SWOV Fact sheet

Headway times and road safety

Summary
The Dutch Ministry of Transport is conducting a campaign to promote a minimum headway time of two seconds. This headway time is based on the reaction time of drivers under various circumstances. A headway time of two seconds is sufficient for the vast majority of drivers to prevent a rear-end collision with the vehicle in front, particularly on motorways where the traffic situation is not very complex. It gives the driver sufficient time to commence emergency braking if necessary. A modern instrument to maintain one's headway is Advance Cruise Control (ACC).

Background
To drive safely behind the vehicle in front in a steady stream of traffic, motor vehicle drivers are advised to keep two seconds headway. This creates a buffer to prevent a rear-end collision, should the driver need to stop in an emergency. Such crashes can occur on all roads but the chance is biggest on motorways and main roads. These roads are also the location for annoying and dangerous tailgating i.e. following at a very short distance. This fact sheet discusses the background of this two-second rule.

Why two seconds headway time?
The two-second rule is based on the reaction time of drivers. This is not the same for every driver, but varies from less than one second to about two seconds, depending on a number of factors. Lamm et al. (1999) observed that the reaction time varies from one driver to another and is a function of alertness, complexity, and expectation.
The driver's alertness is the result of a person's physical condition. Fatigue can play a role here, as well as distraction, such as talking with a passenger or mobile phoning. The reaction time is also determined by the extent to which obstacles are expected. When a driver on a motorway suddenly sees an obstacle, the reaction time is longer than it will be at an intersection. At an intersection he expects an obstacle and can therefore react more quickly. The relation between reaction time and the complexity of the decision is described by Alexander & Lunenfeld (1990). Under all circumstances, the majority of drivers can react within two seconds; only for a small minority this is insufficient time to make complex decisions.

The two-second rule thus guarantees a safe headway for all drivers on motorways and main roads because the traffic situation generally is not complex and the driver only has to keep an eye on the vehicle in front of him, and preferably also on the vehicles ahead. There is sufficient time to react even in the extreme cases of emergency braking. Although an emergency stop perhaps requires more time (see below), the two seconds are sufficient to commence an emergency brake without the vehicles getting too close to each other. After all, all vehicles brake with similar deceleration rates.

How long is the braking distance?
The braking time, and with it the braking distance, is determined by the driving speed (v). The braking time t is linearly dependent on it ($t=v/a$), and the length of the braking distance s is quadratically dependent on t ($s=\frac{1}{2}at^2$), in which a is the braking deceleration.
In *Figures 1* and *2* the braking time and braking distance are shown graphically as a function of the driving speed, in which a constant braking deceleration of 5 m/s^2 is assumed for an emergency stop on a wet road surface. In the case of an emergency stop at 80 km/h, the total braking time is more than five seconds, and the total braking distance is about 70 metres. In the case of an emergency stop at 120 km/h, the total braking time is nearly eight seconds, and the total braking distance has practically doubled to more than 140 metres. Of course the braking distances are shorter on a dry road surface, but the disproportionately longer braking distance at higher speeds remains.

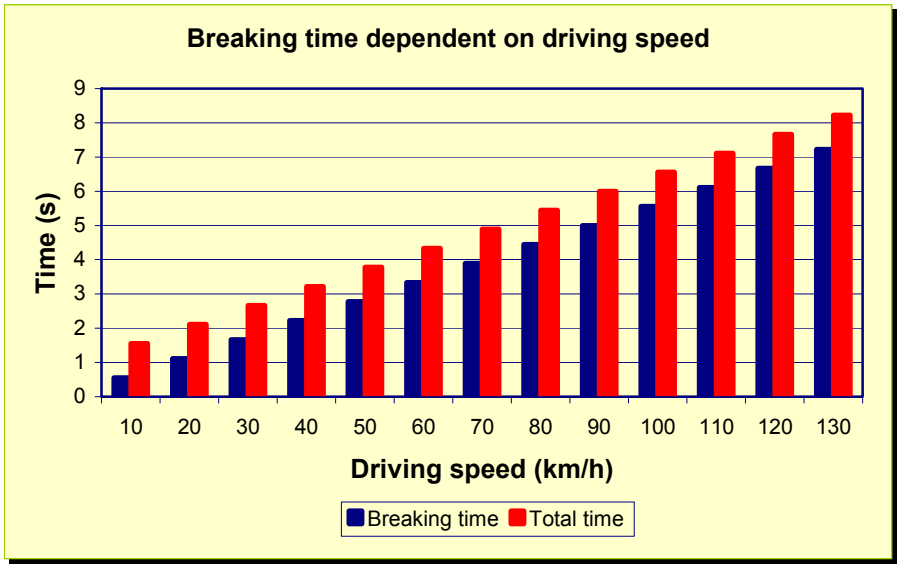

Figure 1. *The braking time for an emergency stop on a wet road surface at various speeds, with a one second reaction time.*

