SWOV Fact sheet

Headway times and road safety

Summary
It is advised to maintain a minimum distance of two seconds to the vehicle in front. This headway time is based on the reaction time of drivers under various circumstances. A headway time of two seconds is sufficient for the majority of drivers to prevent a rear-end collision with the vehicle in front. This is particularly the case on motorways, where the traffic situation is not very complex. It gives the driver sufficient time to commence emergency braking if necessary. However, many people maintain a shorter headway time, which increases the risk of rear-end collisions and multiple collisions. Devices that can be of aid to drivers in maintaining sufficient headway time are auxiliary markings on the carriageway surface, a headway information system and Advanced Cruise Control.

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 risk is highest on motorways and main roads. These are also the locations for annoying and dangerous tailgating, i.e. following at a very short distance. This fact sheet discusses the background of the 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, and varies from less than one second to about two seconds (Lamm et al., 1999). According to Lamm et al. (1999) the reaction time is a function of alertness, complexity, and expectation.
The driver's alertness is related to the person's physical condition. Fatigue can play a role here, as well as distraction, such as talking with a passenger or using a mobile phone. The reaction time is also determined by expectation. When a driver suddenly sees an obstacle on a motorway, 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 guarantees a safe headway for all drivers on motorways and main roads where the traffic situation is generally not complex and the driver only has to keep an eye on the vehicle directly in front, and preferably also on the vehicles further ahead. There is sufficient time to react even in the ultimate case of emergency braking.
Although an emergency stop requires more time (see below), the two seconds are sufficient to commence emergency braking 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, and a one second reaction time is assumed. In the case of an emergency stop at 80 km/h, the total braking time is almost 4.5 seconds, and the total braking distance is about 44 metres. In the case of an emergency stop at 120 km/h, the total braking time is 6.7 seconds, and the total braking distance practically doubles to more than 111 metres. Of course the braking distances are shorter on a dry road surface, but the disproportionately longer braking distance at higher speeds remains.

© SWOV, Leidschendam, the Netherlands
October 2010

Reproduction is only permitted with due acknowledgement

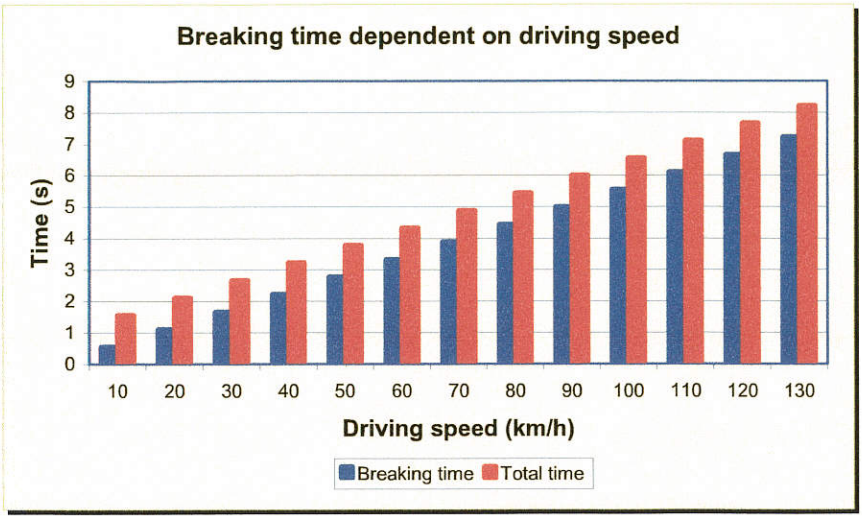

Figure 1. *The braking time for an emergency stop on a wet road surface at various speeds, with a one-second reaction time.*

