

Safety effects of navigation systems

Summary

Increasing numbers of drivers are using navigation systems in their cars. The advantages to the user are obvious: you can get to your destination via the fastest and shortest route. This reduces stress and exposure to other traffic. However, there are also some (unintended) negative effects. For example, using the system while driving can distract your attention from other traffic. The system sometimes directs traffic through small centres of habitation or along unsuitable roads. Moreover, timely information on traffic congestion can make traffic distribution across the road network unmanageable. All in all, it is not yet certain that the use of navigation systems increases road safety.

Background and content

In 2007/2008, over 60% of goods vehicles and over 20% of passenger vehicles were fitted with navigation systems. More recent data is not available, but presently the percentage will probably be higher, considering the great increase in sale of navigation systems (Christoph, 2010). Systems of this type replace traditional maps and make it easier to find your destination. However, aside from the advantage of quick, easy navigation, this system also has its disadvantages. This fact sheet will discuss the use of navigation systems, their advantages and disadvantages, and whether they have (sometimes unintended) safety effects.

Who uses navigation systems, how often and when?

DVS (2008) conducted a survey of 202 drivers who use a navigation system. Most of the respondents (60%) drive at least 20,000 kilometres per year in their own car or in a company car¹. Almost 70% of the respondents never use their navigation system for commuting to work. The system is primarily used for business and recreational journeys.

TNO (Vonk et al., 2007) studied data of 1,144 car drivers. Of this group, 28% owned a navigation system. According to TNO, that is more than the figure of about 20% found by other studies. Over 35% of the car drivers in possession of a navigation system used it on 20% of their trips and over 15% used it on 80% of their trips. The system was mainly used for unfamiliar destinations. The drivers who have a navigation system drive more kilometres per year than the group without such a system: of those who have a system, 60% drive more than 20,000 km per annum; of those without a system, 40% drive more than 20,000 km per annum.

Oei (2002) surveyed 130 navigation system users. 95% of them used the system on unfamiliar routes, while 57% of them used it on (more) familiar routes.

To sum up, in 2007 a fifth to a quarter of car drivers owned navigation systems. These are mainly drivers who annually drive more than the average number of kilometres. They mainly use the navigation system for unfamiliar destinations.

What are the advantages and disadvantages of a navigation system?

As with all (electronic) aids in vehicles, a navigation system is primarily an individual tool. However, the navigation system also has external or collective effects: operating and/or using the system can distract the driver's attention from the other traffic. Also, a possible reduction in traffic along busy routes may go hand in hand with excessive traffic on alternative routes (see also below). We will now discuss a number of advantages and disadvantages.

Less exposure

The main purpose of the navigation system is to find a suitable route to one's destination. The user can usually choose between the fastest and the shortest route. The fastest route will follow main roads insofar as possible, while the shortest route will take secondary roads. A navigation system that takes account of the current traffic conditions can sometimes recommend the fastest route via secondary roads. The fastest route minimizes the user's time in traffic and on the shortest route he covers the

¹ The average annual distance driven in 2006 was 13,840 km (CBS, 2008).

least number of kilometres. In either case, there is less exposure to 'danger'. This has a positive effect on road safety.

In the TNO study (Vonk et al., 2007) of system-equipped vehicles, the test subjects drove in an area unfamiliar to them. The subjects with navigation systems drove shorter distances (-16%) and had a shorter journey time (-18%). This may be because they spent less time stationary and selected a motorway route somewhat more frequently. The reduced exposure (in terms of time and distance) means that there is less chance of an accident. Hoedemaeker et al. (2008) found approximately the same results in similar research done in Germany and the United States.

Less searching

A navigation system ensures that the user does not have to do as much searching. As a result, he can devote more attention to the surrounding traffic and, moreover, drive more directly to the destination (less exposure). Both effects are good for road safety. DVS (2008) notes that almost 60% of the respondents use the system because it reduces the effort of driving. About 86% of the (surveyed) drivers with navigation systems use the 'fastest route' setting; only a few select the shortest route. Arriving at one's destination as quickly as possible and not having to make a detour are two important motives for using a navigation system (both are cited by over 40% of the respondents).

Attention to traffic

For safety reasons, users should adjust their navigation systems before setting off: doing this while driving will distract the attention from the surrounding traffic.

