NAVIGATION SYSTEMS SERIOUSLY UNDERMINE ROAD SAFETY

Software errors are being ignored

Research report of Stichting Onderzoek Navigatiesystemen

Reportnumber: nav-001 - (English version)

The Hague, The Netherlands, December 10th, 2007

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The purpose of Stichting Onderzoek Navigatiesystemen is defined as follows in the articles of association:

1. The foundation serves the purpose of conducting comparative research on the market for navigation systems, at home and abroad, and carrying out any activity in any way related to or in support of this purpose.

2. The foundation covers a wide range of activities in achieving its objective and may conduct comparative research on the market for navigation systems, at home and abroad, as it sees fit. In addition to pointing out the material differences of different navigation products for the benefit of market transparency, the foundation also seeks to contribute to increasing road safety.

3. One research criterion is defining and applying uniform criteria for comparison and determining to what extent lessons may be learned from observations that may translate into recommendations for interventions conducive to safety.

4. The foundation publishes a particular research project's findings in a research report and research certificates. The reports promote transparency in the market for navigation systems and offer recommendations about measures that may be taken in order to improve systems and safety. The recommendations are addressed to those individuals and institutions who, because of their position of responsibility, have the power to take those measures. Consequently, recommendations are not only offered to government ministers, but also to public authorities, companies and other organisations in society.

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The Hague, The Netherlands, December 10th, 2007

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Secretary

Stichting Onderzoek Navigatiesystemen wishes to thank everyone who has contributed to this report.

The full report by the Stichting Onderzoek Navigatiesystemen, entitled "Navigation Systems Seriously Undermine Road Safety, Software Errors are Being Ignored. Research report, reportnumber: nav-001 – (English version), The Hague, The Netherlands, December 10th, 2007", may be consulted on the website of the Stichting Onderzoek Navigatiesystemen (www.stichtingonderzoeknavigatiesystemen.nl). For further information, please feel free to e-mail the secretariat of the Stichting Onderzoek Navigatiesystemen: E-mail: secretariaat@stichtingonderzoeknavigatiesystemen.nl

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2. Preface

Using a novel research approach, Stichting Onderzoek Navigatiesystemen has discovered why navigators fail to identify ring roads in built-up areas. The problem is caused by flaws in the software. Stichting Onderzoek Navigatiesystemen predicts catastrophic consequences if the government does not intervene: more traffic accidents and casualties, and roads that were never intended for heavy use being congested with traffic from elsewhere.
The research approach has been developed with a view to testing whether mobile phones can navigate. The conclusion drawn from the research is that they can in principle, but not all products do.

This report spells out the findings and recommendations.

3. Summary

Stichting Onderzoek Navigatiesystemen has investigated whether telephone navigators really can navigate. It has found that only Nav4All offers the proper route and meets all the criteria tested. The other 12 navigators failed almost all tests. Consumers are urged to refrain from purchasing these products, and the government is urged to ban them because their use will increase the number of traffic accident casualties.

The flawed navigators cause motorists to behave like ‘kid killers’, driving through designated low-traffic residential areas not intended for through traffic. These products fail to detect ring roads. Flaws in the software are to blame. The argument put forward by TomTom, alleging the government is at fault, is incorrect because the Nav4All product, which is distributed free of charge, has been found to meet all the criteria tested.

One effect of these flaws in the software is that the automatic re-routing function, that navigators like TomTom use, in response to approaching road congestion diverts motorists from congested roads to local roads unsuited to handling congestion-avoiding traffic. This increases the number of traffic accidents and casualties and damages the quality of life and the environment in residential areas.

4. Table of contents

5. Introduction

Your telephone is becoming your personal assistant. It offers you email, internet, text messages, photographs, film, radio, TV, music, and now even navigation. 'Don't ask how it works, just enjoy!', as the saying goes. Now that the mass market is opening up, we see the need to investigate whether a telephone navigator can do its work properly. Is it capable of finding the correct route and can it successfully direct the driver, removing all doubt and alleviating all need for searching behaviour? The investigation will concentrate on these two points.
Below is a short description of the investigation's structure.

Finding the correct route

There are four basic abilities a navigation system must have if it is to work out the correct route from A to B. It must be able to avoid routes through designated low-traffic areas as this is not permitted. It must be able to avoid routing through traffic in built up areas through residential areas. It must not direct through traffic outside built up areas along roads not meant for that purpose and, finally, it must not direct motorway traffic along short cuts that use local roads.
A test has been developed for each of these abilities to discover whether the navigator can fulfil the requirement. The results are given in chapter 7. A separate document has been compiled on the test for each ability, giving all relevant details, including advice to manufacturers, consumers and government.

Directing the driver

The navigator must also give correct instruction to the driver at the right moment: turn left, turn right, go straight on, and so on. The investigation concentrates on the instructions that are directly related to road safety. This mainly concerns driving on motorways and other multi lane roads. On these roads, not giving lane instructions in good time results in searching behaviour, hesitation, and panic reactions, and these can lead to traffic queues, accidents and casualties. The high driving speeds on these roads mean that mistakes always lead to dangerous situations for the driver and for other road users. The criteria tested are described in chapter 8.

Criteria to be set for on screen navigation information

The navigation instructions must all be in spoken form so that drivers can keep their eyes on the road. It must be possible to interpret on screen instructions at a glance. This is only possible if the symbols are clear and legible from 1.5 meters away. The criteria are discussed in chapter 8.

Extension of the test group

Because of disappointing test results for telephone navigation systems, other systems from important players in the market, Nokia and TomTom, were also tested.

Results of the investigation

All the systems investigated were tested for the criteria described. The results are comprehensively presented in test certificates (See chapter 8).
An error description for each criterion is given on the test certificates.

