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SWOV Fact sheet

Headway times and road safety

Summary

In road traffic, the advice is 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 mainly 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 help drivers to maintain sufficient headway time are auxiliary markings on the carriageway surface, a headway information system, Advanced Cruise Control and Following Distance Warning systems.

Background and content

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 so-called 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 unexpectedly 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, by far 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 mainly provides a safe headway for all passenger cars on motorways, because the traffic situation is generally not complex there 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, at least for passenger cars, to commence emergency braking without the vehicles getting too close to each other. After all, all passenger cars brake with similar deceleration rates. In general, buses and lorries carrying freight need to brake more carefully and therefore have a longer braking distance. Such vehicles should therefore maintain a somewhat longer headway time.

How much time does an emergency stop take?

The total time needed to make the vehicle stop consists of the abovementioned reaction time of the driver plus the braking time (t) needed to decelerate the vehicle 'to zero'. This braking time t is determined by the driving speed (v) and the braking deceleration (a): $t=v/a$. The total distance covered before a vehicle stands still consists of the 'reaction distance' (reaction time x v) plus the braking distance s that is covered while braking. The braking distance s is related to braking deceleration and braking time as follows: $s=\frac{1}{2}at^2$.

In *Figures 1 and 2* the braking time and braking distance in an emergency stop are shown as a function of the driving speed. The example used here is that of a 'reasonably quick' reaction of the driver in suboptimal circumstances: a constant braking deceleration of 5 m/s^2 and a one second reaction time on a wet road surface. In the case of an emergency stop at 80 km/h, the total braking time is far above 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 practically doubles 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.

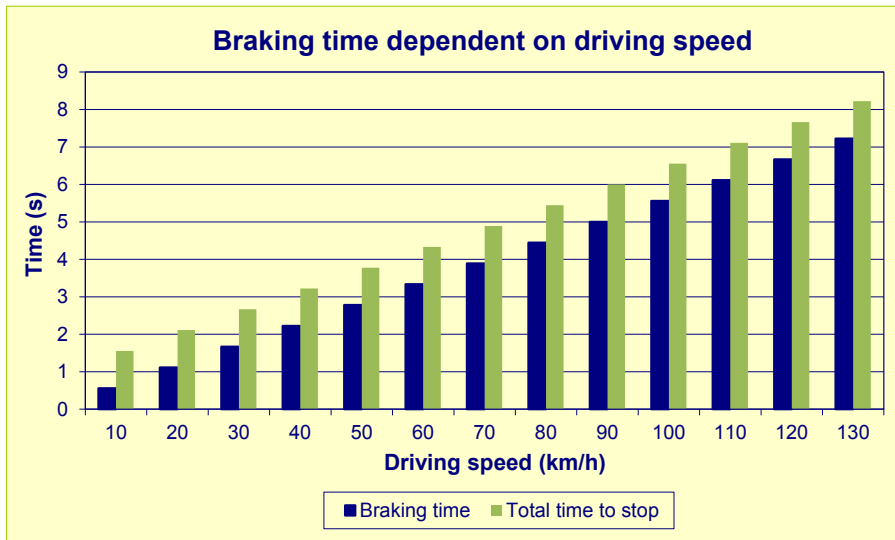


Figure 1. The braking time and the total time needed for an emergency stop on a wet road surface at various speeds, with a one-second reaction time.