According to TNO (Vonk et al., 2007), nearly 80% of drivers say that a navigation system gives them more control over their journeys and nearly 70% say that it reduces stress. Furthermore, 60% of drivers say that the system makes it easier to keep one's attention on the road. TNO has also used a navigation system equipped car to study the mental effort made by drivers. This was a small-scale experiment with 36 drivers. Drivers who had a navigation system required less mental effort than those without a system, according to the drivers themselves as well as to the results of objective measurement. A large majority of the users surveyed by Oei (2002) considered it dangerous to adjust the system while driving. Nevertheless, 64% of them said that they did so sometimes or frequently. In addition to visual directions (via a screen), it is possible to get audio directions (generated voice). According to DVS (2008), 85% of drivers make use of both the spoken and visual facilities. A group of 12% uses only the display and only 3% use just the voice instructions. In Oei's study (2002), 83% of the respondents preferred the facility to also get directions by voice. The visual information will distract the driver's attention from the driving task more than the audio information (Verwey & Janssen, 1988).

Distribution on the road network

A navigation system with information on the current traffic situation can give the user early warning of upcoming traffic problems. However, if there are many vehicles on the road with such navigation systems, this can noticeably affect the distribution of traffic on the road network and even make it unmanageable. According to DVS (2008), a fifth of the respondents used the option to automatically change their route based on information about traffic congestion. Over a third of the respondents selected a route without also taking into account (potentially available) information about current or regularly occurring traffic jams.

Out-of-date or incorrect information

Out-of-date or incorrect information in the navigation system can lead to wrong decisions: undesirable or unsuitable routes (through traffic via streets in residential areas, heavy goods vehicles through town centres) or even incorrect routes (one-way traffic, physical obstructions, roadworks, roads with height limitations, viaducts and bridges unable to bear the vehicle's weight). Nearly half of the respondents in the DVS study (2008) knew how long ago their own map had been updated. About 60% had not refreshed the map details in the past two years. Important reasons for not doing so were cost (36%) and that it was too much trouble (19%). Important reasons for updating were notification of an available update (over 15%) and 'it's time to do so' (over 25%). Incidents of taking the wrong route or receiving wrong advice were barely cited as reasons for updating.

Desirable road categorization

The road categorization in the navigation system is a determining factor for route choice. The question remains which categorization is desirable for road safety purposes. Cartographers use more road types and categories – and different ones – than the Sustainable Safety vision (Donkers, 2007). Navigation systems do lead the user to a higher road category as quickly as possible, which

corresponds to the Sustainable Safety requirements on functional route selection. According to DVS (2008), users say that they take motorways (32%) and trunk roads (28%) more often when using a navigation system than when driving without it. They also drive more frequently via access roads (16% outside urban areas, 15% within urban areas); according to the users, these roads form part of the recommended fastest route. Of the users surveyed by TNO (Vonk et al., 2007), 18% said that they drove more via highways, 17% said that they drove more via secondary roads and 6% said that they drove more via urban roads.

From the point of view of road safety, it is better that routes follow motorways as much as possible and minimize the use of the other road classes.

Heavy goods vehicles

According to a 2007 AVV study, more than 60% of all lorries had a navigation system on board at that time. It is possible to supplement a navigation system with information of importance for heavy goods vehicles, such as height and weight restrictions. But far from all heavy goods vehicles have this option (Goudappel Coffeng, 2007; DVS, 2008). This results in heavy goods vehicles finding themselves in residential neighbourhoods, getting stuck under viaducts or driving along excessively narrow roads. Goudappel Coffeng (2007) surveyed 493 road authorities about situations like this. 78% of them said they suspected that use of a navigation system caused the problem in at least one of the situations. Four hundred situations were then studied in more detail. According to the road authorities concerned, a road safety problem arose in 83% of these situations.

In summary

The overall effects of navigation systems are (1) less exposure at the expense of attention for the surrounding traffic, and (2) the distribution of traffic over the road network may become unmanageable if the number of users receiving current information increases. High-quality information is a prerequisite for achieving the desired aim (finding a suitable route).

Who plays which role here?

Four distinct groups are involved in navigation systems: road authorities, map producers, navigation system manufacturers and the users.