6. Finding the correct route

The correct route to drive from A to B is partly determined by the structure of the road network. Nowadays this network is based on extensive scientific research, with the aim of making the road network conform to the "Sustainable Safety" traffic policy.
The Stichting Onderzoek Navigatiesystemen [Foundation for Navigation System Research] will conform to the basic principles of the "Sustainable Safety" policy. Preventing searching behaviour by vehicle drivers also plays an important role here. In order to limit the size of this report readers are referred to the extensive bibliography. Appendix 1 contains a definition sheet where the three road categories and their characteristics are described.

In brief, the road network is divided into three types of road:

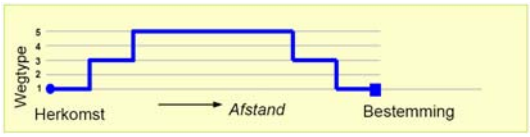
a) residential access roads (including designated low traffic residential areas)
These roads are designed for safe access to residential areas and are not intended for through traffic. Pedestrians, cyclists, motorcyclists and other motorised traffic often share the same road. In built up areas these are the roads that are made safe by using road narrowing, chicanes and the reduction in the speed limit to 30km/h.
Outside built up areas, the speed limit is 60km/h. Depending on the road type, this speed creates a dangerous situation, partly because cyclists and pedestrians are not sufficiently protected against motor traffic.
Computer navigation systems are not allowed to use these roads for through traffic. However, it is not against the law.

b) through roads (high speed roads)
These are roads designed to handle large volumes of traffic travelling at speeds of 100 to 120km/h.
The safety of these roads is due to their construction, which usually features separate carriageways, and the fact that only motor traffic is allowed to use them. Motorways belong to this category.

Wegcategorie kruist met	SW100/120	GOW80	GOW50/70	ETW60	ETW30
SW100/120	knooppunt	ongelijk-vloers	*ongewenst*	*ongewenst*	*ongewenst*
GOW80		rotonde	rotonde	rotonde	*ongewenst*
GOW50/70			rotonde	voorrangs-kruispunt	voorrangs-kruispunt
ETW60				plateau	plateau
ETW30					plateau

c) connecting roads between A and B
These roads are also referred to as area access roads.

The first diagram shows what ideal connection points between the various road types should look like. For more information, please refer to the literature.



The correct route usually begins and ends on a residential access road reached by a connecting road. Where the route is long distance the greatest part of the distance will be driven on through roads (see route diagram).

In choosing the route it is important to follow the ideal model in this diagram. Doing so automatically reduces to a minimum the number of kilometres on roads with the highest accident risk (see the accident table).

	Aantal ernstige ongevallen	Aantal ernstige ongevallen per 1.000 kilometer weglengte	Aantal ernstige ongevallen per miljard motorvoertuigkilometers
Binnen de bebouwde kom			
30 km/uur	494	18	137
50 km/uur	4.891	162	199
70 km/uur	148	122	31
Buiten de bebouwde kom			
60 km/uur	320	28	238
80 km/uur	2.928	66	52
100/120 km/uur	912	178	22

This investigation tests whether computer navigators succeed in applying the guidelines of the "Sustainable Safety" policy. In order to find the correct route these navigators must have four abilities. Thus, to investigate adherence to these four abilities, four tests are drawn up and designated as "examination criteria".

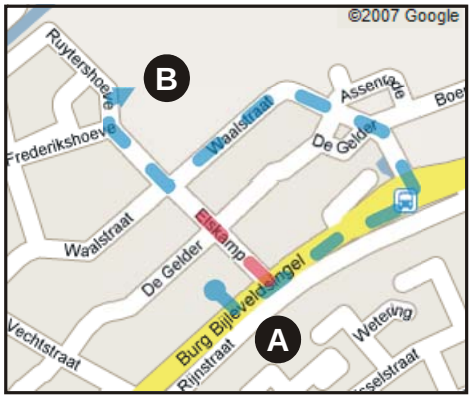
Investigation: four tests for the correct route (examination criteria)
1. Driving in designated low traffic residential areas is not permitted (kid killer).
2. Through traffic is not allowed on residential access roads in built up areas.
3. Through traffic is not allowed on residential access roads outside built up areas.
4. Motorway traffic is not allowed to seek shorter routes by temporarily leaving the motorway.

A separate document is compiled for each test, giving the aim of the test, the research method, a description of any error that occurs and the seriousness of the error. The sheet also includes advice to manufacturers, consumers and the government (See chapter 7).

7. Test group: choosing the proper route

Test item 1. Routes leading through designated low-traffic residential areas ("kid killer")

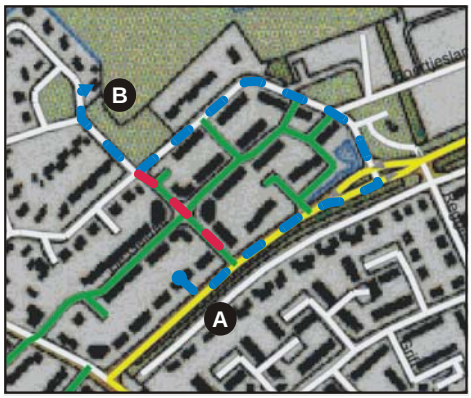
Navigation principle
Designated low-traffic residential areas are marked with road signs showing (among others) children playing against a blue background. Roads marked with this sign are intended first and foremost for residential activities (walking, playing, meeting neighbours), and not to facilitate traffic. Government regulation in the Netherlands (Traffic Regulations and Road Signs 1990, or RVV 1990) provides the following specifications for such areas: pedestrians may use the full width of the street for walking and playing, and vehicles are only allowed to drive at a walking pace. Pedestrians have right of way in all circumstances, cyclists have priority over motorised traffic, but road users should not unnecessarily obstruct one another.
A designated low-traffic residential area is intended for local-destination traffic only. Through traffic should therefore not take short cuts through such areas. While not illegal, driving through low-traffic residential areas is considered unacceptable social behaviour.