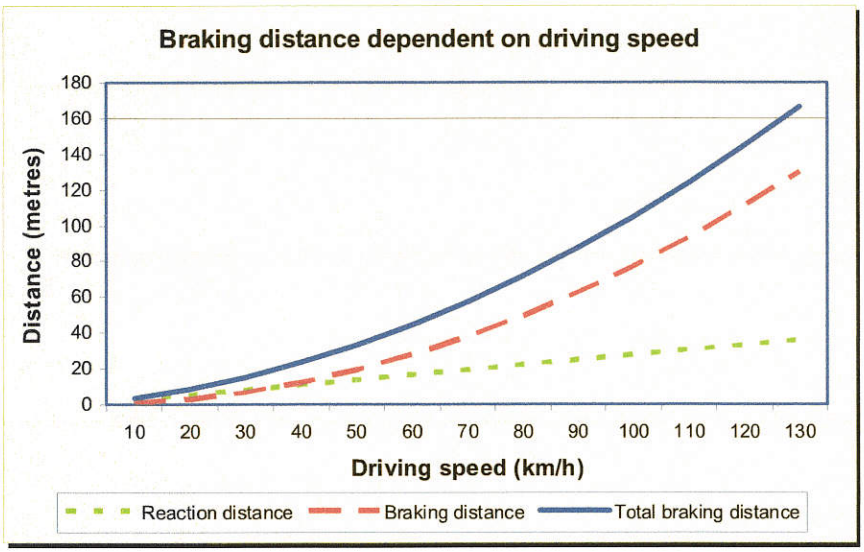

Figure 2. *Distance in metres needed for an emergency stop on a wet road surface, with a one-second reaction time.*

In any case it is clear that, even at fairly low speeds, 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.

Which headway times are maintained in practice?
Using an instrumented vehicle, Hansen & Minderhoud have collected data on the headway between passenger cars and lorries on a Dutch motorway. As the speed of vehicles increases, the average headway time decreases. At speeds from about 90 km/h, the average headway of passenger cars is less than 1 second. In general, the headway time of lorries is somewhat higher and averages about 1.3 seconds at higher speeds.

How high is the risk of rear-end collisions and multiple collisions?
The crash statistics show that in the 2004-2008 period an annual average of threehundred serious rear-end crashes (crashes with fatalities or inpatients) occurred in the Netherlands, which is 32% of all

© SWOV, Leidschendam, the Netherlands
October 2010

Reproduction is only permitted with due acknowledgement

serious motorway crashes. On average, 23 of these crashes per year were fatal, which is 22% of all fatal motorway crashes. The percentage of rear-end crashes is somewhat higher still for minor injury crashes and Material Damage Only (MDO) crashes, namely 49% and 39% respectively.

In the 2004-2008 period, more than one third of the serious rear-end crashes on motorways involved more than two vehicles. In an average of five of the serious rear-end crashes more than five vehicles were involved.

The frequency of rear-end collisions depends on the amount of traffic. They occur much more often during the rush hours than during 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 6 p.m.; this is even more so for rear-end collisions.

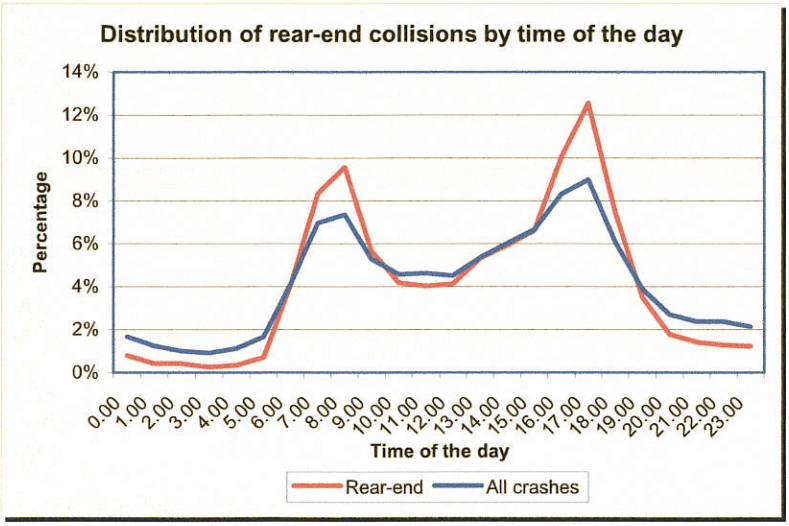

Figure 3. *Distribution of rear-end collisions (including MDO, average over the 2004-2008 period) on motorways and main roads by time of day, compared with that of all Killed and Serly Injured (KSI) crashes on these roads.*

It goes without saying that the average headway (distance and time), which on busy roads is often shorter than on quieter roads, influences such rear-end collisions and multiple collisions occurring. The police register too little headway as the cause in 80% of rear-end collisions.

