	52%	45%	62%	-	38%
Individual citizens	4%	95%	-	-	-
1) Option 3: Manually operated and advanced MVO-unit immediately compulsory for new cars. 2) Option 5: Only an advanced MVO-unit compulsory for new cars.					

Tabel 1. *Result of an EU consultation in 2006 about the desirability of introducing DRL and the type of system.*

A large majority among governments, companies and associations appears to be in favour of the introduction of DRL; private individuals are opposed to the idea. The European Commission is considering proposals for behavioural measures or solely vehicle demands for DRL. At this moment it is still unclear when the European Commission will make a definite decision on this issue. While awaiting possible European legislation for new vehicles, the Netherlands has intended to conduct a government campaign to stimulate voluntary DRL use.

Conclusion
DRL can make a contribution to further improvement of road safety. There is no scientific evidence for the frequently mentioned negative effects for pedestrians, cyclists or motorcyclists. The introduction of DRL as a behavioural measure can best coincide with the installation of an advanced DRL unit in new cars. This will result in a combination of a large casualty reduction and relatively low emission, especially when LED lamps are used. For the time being, such a behavioural measure will not be taken in the Netherlands. However, a campaign will be conducted to stimulate voluntary DRL use.
The European Commission is now considering proposals for behaviour rules and vehicle requirements. Vehicle requirements can only be introduced at the EU level. Once these proposals are ready, national governments and the European parliament will have to decide on their positions.

Publications and sources
(SWOV reports in Dutch have an English summary)

Brouwer, R.F.T., Jansen, W.H., Theeuwes, J., Duistermaat, M. & Alferdinck, J.W.A.M. (2004). *Do other road users suffer from the presence of cars that have their daytime running lights on?* TNO-report TM-04-C001. TNO Human Factors, Soesterberg.

CNSR (2003). *Les feux de jour*. Rapport d'étape établi à partir des travaux de la Commission feux de jour du Conseil National de la Sécurité Routière. Conseil National de la Sécurité Routière CNSR, Paris.

Commandeur, J. (2003). *State of the art with respect to implementation of daytime running lights.* R-2003-28. SWOV, Leidschendam.

Commandeur, J., Mathijssen, R., Elvik, R., Janssen, W. & Kallberg, V.-P. (2003). *Scenarios for the implementation of daytime running lights in the European Union.* R-2003-29. SWOV, Leidschendam.

EC (2006). *Saving lives with daytime running lights (DRL)*. A Consultation Paper presented by the inland transport services of the Directorate General for Energy and Transport. European Commission, 1 August 2006.

Elvik, R. (1996). *A meta analysis of studies concerning the safety effects of daytime running lights on cars.* In: Accident Analysis & Prevention, Vol. 28, Nr. 6, p. 685-694.

Elvik, R., Christensen, P. & Olsen, S.F. (2003). *Daytime running lights; A systematic review of effects on road safety.* Report 688/2003. Institute of Transport Economics TØI, Oslo.

ETSC (2003). *Cost Effective EU Transport Safety Measures.* European Transport Safety Council ETSC, Brussels.

European Commission. *Daytime running lights*. Web site European Commission, Brussels.

Hagenzieker, M.P. (1990). *Visual perception and daytime running lights (DRL); A literature survey.* R-90-43. SWOV, Leidschendam.

Koornstra, M. (1993). *Daytime running lights; Its safety revisited. Paper presented at 26th International Symposium on Automotive Technology and Automation: Road and vehicle safety, Aachen, Germany, 13-17 September 1993.* D-93-25. SWOV, Leidschendam.

Koornstra, M., Bijleveld, F. & Hagenzieker, M. (1997). *The safety effects of Daytime Running Lights; A perspective on Daytime Running Lights (DRL) in the EU: the statistical re-analysis and a meta-analysis of 24 independent DRL-evaluations as well as an investigation of possible policies on a DRL-regulation in the EU.* R-97-36. SWOV, Leidschendam.

Lindeijer, J.E. & Bijleveld, F.D. (1994). *Het gebruik van motorvoertuigverlichting overdag in Nederland: november 1989 t/m december 1993.* R-94-88. SWOV, Leidschendam.

Pfleger, E. (2007). *Untersuchung von blicktechnischen Interaktionen im realen Straßenverkehr in Ortsgebieten und Freiland*. Epigus, Institut für ganzheitliche Unfall- und Sicherheitsforschung. Wien.

Robert, C. (2000). *La question de l'allumage des feux de croisement de jour; Rapport pour le Ministre de l'equipement, des transports et du logement.* Conseil Général des Ponts et Chaussées, Paris.

Schoon, C.C. (1991). *Praktijkervaringen met verlichtingsautomaten bij twee bedrijven in de gemeente Dordrecht.* R-91-48. SWOV, Leidschendam.

Wildervanck, C. (1994). *Motoren, motorrijders en motorrijden.* In: Mobiliteitschrift, Vol. 28, Nr. 6, p. 7-14.