Objective of the test sample
The test was carried out, as an example, to investigate whether a navigation system was programmed with a view to ensuring that recommended routes did not include short cuts through designated low-traffic residential areas.

Research method
Distribution addresses on either side of the "Elskamp" low-traffic residential area were fed into the navigator to see whether the route recommended led through this area or around it, via Waalstraat.

Departure address (A): Burgemeester Bijleveldsingel 36, Hattem
Destination address (B): Ruytershoeve 2, Hattem



Test results:

NAVIGATOR	Network	"Kidkiller" test
1 Nav4All	Navteq	OK
2 KPN op Weg (Wisepilot)	Navteq	Failed
3 Wayfinder	Teleatlas	Failed
4 Jentro (Activepilot)	Navteq	Failed
5 Webraska	Navteq	Failed
6 AmazeGPS		Failed
7 Telmap (Vodafone)	Navteq	Failed
8 Nokia navigator	Navteq	Failed
9 TomTom Go	Teleatlas	Failed
10 TomTom One	Teleatlas	Failed
11 TomTom Rider	Navteq	Failed
12 TomTom One XL	Teleatlas	Failed
13 TomTom Gp 720T	Teleatlas	Failed

Test results - Explanation
Only one of the systems tested, Nav4All, offered the proper route around the low-traffic residential area, via Waalstraat. All other systems wrongly recommended a route through the "Elskamp" residential area.

Qualification of the error
Proposing a route through a low-traffic residential area when the final destination is not in that area should be regarded as an error in the software. The Dutch road system is designed so as to keep non-destination traffic out of low-traffic residential areas. Navigation software should not offer short cuts through such areas. Software errors like these can be detected and eliminated easily by running simple tests.

Severity of the error
Systems offering routes through play areas are colloquially known as "kidkillers". This is reckless driving taken to extremes! The navigator purposely guides the driver into a situation of unacceptable social behaviour. Manufacturers and suppliers of navigation software can be held directly responsible for the increase in accidents and casualties observed in the statistics [61] because of the causal link with the software error. This type of error is considered as a low level of social responsibility in the literature [11,12]. See also the jurisprudence in the Ford case [37], in which damages were awarded because a construction defect had been hushed up with a view to maintaining the manufacturer's profits.

Recommendation to manufacturers and suppliers of a product with this error:
Manufacturers and suppliers should warn their customers immediately about the consequences of this error, and inform them about a call-back campaign to have it corrected.

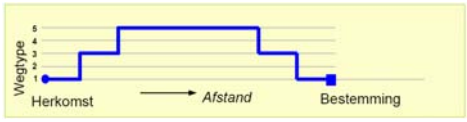
Recommendation to the consumer regarding a product with this error:
Don't buy it. If you have bought it, ask the shop to have this error corrected or insist on a refund on the basis of the conformity principle. You are not restricted to the warranty period in this case. This is EU law.

Recommendation to the government regarding products with this error:
Ban the sale and use of systems with this error, because it will increase traffic accidents and casualties, and have a negative impact on the living environment of children and the neighbourhood. Moreover, this error is at odds with the government's "Sustainable Safety" traffic policy. One of the government's prime responsibilities is to protect the residential areas it has created for children and neighbourhoods from undesirable external influences.

Test item 2. Through-traffic should not use residential roads in built-up areas

Navigation principle
In preparing the research, roads were divided into three categories: residential roads, through roads (high-speed roads) and connecting roads. Road selection typically starts with a residential road (A) leading to a connecting road which (over short distances) in turn leads to another residential road. Longer routes will often include a through road. Within built-up areas, vehicles should take the shortest possible route to the connecting road and stay on that road. The route selected, from A to B, should not advise the driver to leave the connecting road in order to take a short cut via residential roads.

NOTE: driving over residential roads is not illegal. Formally, roads are open to everyone. Navigation software, however, should meet other priorities: respect for public planning and road safety – these standards and rules take priority over finding the shortest route. Not complying with these standards and rules is considered unacceptable social behaviour.



Objective of the test sample
The test was carried out, as an example, to investigate whether a navigation system planned the route via the ring road. See map: A → C → B.

Research method
The test sample was based on the case featured in the "Rijdende Rechter" (Judge Calling) TV programme, in the town of Hattem, the Netherlands. The test involved a check on location (A) to see whether the proposed route ran via the ring road. See map: A → C → B – the blue dotted line.

Departure address (A): Hoopjesweg 1, Hattem

Destination address (B): Keizersweg 81, Hattem

Wegcategorie kruist met	SW100/120	GOW80	GOW50/70	ETW60	ETW30
SW100/120	knooppunt	ongelijk-vloers	*ongewenst*	*ongewenst*	*ongewenst*
GOW80		rotonde	rotonde	rotonde	*ongewenst*
GOW50/70			rotonde	voorrangs-kruispunt	voorrangs-kruispunt
ETW60				plateau	plateau
ETW30					plateau

	Aantal ernstige ongevallen	Aantal ernstige ongevallen per 1.000 kilometer weglengte	Aantal ernstige ongevallen per miljard motorvoertuigkilometers
Binnen de bebouwde kom			
30 km/uur	494	18	137
50 km/uur	4.891	162	199
70 km/uur	148	122	31
Buiten de bebouwde kom			
60 km/uur	320	28	238
80 km/uur	2.928	66	52
100/120 km/uur	912	178	22

Test results:

NAVIGATOR	Network	Hattem ring road
1 Nav4All	Navteq	OK
2 KPN op Weg (Wisepilot)	Navteq	Failed
3 Wayfinder	Teleatlas	Failed
4 Jentro (Activepilot)	Navteq	Failed
5 Webraska	Navteq	Failed
6 AmazeGPS		Failed
7 Telmap (Vodafone)	Navteq	Failed
8 Nokia navigator	Navteq	Failed
9 TomTom Go	Teleatlas	Failed
10 TomTom One	Teleatlas	Failed
11 TomTom Rider	Navteq	Failed
12 TomTom One XL	Teleatlas	Failed
13 TomTom Gp 720T	Teleatlas	Failed

Test results – Explanation
Only one of the systems tested, Nav4All, planned the proper route via the ring road (A → C → B). All other systems wrongly recommended a route via residential roads, which included 19 speed ramps and one low-traffic residential area. See map: A → D → B – the red dotted line.