Road authorities supply information to map producers about (temporary) changes in the road network. It is estimated that there are 120,000 changes per year (DVS, 2008). Map producers then supply their map information to the manufacturers of navigation systems. Finally, these manufacturers sell their products to the users.

Hitches and errors can occur in this supply chain, with the result that the end user takes to the road with incorrect information. Ideally, road authorities should be fully aware of all relevant changes. This information should then reach the various map producers in full and without errors, after which the map producers should promptly pass on all the changes to the navigation system manufacturers. Finally, the users should also receive all the changes in time. The actual situation is far from ideal. The main problems are as follows:

- The navigation system determines the route choice by observing a hierarchy in the road network – a form of road categorization. The road authority has established this hierarchy and passed it on to the map producer. This hierarchy usually deviates from the three road categories according to Sustainable Safety (Donkers, 2007).
- There is no national data bank with all relevant information about the road network, such as its layout and the amount of traffic using it. The information that is available is stored and delivered in various different ways. This means that it is no simple task for all those concerned to get an overview of the relevant current information. On these matters, Donkers (2007) gives the following main recommendations for improvement: national and regional direction of data collection, introduction of a central database based on the National Roads Database, coordination of road categorization between road authorities and map producers, and management of roadworks and events.
- The users can buy the information in one purchase or periodically, or download the changes online. When information is obtained periodically or in one purchase, the user has no insight into the latest changes and will therefore come up against unexpected situations such as roadworks or closed roads.

Is it safer to drive with a navigation system than without one?

The crash registration does not include any information about the presence of navigation systems in the vehicles involved, which means it is not possible to conduct a crash analysis.

TNO draws the conclusion that a navigation system leads to increased safety (Vonk et al., 2007). Their research makes it clear, in any case, that a navigation system eases the driving task. There is also less exposure due to the fact that users cover less distance (-16%) and spend less time in traffic (-18%). A disadvantage is the amount of time that drivers exceed the permitted speed limit (+5%). No significant change in average speed has been found.

Perez et al. (1996) describe a study in which data was collected for a year from one group of vehicles with navigation systems and another group without them. They found that the navigation system has a favourable effect on driving performance and a small positive (but not significant) effect on the number of incidents, crashes and near-crashes. These authors also carried out a simulation study, which showed that vehicles with a navigation system opted more frequently for less congested routes. However, these routes follow roads with a higher crash rate, which means that the lack of safety is greater for these vehicles than for vehicles without a system.

Tijerina et al. (2000) found that the operation of various navigation systems did not meet their safety criterion, which is a maximum operating time of fifteen seconds. They had test subjects carry out operating tasks with navigation systems in a parked car and during a driving task (following the road lane). In both situations, the operating time was more than fifteen seconds.

Feenstra et al. (2009) have executed a test among lorry drivers, where the navigation systems offered the choice between the safest or the quickest route. The safest routes turned out to be somewhat (yet significantly) longer than the quickest routes, while the (significantly) quickest routes were somewhat less safe than the safest routes (based on the risk data by Janssen, 2005). In 78% of the routes, the quickest and the safest routes were one and the same. Without knowing this beforehand, the 30 participating lorry drivers chose the 'quickest' routes for around 60% of the more than 1,200 routes, and chose the 'safest' for 40% of the routes. The navigation system used the scoring method of Dijkstra & Drolenga (2006) to calculate the safest route. For each new route the ten quickest routes were calculated, from which the safest route was then selected and offered.

Christoph (2010) finds no indication in recent literature about the quantitative effects of navigation systems on road safety.

Conclusions and recommendations

According to the latest known figures dating from 2007/2008, a fifth to a quarter of car drivers own navigation systems. Presently, this proportion is probably higher. Mainly drivers who drive more than the average number of kilometres per annum own a navigation system, and they mostly use the navigation system for unfamiliar destinations.

High-quality information is a prerequisite for achieving the desired purpose of finding a suitable route. In all cases, the information should include specific details for heavy goods vehicles.

When used properly – i.e. when the system is adjusted before starting to drive – navigation systems ease the driving. The routes followed are shorter (in terms of both time and distance), so that exposure to 'danger' is reduced. The advantage of taking a shorter route can be undone if the shorter route follows roads with a higher risk (especially distributor roads). Routes that take drivers along access roads will reduce safety: navigation systems should advise against the use of such roads as much as possible.

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