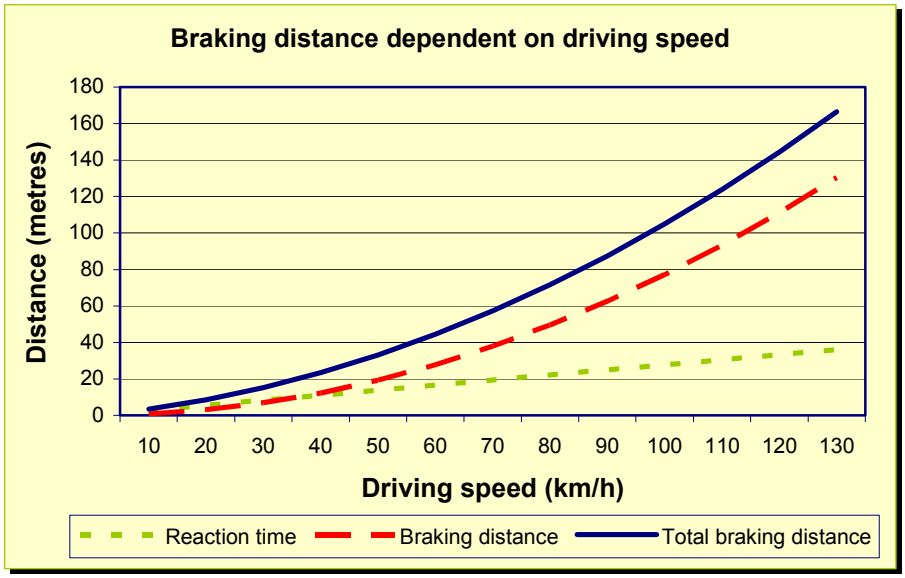

Figure 2. *Distance in metres needed for an emergency stop on a wet road surface, with a one second reaction time.*

In any case it is clear that, already at a fairly low speed, a lot more than two seconds are needed for a complete emergency stop. We emphasize that this headway time is only sufficient to make an emergency stop possible and to keep one's distance from the vehicle in front.

How high is the risk of multiple collisions?

The crash statistics show that, in the Netherlands, in the 2001-2006 period an average of 42% of injury crashes on motorways and main roads were rear-end collisions. This was the case in 36% of all registered Material Damage Only (MDO) crashes, and in 20% of all fatal crashes.

The frequency of rear-end collisions depends on how busy the traffic is. They occur more often during the rush hours than other hours, and they are more frequent than other crash types during rush hours (see *Figure 3*). Most of the crashes on motorways and main roads occur between 8 and 9 a.m. and between 5 and 7 p.m.; this is even more so for rear-end collisions.