Qualification of the error
The error is one in a category of software errors which should have been detected in trial runs and eliminated. As a result of this error residential roads are not excluded for through-traffic when the route is planned. Residential roads can easily be excluded with the available network data.

Severity of the error
The error frustrates the government's "Sustainable Safety" policy aimed at making residential areas safer by keeping out through-traffic and lowering traffic speed by introducing speed ramps, narrowing roads and chicanes. Low-speed roads are intended to be used simultaneously by children, pedestrians, cyclists, mopeds and the motorised vehicles of local residents and visitors. The error in the navigator means "strangers" are unwittingly directed to roads not intended for through-traffic. In other words, the navigator purposely causes drivers to do something that society considers unacceptable. Statistics show this has led to a fourfold increase in the number of casualties caused by traffic accidents. Because of the causal link with the software error, manufacturers and suppliers of navigation software can be held directly responsible for the increase in accidents and casualties. This type of error is considered as a low level of social responsibility in the literature [11,12]. See also the jurisprudence in the Ford case [37], in which damages were awarded because a construction defect had been hushed up with a view to maintaining the manufacturer's profits.

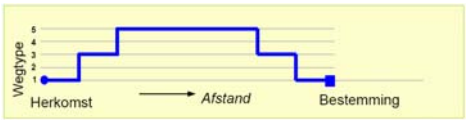
Recommendation to manufacturers and suppliers of a product with this error:
Manufacturers and suppliers should warn their customers immediately about the consequences of this error, and inform them about a call-back campaign to have it corrected.

Recommendation to the consumer for a product with this error:
Don't buy it. If you have bought it, ask the shop to have this error corrected or insist on a refund on the basis of the conformity principle. You are not restricted to the warranty period in this respect. This is EU law.

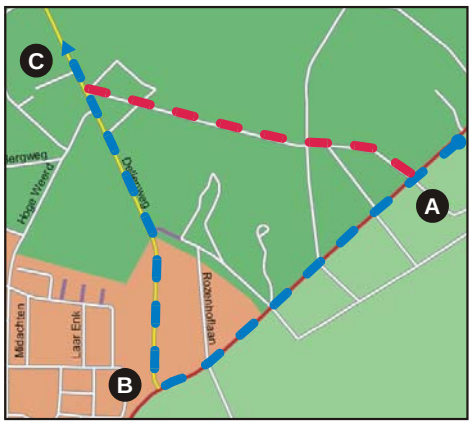
Recommendation to the government regarding products with this error:
Ban the sale and use of systems with this error, because it will increase traffic accidents and casualties, and have a negative impact on the living environment of children and the neighbourhood. Moreover, this error is at odds with the government's "Sustainable Safety" policy. One of the government's prime responsibilities is to protect the residential areas it has created for children and neighbourhoods from undesirable external influences.

Test item 3. Through-traffic should not use residential roads outside built-up areas

Navigation principle
With 238 serious accidents for every billion vehicle kilometres, residential roads outside built-up areas are the most dangerous of all. The reason is that children, pedestrians, cyclists, mopeds and motorised vehicles, farming equipment included, all use the same narrow road with a maximum speed of 60 km per hour. To make matters worse, residential roads tend to be linked to area connecting roads by means of an intersection (where the area connecting road has right of way) rather than roundabouts, as recommended. Given their purpose, residential roads outside built-up areas should also be excluded from routes proposed by navigators.



NOTE: driving over residential roads is not illegal. Formally, roads are open to everyone. Navigation software, however, should meet other priorities: respect for public planning and road safety – these standards and rules take priority over finding the shortest route. Not complying with these standards and rules is considered unacceptable social behaviour.



Objective of the test sample
The test was carried out, as an example, to investigate whether the navigator planned a shorter route by including residential roads outside built-up areas.

Research method
The test sample was based on feedback from people attending conferences at the Golden Tulip on Dellenweg in the community of Epe. They complained that, upon leaving the A50 motorway, they were directed to narrow forest lanes by their navigators. The test had to demonstrate whether the navigator offered the proper route A → B → C or instead suggested an inappropriate route via narrow residential road: Burgemeester Diepenhorstlaan in Epe (A → C on the map).

Departure address (A): Eperweg, Heerde
Destination address (B): Golden Tulip conference centre, Dellenweg, Epe

Test results:

NAVIGATOR	Network	Traject A→B→C (see map)
1 Nav4All	Navteq	OK
2 KPN op Weg (Wisepilot)	Navteq	Failed
3 Wayfinder	Teleatlas	Failed
4 Jentro (Activepilot)	Navteq	Failed
5 Webraska	Navteq	Failed
6 AmazeGPS		Failed
7 Telmap (Vodafone)	Navteq	Failed
8 Nokia navigator	Navteq	Failed
9 TomTom Go	Teleatlas	Failed
10 TomTom One	Teleatlas	Failed
11 TomTom Rider	Navteq	Failed
12 TomTom One XL	Teleatlas	Failed
13 TomTom Gp 720T	Teleatlas	Failed

	Aantal ernstige ongevallen	Aantal ernstige ongevallen per 1.000 kilometer weglengte	Aantal ernstige ongevallen per miljard motorvoertuigkilometers
Binnen de bebouwde kom			
30 km/uur	494	18	137
50 km/uur	4.891	162	199
70 km/uur	148	122	31
Buiten de bebouwde kom			
60 km/uur	320	28	238
80 km/uur	2.928	66	52
100/120 km/uur	912	178	22

Test results – Explanation
Only one of the systems tested, Nav4All, planned the proper route (A → B → C). All other systems tested wrongly recommended the shorter route (A → C) via residential roads – that is to say, along Burgemeester Diepenhorstlaan and Holleweg in the community of Epe, neither of which is suitable for through-traffic.