When may we speak of tailgating?
According to the regulation road crashes, tailgating (following a vehicle at very short distance) takes place when the distance of a person's vehicle to the vehicle in front is such that he is incapable of stopping the vehicle within the distance where he has an overview on the road and where this road is unobstructed (art. 19 Traffic Code 1990). This is the case when the distance between vehicles is smaller than the distance covered in the reaction time. For example, at a speed of 110 km/h the vehicle covers more than 30 m/s; at a very good reaction time of 0.5 seconds, tailgating takes place in this situation when the distance between vehicles is less than 15 m. Police policy aims at fighting tailgating because it is not only annoying, but also dangerous. Fines have been tuned to this.

How do we keep the headway time at two seconds?
In a number of traffic safety campains the Dutch Ministry of Transport has paid attention to keeping sufficient distance, using slogans such as 'Little distance, a great risk' 'Keep a two-seconds headway' and 'I love keeping distance'. Various ways have been devised to help motorists keep the two seconds headway time. The police advice is to choose a particular fixed point alongside the road and to start counting from the moment that the vehicle in front passes that point. 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 (chevron arrows) which are also used to determine a safe speed when the visibility is poor. The speed must be

© SWOV, Leidschendam, the Netherlands
October 2010

Reproduction is only permitted with due acknowledgement

adjusted in such a way that that two or three such markings are visible (Helliar-Symons et al., 1995; Beek et al., 2008).
In addition, at two provincial roads in Noord-Brabant a headway information system has been tested, which shows the driver the headway time to the vehicle in front on electronic signs alongside the road. The chevron arrows as well as the headway information system resulted in longer headway times (Beek et al., 2008).
A different way to maintain a fixed headway time is by using Advanced Cruise Control (ACC). This system was originally designed as a *comfort* system (cruise control), to be used for large distances with a more or less unobstructed traffic flow. However, the more advanced type of ACC can be set at a particular headway time as well as a specific speed and can control them. The system itself can intervene by decelerating and (slightly) braking to a maximum of 1.5 m/s^2, and warns the driver if more serious intervention is needed. According to Alkim et al. (2007), ACC decreases the number of very short distance headways. However, negative effects of ACC have also been found. More information can be found in the SWOV Fact sheet *Advanced Cruise Control (ACC)*.

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. However, when the road gets busier, the two seconds are often reduced to less. Short headway times increase the risk of rear-end collisions and multiple collisions. Around three hundred serious rear-end crashes occur on Dutch motorways and main roads per year. Relatively often, these crashes occur during rush hours.
Various instruments are available to help drivers maintain two seconds headway time, such as auxiliary markings on the carriageway surface and Advanced Cruise Control.

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.

Alkim, T., Bootsma, G. & Looman, P. (2007). *De Rij-Assistent; systemen die het autorijden ondersteunen*. Studio Wegen naar de Toekomst (WnT), Directoraat-Generaal Rijkswaterstaat, Delft.

Beek, W. van, Martens, G. & Quirijns, G. (2008). *Volgtijd Informatie Stysteem VIS of visgraat? Volgtijdinformatie getest in Noord-Brabant*. In: Verkeerskunde, vol. 59, nr. 3, p. 40-45.

Hansen, I.A. & Minderhoud, M.M. (2003). *Empirisch onderzoek naar minimale volgtijden en time-to-collisions van auto- en vrachtwagenbestuurders op autosnelwegen*. In: Verkeerskundige werkdagen 2003, Ede.

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

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

© SWOV, Leidschendam, the Netherlands
October 2010

Reproduction is only permitted with due acknowledgement