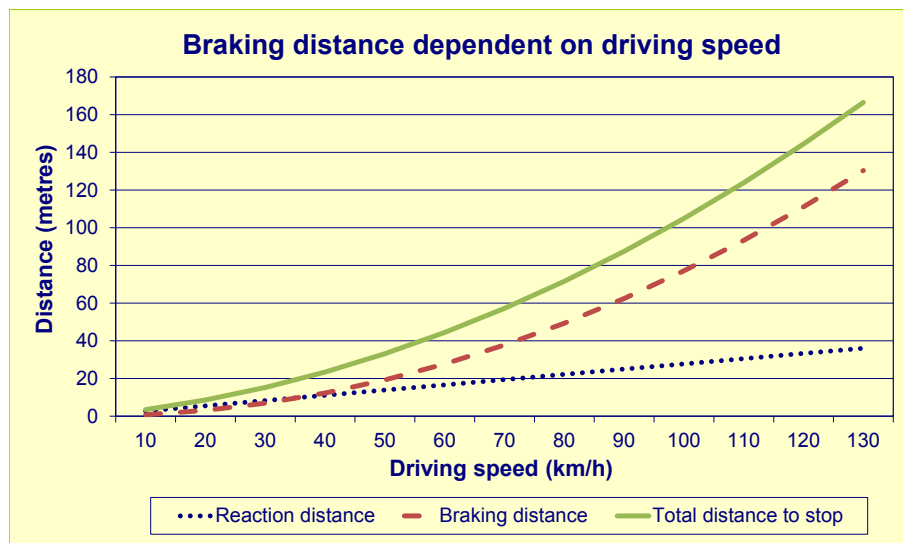


Figure 2. Distance in metres needed for an emergency stop on a wet road surface at various speeds, with a one-second reaction time.

In any case it is clear that, even at fairly low speeds, many more than two seconds are needed for a complete emergency stop, also when there is a reasonably quick reaction time of one second. We emphasize therefore that this two second headway time is only sufficient to make an emergency stop possible and keep one's distance from the vehicle in front.

Which headway times are maintained in practice?

Using an instrumented vehicle, Hansen & Minderhoud (2003) collected data on the headway between passenger cars and lorries on a Dutch motorway. They mainly observed speeds between 60 and 100 km/h. In addition, lower speeds, between 0 and 60 km/h, were also observed. 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. The shorter headway times that are measured in practice lead to a higher road capacity of motorways. If everyone on the motorway would maintain a headway time of two seconds, the capacity would be $3600/2 = 1800$ vehicles per hour per lane. In practice, motorways have a capacity of 2000 to 2500 vehicles per hour per lane.

How high is the risk of rear-end collisions and multiple collisions?

The headway time (and therefore also the headway distance) influences the risk of rear-end collisions and multiple collisions. The police registers (too) short headway times as the cause of 80% of all rear-end collisions. The crash statistics show that in the 2005-2009 period an annual average of 250 serious rear-end crashes (crashes with fatalities or serious road injuries) occurred in the Netherlands, which is 34% of all registered serious motorway crashes. On average, 20 of these crashes per year were fatal, which is 25% 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 51% and 38% respectively. In the more recent years 2010 and 2011 the registration in the Dutch Database Registered Crashes in the Netherlands (BRON) was insufficient to give a reliable estimation of the actual number of rear-end collisions. However, the shares of rear-end collisions in the total number of crashes in 2010 and 2011 are similar to those in previous years¹. In the years 2007-2011 serious rear-end crashes made up 36% of all registered serious crashes and 25% of all registered fatal crashes.

In the 2005-2009 period, more than two vehicles were involved in more than one third of the serious rear-end crashes on motorways. In that same period, more than five passenger cars were involved in an annual average of three of the serious rear-end crashes.

The average headway times are often smaller on busy roads than on quiet roads, and rear-end collisions take place more frequently when traffic is busy. They occur much more frequently during the rush hours than during other hours, and during rush hours they are more frequent than other crash types (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 the case for rear-end collisions.