Qualification of the error
The error is one in a category of software errors which should have been detected in trial runs and eliminated. This error means residential roads are not excluded for through-traffic when the route is planned. Residential roads can easily be excluded with available network data.

Severity of the error
1. A dangerous situation arises at point A on Heerdeweg because the vehicle, driving along a road with a maximum speed of 80 km per hour, has to give way here to any cyclists on the bicycle lane that runs parallel to the road. This problem does not arise at point B, where the maximum speed on Heerdeweg has been reduced to 50 km per hour and the crossroad has been adapted so that the vehicle outside Heerdeweg can give way to cyclists on the bicycle lane.

2. As stated above under the heading "Navigation principle", residential roads outside built-up areas are the most dangerous types of roads, with 238 serious accidents for every billion vehicle kilometres. The reason is that children, pedestrians, cyclists, mopeds and motorised vehicles – agricultural equipment included – all use the same road with a maximum speed of 60 km per hour. If something goes wrong at that speed, the many road users are unprotected and highly vulnerable.

3. The error in the navigation software means "strangers" are unwittingly directed to roads not intended for through-traffic. The navigator purposely causes drivers to behave in a manner considered unacceptable by society. Statistics show this has led to a fourfold increase in the number of casualties caused by traffic accidents. Because of the causal link with the software error, manufacturers and suppliers of navigation software can be held directly responsible for the increase in accidents and casualties. This type of error is considered as a low level of social responsibility in the literature [11,12]. See also the jurisprudence in the Ford case [37], in which damages were awarded because a construction defect had been hushed up with a view to maintaining the manufacturer's profits.

Recommendation to manufacturers and suppliers of a product with this error:
Manufacturers and suppliers should warn their customers immediately about the consequences of this error, and inform them about a call-back campaign to have it corrected.

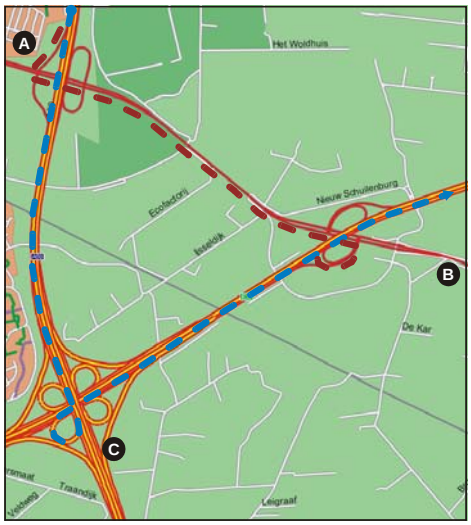
Recommendation to the consumer regarding a product with this error:
Don't buy it. If you have bought it, ask the shop to have this error corrected or insist on a refund on the basis of the conformity principle. You are not restricted to the warranty period in this case. This is EU law.

Recommendation to the government regarding products with this error:
Ban the sale and use of systems with this error, because it will increase traffic accidents and casualties, and have a negative impact on the living environment of children and the neighbourhood. Moreover, this error is at odds with the government's "Sustainable Safety" policy. One of the government's prime responsibilities is to protect the residential areas it has created for children and neighbourhoods from undesirable external influences.

Test item 4. Motorway traffic should not take short cuts by temporarily leaving the motorway

Navigation principle
On motorways, vehicles should preferably stick to the routes indicated by the overhead road signs. Shortening travel routes by temporarily leaving the motorway and using connecting roads should be avoided if at all possible. Such short cuts require additional manoeuvres which cause delays. Moreover, motorists in this case use connecting roads that serve a different purpose: handling regional traffic. These roads are far less safe than motorways.

NOTE: driving over residential roads is not illegal. Formally, roads are open to everyone. Navigation software, however, should meet other priorities: respect for public planning and road safety – these standards and rules take priority over finding the shortest route. Not complying with these standards and rules is considered unacceptable social behaviour.



Objective of the test sample
The test was carried out, as an example, to investigate whether the navigator sticks to the motorway and does not resort to connecting roads to create a shorter route.

Research method
The test sample involves a route from the community of Vaassen along the A50 motorway towards the A1 motorway in the direction of Deventer and passes the Beekbergen intersection. The purpose of the test was to find out whether the navigator offered a route via the Beekbergen intersection, or instead inappropriately suggested leaving the A50 motorway and taking the Apeldoorn-Zutphen connecting road in order to shorten the route to the A1 motorway heading towards Deventer.

Wegcategorie kruist met	SW100/120	GOW80	GOW50/70	ETW60	ETW30
SW100/120	knooppunt	ongelijk-vloers	*ongewenst*	*ongewenst*	*ongewenst*
GOW80		rotonde	rotonde	rotonde	*ongewenst*
GOW50/70			rotonde	voorrangs-kruispunt	voorrangs-kruispunt
ETW60				plateau	plateau
ETW30					plateau

	Aantal ernstige ongevallen	Aantal ernstige ongevallen per 1.000 kilometer weglengte	Aantal ernstige ongevallen per miljard motorvoertuigkilometers
Binnen de bebouwde kom			
30 km/uur	494	18	137
50 km/uur	4.891	162	199
70 km/uur	148	122	31
Buiten de bebouwde kom			
60 km/uur	320	28	238
80 km/uur	2.928	66	52
100/120 km/uur	912	178	22