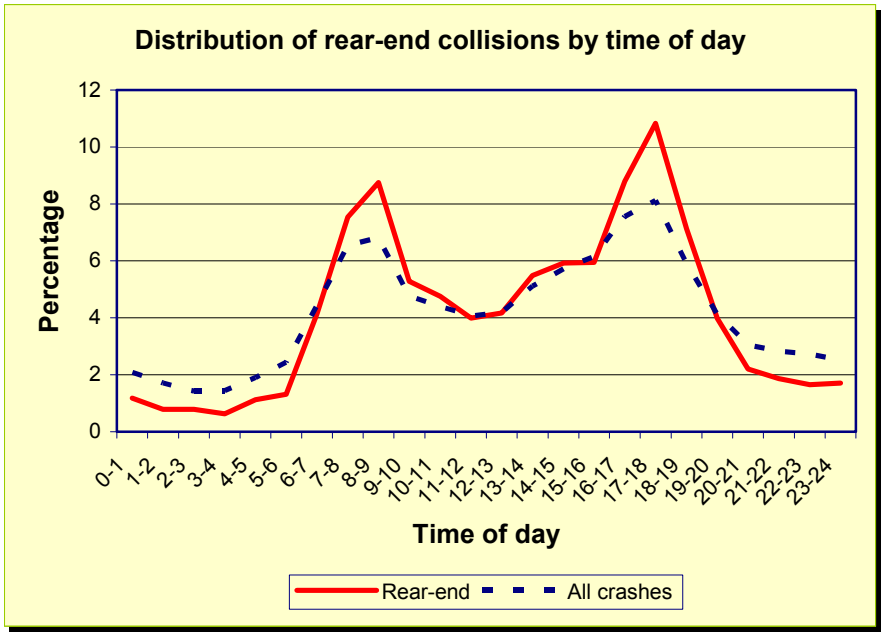

Figure 3. *Distribution of Killed and Severely Injured (KSI) rear-end collisions on motorways and main roads by time of day, compared with that of all KSI crashes on these roads.*

It goes without saying that the average headway distance and time, which on busy roads are often shorter than on quieter roads, influence such rear-end collisions happening. The police are certainly convinced that rear-end collisions are the result of keeping too short a distance; they register this as being the cause in 80% of rear-end collisions. The Dutch Public Prosecution Service also follows this line in tracking down and prosecuting tailgaters (see below).

When may we speak of tailgating?
Police policy correctly aims at fighting tailgating because it is not only annoying, but also dangerous. We speak of tailgating if the headway time is considerably less than one second, e.g. a half-second. Fines have been tuned to this. We can conclude from this that tailgating is at no time regarded as normal traffic behaviour, even if motorists are 'forced' to keep headway distances shorter than two seconds when, for example, there is a lot of traffic.

How do we keep the headway time at two seconds?
Various ways have been devised to help motorists keep the two seconds headway time. The police advise them to choose a particular point alongside the road and to count from the moment that the vehicle in front passes it. If the motorist can count to two or further before passing that point himself, the headway distance is sufficient.
At specific locations, some roads have auxiliary markings on the carriageway surface which can also be used to drive at a safe speed when the visibility is poor. The speed must be adjusted in such a way that that two or three such markings are visible (Helliar-Symons et al., 1995).
A more modern way to maintain a fixed headway time is by using Advanced Cruise Control (ACC). This system can not only be set at a specific speed (cruise control) but can also control an adjustable headway time. The system can itself intervene by decelerating and (slightly) braking to a maximum of 1.5 m/s^2, and warns the driver if a more serious intervention is needed. A SWOV literature study shows that fewer short headway distances are kept when the system is used (Hoetink, 2003). Besides this, on a not too busy main road it can result in more homogeneous speeds. There are also disadvantages of ACC, such as a more restless traffic dispersion in busier traffic because motorists with ACC wait until their system raises the alarm before using the brakes themselves. This results in stronger braking forces. Future versions of ACC should also be usable in busier traffic by, for example, keeping headway times of about one second. A precondition is that these systems are able to brake quicker than the current 1.5 m/s^2. For the time being, however, there is no reason to dispense with the two-second rule.

Conclusion
Using the two-second rule and the headway distance that goes with it (which varies from several to many dozens of metres, depending on the driving speed) works well on motorways and main roads with little traffic, but can come under pressure when the road gets busier. Then, the two seconds are often reduced to less. A modern instrument to keep one's distance is Advance Cruise Control (ACC). ACC has the possibility to set both the driving speed and the headway distance separately. The system was originally designed as a *comfort* system (cruise control) for use on long distances with a more or less uninterrupted stream of traffic, but its added value lies in maintaining an automatic and sufficiently long headway distance. Current ACC systems have not yet been adapted to also being used in busy traffic with changing driving speeds; one of the things required for this is a more powerful braking deceleration than the 1.5 m/s^2 of current systems.

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

Alexander, G.H. & Lunenfeld, H. (1990). *A user's guide to positive guidance*. (Third edition). FHWA-SA-90-017. Federal Highway Administration FHWA, U.S. Department of Transport, Washington D.C.

Helliar-Symons, R., Webster, P. & Skinner, A. (1995). *The M1 Chevron Trial*. In: Traffic Engineering and Control, Vol. 36, Nr. 10, p. 563-567.

Hoetink, A.E. (2003). *Advanced Cruise Control and Road Safety; a literature study*. R-2003-24. SWOV Institute for Road Safety Research, Leidschendam.

Lamm, R., Psarianos, B. & Mailaender, T. (1999). *Highway design and traffic safety engineering handbook*. McGraw-Hill, New York.