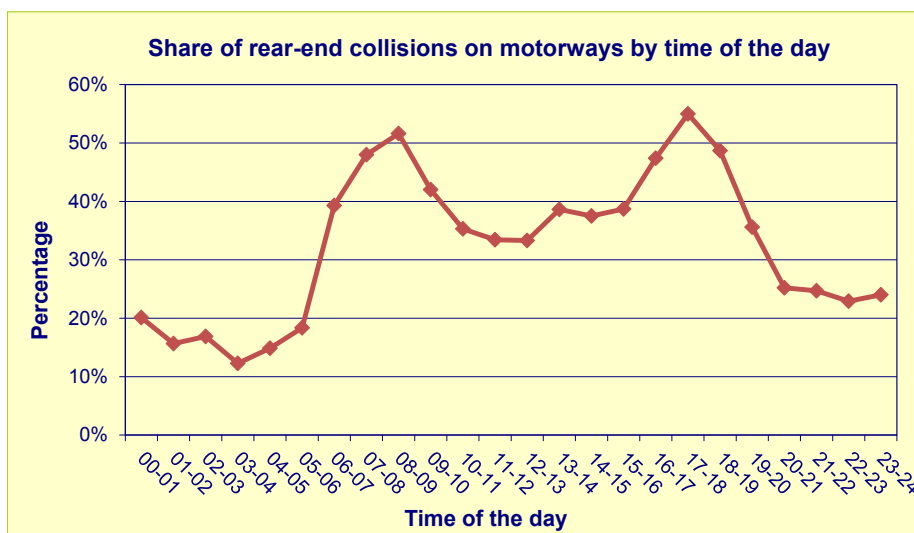


Figure 3. Share of rear-end collisions in the total number of crashes (including MDO, average over the 2005-2009 period) on motorways by time of day (source: lenM – BRON)

¹ This cannot be said for MDO crashes, the causes of which are often no longer registered.

When do we speak of tailgating?

In publications, tailgating is defined as following a vehicle in front at such little headway that it is no longer possible to stop the vehicle in time when that vehicle in front makes an emergency stop (Mesken, Goldenbeld & Vlakveld, 2011). Article 19 of the Traffic Code of 1990 formulates the regulation that covers tailgating as follows: "The driver must be capable of stopping his vehicle within the distance in which he has an overview of the road and in which this road is unobstructed." If one has very little headway time for a very short period of time in busy traffic, this is not necessarily tailgating. We only speak of tailgating when there is too little headway time for a longer period of time. Police policy aims at fighting tailgating because it is not only annoying, but, more importantly, it is also dangerous.

How do we keep the headway time at two seconds?

In a number of traffic safety campaigns the Dutch government has paid attention to keeping sufficient distance, using slogans such as 'Short distance, a great risk', 'Keep a two-seconds headway' and 'I love keeping distance'. Various ways have been devised to help drivers keep the two seconds headway. 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 now have auxiliary markings on the lanes (chevron arrows) which are also used to determine a safe distance when the visibility is poor. The headway time must be adjusted in such a way that that two or three such markings are visible between one's own vehicle and the vehicle in front (Helliard-Symons et al., 1995; Beek et al., 2008).

Furthermore, a headway information system has been tested on two provincial roads in the Dutch province Noord-Brabant, 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).

Other ways of maintaining a safe headway time is by using Advanced Cruise Control (ACC) or a Following Distance Warning (FDW) system. Cruise Control was originally designed as a *comfort* system 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 at a specific speed and can control them both. The system itself can intervene by decelerating and (slightly) braking to a maximum of 1.5 m/s^2 , and warn the driver if more serious intervention is needed. According to Alkim et al. (2007), ACC reduces the number of very short distance headways. However, negative effects of ACC have also been found. For more information see SWOV Fact sheet [Advanced Cruise Control \(ACC\)](#). FDW systems continuously measure the headway time to the vehicle in front with a wave radar or laser radar. The moment the headway time is too short, the driver receives a visual or auditory warning. An evaluation in Australia shows that FDW causes a higher average headway time and less variation in headway time (Regan et al., 2006).

Matrix signs above the road in case of traffic jams is a more conventional instrument to prevent rear-end collisions, though it does not prevent short headway distances. These signs warn all traffic for the congestion ahead and give the advice to reduce speed.

Conclusion

A headway time of two seconds is recommended for safely driving behind a vehicle in front. However, in practice the headway time is often less than two seconds, especially at higher speeds.

Short headway times increase the risk of rear-end collisions and multiple collisions. Up to 2009, slightly more than two hundred and fifty serious rear-end crashes were registered annually on Dutch motorways. 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, a headway information system and the intelligent vehicle systems Advanced Cruise Control and Following Distance Warning.

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

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