Test results:

NAVIGATOR	Network	Motorway
1 Nav4All	Navteq	OK
2 KPN op Weg (Wisepilot)	Navteq	OK
3 Wayfinder	Teleatlas	Failed
4 Jentro (Activepilot)	Navteq	Failed
5 Webraska	Navteq	OK
6 AmazeGPS		OK
7 Telmap (vodafone)	Navteq	Failed
8 Nokia navigator	Navteq	OK
9 TomTom Go	Teleatlas	OK
10 TomTom One	Teleatlas	OK
11 TomTom Rider	Navteq	OK
12 TomTom One XL	Teleatlas	OK
13 TomTom Gp 720T	Teleatlas	OK

Test results - Explanation
Only Wayfinder, Jentro and Telmap inappropriately suggested exiting the A50 and taking a shorter route to the A1, in the direction of Deventer, by following the Apeldoorn-Zutphen connecting road.

Qualification of the error
The error is one in a category of software errors which should have been detected in trial runs, and eliminated.

Severity of the error
1. The navigator directs vehicles along a connecting road which is intended for regional traffic between the towns of Apeldoorn and Zutphen and lacks the spare capacity to facilitate the motorway traffic directed to it by many navigators. The regional infrastructure in the area of Apeldoorn and Zutphen has become highly congested as a result.

2. Road safety is affected because the road recommended has twice the number of accidents for every billion vehicle kilometres as the motorway.

3. Traffic flow is seriously obstructed by the additional manoeuvres involved in exiting the motorway and re-entering it later on. The purpose of motorway exits and approaches is to connect the motorway to the regional road network, not to divert motorway traffic.

Recommendation to manufacturers and suppliers of a product with this error:
Manufacturers and suppliers should warn their customers immediately about the consequences of this error, and inform them about a call-back campaign to have it corrected.

Recommendation to the consumer regarding a product with this error:
Don't buy it. If you have bought it, ask the shop to have this error corrected or insist on a refund on the basis of the conformity principle. You are not restricted to the warranty period in this case. This is EU law.

Recommendation to the government regarding products with this error:
Ban the sale and use of systems with this error, because it will increase traffic accidents and casualties, and have a negative impact on the living environment of children and the neighbourhood. Moreover, this error is at odds with the government's "Sustainable Safety" policy.

8. The navigation test: preventing searching behaviour

The basic principles of the navigation test.

The computer navigator has the same task as the rally sport navigator who sits next to the driver. The navigator tells the driver the direction to drive, allowing them to concentrate as much as possible on the road and the vehicle. The driver must never need to hesitate about "where to drive" because this causes searching behaviour.

The navigator's task is to give the right instruction at the right moment. In addition to giving directions such as left, right and straight on, it is especially important that the navigator specifies the amount of lanes to be used. If the driver enters a multi lane road on the navigator's advice, the navigator must ensure that the driver gets into the correct lane in preparation for any subsequent left or right turn.

Care is particularly necessary if the slip road and the next exit are in the same lane. Because the speed of driving is so high, any delay in giving instructions leads to the driver panicking in a matter of seconds. Drivers suddenly realise that they are about to leave the motorway even though that was not the intention. The opposite situation also occurs.

If the exits on a motorway are close together, the navigator must also warn the driver well in advance <u>not</u> to take particular exits.

In order to confirm that the driver is on the correct route, it is important that the navigator give the main destination on the road sign that agrees with the route to the destination address.

On multi lane roads outside built up areas it is an important task of the navigator to indicate what lane to use in preparation for a subsequent turn off. This is in order to avoid being boxed in by heavy traffic. For the same reason, the navigator should also give good lane instructions on motorways. Incorrect lane instructions lead to inefficient use of the lanes available and to excessive lane switching. This hinders traffic flow and reduces road safety.

The instructions mentioned above are taken over by computer navigators. We here test whether they do this well. In these tests the computer navigator faces two additional difficulties.

1. GPS cuts out in a tunnel and so the navigator must anticipate the situation by indicating in advance what will happen after the tunnel. This enables the driver to choose the correct lane in time while in the tunnel.

2. Communication between driver and computer navigator is also important. Navigation instructions must all be available in spoken form. If on screen support is offered, it may only be given using clear symbols that are legible from 1.5 meters and that can be interpreted at a glance (in an instant). Otherwise the driver's attention is no longer on the road. In this context it is undesirable for there to be anything more on the screen than is strictly necessary for navigation instruction. On this subject we refer the reader to the large amount of literature available relating to symbol technology and road signing in its broadest sense.

Limits of the investigation
This investigation is limited to the above mentioned navigation criteria. These are related to traffic situations in which the driving speed is high and the driver is surrounded by other road users. Searching behaviour immediately affects all road users in the vicinity and the consequences are traffic queues, traffic accidents and casualties.

Results of the investigation
All the systems under investigation were tested for the criteria described. The results are comprehensively presented in test certificates. Nav4All fulfils all criteria relating to instructions to the driver while driving (section 8.1). All the other systems fulfil hardly any of the criteria. These systems are therefore presented in one test certificate. The test certificate provides details of the error for each criterion. The abbreviated results from chapter 7 of this investigation report, relating to selecting the correct route, are also given on the test certificates. It should be noted that the investigation is set up for off board navigation systems and that Nokia and TomTom were added later because they are market leaders (52% market share). For this reason it is relevant to test whether or not they are able to fulfil the test criteria that were set.

The test on AmazeGPS was halted as the number of failures to meet the test criteria was so large that further testing made no sense.

Importance of the criteria tested

Failure to fulfil the criteria set out above causes searching behaviour by the driver. This can have serious consequences for road safety. When given adequate instructions while navigating the driver can concentrate on the road, his vehicle and everything that happens around him. A lack of such instructions can lead to delays, queues, serious traffic accidents and casualties. Uncertainty about the correct lane to use leads to excessive lane switching, often at the last moment. The same holds for incomplete instructions in tunnels. In addition, unnecessary driving on the left or the right contributes to the creation of traffic jams. Hard to read instructions keep the driver's gaze from the road unnecessarily, again to the detriment of road safety.

It is noteworthy that in the test case featuring the reading of direction signs at motorway exits, all the systems that were rejected committed the same error. Instead of selecting the place name that agreed with the destination address, these systems chose a place name that sent the driver in the opposite direction. This will cause the driver to demonstrate searching behaviour, with all the consequences of such behaviour. This is a typical example of stimulating searching behaviour.

8.1 Test certificate for Nav4All off-board navigation system

Stichting Onderzoek Navigatiesystemen Muzenstraat 89, 2511 WB The Hague NL Email: secretariaat@stichtingonderzoeknavigatiesystemen.nl		**Test certificate**
This certificate relates to the following systems tested: **Nav4All**		**Test date: November 2007** **Test protocol: see this report**
Description	**Result**	**Error details**
Test investigation: finding the correct routes		
A – Avoid residential areas in route (kid killer test)	ok	
B – Avoid residential access roads in route within built up area	ok	
C – Avoid residential access roads in route outside built up area	ok	
D – Avoid local roads when driving on motorways	ok	
Test investigation: preventing searching behaviour		
1 – Motorways		
A – Show number of lanes when motorway divides	ok	
B – Show number of lanes at exit	ok	
C – Show exits close together, warning	ok	
D – Lane instructions at motorway junctions	ok	
E – Warning when slip road turns into exit	ok	
2 – Non motorways		
A – Indicate sorting lane	ok	
B – Warning ahead of lane selection	ok	
3 – Various		
A - Tunnel navigation	ok	
B – Road signs – motorways	ok	
C – Road signs – exits	ok	
4 – Display		
A – No superfluous data	ok	
B – Data easy to read	ok	
C – Symbol qualityt	ok	
Final conclusion: Nav4All fulfils all the criteria set by the government's "Sustainable Safety" policy. The navigation system anticipates well in order to avoid searching behaviour by the driver. The information on the display fulfils the criteria that have been set.		

8.2 Test certificate for rejected off-board navigation systems (group 1)

Stichting Onderz1oek Navigatiesystemen Muzenstraat 89, 2511 WB The Hague NL Email: secretariaat@stichtingonderzoeknavigatiesystemen.nl	**Test certificate**
This certificate relates to the following systems tested: Wayfinder, Jentro (activepilot), Telmap (Vodafone)	**Test date: November 2007** **Test protocol: see this report**

Description	**Result**	**Error details**
Test investigation: finding the correct routes		
A – Avoid residential areas in route (kid killer test)	error	KILLING ERROR
B – Avoid residential access roads in route within built up area	error	KILLING ERROR
C – Avoid residential access roads in route outside built up area	error	KILLING ERROR
D – Avoid local roads when driving on motorways	error	KILLING ERROR
Test investigation: preventing searching behaviour		
1 – Motorways		
A – Show number of lanes when motorway divides	error	dangerous manoeuvres, traffic jams, risc of accidents
B – Show number of lanes at exit	error	dangerous manoeuvres, traffic jams, risc of accidents
C – Show exits close together, warning	error	dangerous manoeuvres, traffic jams, risc of accidents
D – Lane instructions at motorway junctions	error	dangerous manoeuvres, traffic jams, risc of accidents
E – Warning when slip road turns into exit	error	dangerous manoeuvres, traffic jams, risc of accidents
2 – Non motorways		
A – Indicate sorting lane	error	slowing of traffic flow
B – Warning ahead of lane selection	error	dangerous manoeuvres
3 – Various		
A - Tunnel navigation	error	dangerous manoeuvres, traffic jams, risc of accidents
B – Road signs – motorways	error	false information, traffic jams, risk of accidents
C – Road signs – exits	error	false information, traffic jams, risk of accidents
4 – Display		
A – No superfluous data	error	concentration errors, traffic jams, risk of accidents
B – Data easy to read	error	concentration errors, traffic jams, risk of accidents
C – Symbol qualityt	error	concentration errors, traffic jams, risk of accidents

If you see KILLING ERROR, the Stichting Onderzoek Navigatiesystemen advises you not to use the navigator.

Final conclusion: none of the systems listed on this certificate fulfils the criteria investigated. Due to the errors observed they constitute a threat to road safety. Using them will cause the number of serious traffic accidents and casualties to increase.

They fail to find the ring roads and thus use roads that are not intended for through traffic. Because they even drive through residential areas where children are playing, they are popularly known as “kid killers”. The Stichting Onderzoek Navigatiesystemen puts the cause down to software faults, which could have been prevented by good testing procedures.

No lane instructions are given on motorways and multi lane roads, and difficult situations are not correctly signalled. In view of the high traffic density and high driving speeds, these navigators put the driver and their surroundings in danger. This results in queues, traffic jams and accidents.

It is noteworthy that all the navigators fail to read the correct direction from the road sign on a motorway exit. This confuses the driver.

Most of the information on the colour display is illegible for the driver. This causes searching behaviour, so that the driver’s attention is no longer concentrated on the vehicle and the road. This also causes queues, traffic accidents and casualties.

8.3 Test certificate for rejected off-board navigation systems (group 2)

Stichting Onderzoek Navigatiesystemen Muzenstraat 89, 2511 WB The Hague NL Email: secretariaat@stichtingonderzoeknavigatiesystemen.nl	**Test certificate**
This certificate relates to the following systems tested: KPN op Weg (wisepilot), Webraska, AmazeGPS	**Test date: November 2007** **Test protocol: see this report**

Description	**Result**	**Error details**
Test investigation: finding the correct routes		
A – Avoid residential areas in route (kid killer test)	error	KILLING ERROR
B – Avoid residential access roads in route within built up area	error	KILLING ERROR
C – Avoid residential access roads in route outside built up area	error	KILLING ERROR
D – Avoid local roads when driving on motorways	ok	
Test investigation: preventing searching behaviour		
1 – Motorways		
A – Show number of lanes when motorway divides	error	dangerous manoeuvres, traffic jams, risk of accidents
B – Show number of lanes at exit	error	dangerous manoeuvres, traffic jams, risk of accidents
C – Show exits close together, warning	error	dangerous manoeuvres, traffic jams, risk of accidents
D – Lane instructions at motorway junctions	error	dangerous manoeuvres, traffic jams, risk of accidents
E – Warning when slip road turns into exit	error	dangerous manoeuvres, traffic jams, risk of accidents
2 – Non motorways		
A – Indicate sorting lane	error	slowing of traffic flow
B – Warning ahead of lane selection	error	dangerous manoeuvres
3 – Various		
A - Tunnel navigation	error	dangerous manoeuvres, traffic jams, risk of accidents
B – Road signs – motorways	error	false information, traffic jams, risk of accidents
C – Road signs – exits	error	false information, traffic jams, risk of accidents
4 – Display		
A – No superfluous data	error	concentration errors, traffic jams, risk of accidents
B – Data easy to read	error	concentration errors, traffic jams, risk of accidents
C – Symbol qualityt	error	concentration errors, traffic jams, risk of accidents

If you see KILLING ERROR, the Stichting Onderzoek Navigatiesystemen advises you not to use the navigator.

Final conclusion: the navigators listed on this test certificate are a threat to road safety due to the errors observed. They fail to meet almost all test criteria that were investigated. Using them will cause the number of serious traffic accidents and casualties to increase.

They fail to find the ring roads and thus use roads that are not intended for through traffic. Because they even drive through residential areas where children are playing, they are popularly known as “kid killers”. The Stichting Onderzoek Navigatiesystemen puts the cause down to software faults, which could have been prevented by good testing procedures.

No lane instructions are given on motorways and multi lane roads, and difficult situations are not correctly signalled. In view of the high traffic density and high driving speeds, these navigators put the driver and their surroundings in danger. This results in queues, traffic jams and accidents. It is noteworthy that all the navigators fail to read the correct direction from the road sign on a motorway exit. This confuses the driver.

Most of the information on the colour display is illegible for the driver. This causes searching behaviour, so that the driver’s attention is no longer concentrated on the vehicle and the road. This also causes queues, traffic accidents and casualties.

The test investigation of searching behaviour was not carried out for Amaze (see p.13).

8.4 Test certificate for Nokia 6110 on-board navigation system

Stichting Onderzoek Navigatiesystemen
Muzenstraat 89, 2511 WB The Hague NL
Email: secretariaat@stichtingonderzoeknavigatiesystemen.nl

Test certificate

This certificate relates to the following systems tested:

Nokia
Nokia onboard navigation

Test date: November 2007

Test protocol: see this report

Description	Result	Error details
Test investigation: finding the correct routes		
A – Avoid residential areas in route (kid killer test)	error	KILLING ERROR
B – Avoid residential access roads in route within built up area	error	KILLING ERROR
C – Avoid residential access roads in route outside built up area	error	KILLING ERROR
D – Avoid local roads when driving on motorways	ok	
Test investigation: preventing searching behaviour		
1 – Motorways		
A – Show number of lanes when motorway divides	error	dangerous manoeuvres, traffic jams, risk of accidents
B – Show number of lanes at exit	error	dangerous manoeuvres, traffic jams, risk of accidents
C – Show exits close together, warning	error	dangerous manoeuvres, traffic jams, risk of accidents
D – Lane instructions at motorway junctions	error	dangerous manoeuvres, traffic jams, risk of accidents
E – Warning when slip road turns into exit	error	dangerous manoeuvres, traffic jams, risk of accidents
2 – Non motorways		
A – Indicate sorting lane	error	slowing of traffic flow
B – Warning ahead of lane selection	error	dangerous manoeuvres
3 – Various		
A - Tunnel navigation	error	dangerous manoeuvres, traffic jams, risk of accidents
B – Road signs – motorways	error	false information, traffic jams, risk of accidents
C – Road signs – exits	error	false information, traffic jams, risk of accidents
4 – Display		
A – No superfluous data	error	concentration errors, traffic jams, risk of accidents
B – Data easy to read	error	concentration errors, traffic jams, risk of accidents
C – Symbol qualityt	error	concentration errors, traffic jams, risk of accidents

If you see KILLING ERROR, the Stichting Onderzoek Navigatiesystemen advises you not to use the navigator.

The Nokia 6110 on-board navigation system was included in the investigation at a later date because the results of the off-board systems tested, with the exception of Nav4All, were so bad. The Stichting Onderzoek Navigatiesystemen was interested in seeing how a major market player such as Nokia would perform when tested against the criteria. The conclusion is that this Nokia system is unable to fulfil any of the test criteria.

Nokia fails to find the ring roads and consequently uses roads that are not intended for through traffic. Navigation systems that direct drivers through residential areas where children play are popularly known as “kid-killers”. The Stichting Onderzoek Navigatiesystemen blames this on software faults which could have been avoided by using good testing procedures.

On motorways and multi lane roads no lane instructions are given and drivers are not correctly warned about difficult situations ahead. In view of the high traffic density and high driving speed, these navigation systems put the driver and those around him in danger. This causes traffic queues, congestion and accidents.

Nokia fails to read the correct direction at a motorway exit, thus confusing the driver.
It was considered to be a serious error that Nokia did not interpret the road signs at all and placed the whole list on the display, which was illegible for the driver.
In Nokia’s case as well the information on the colour display is mostly illegible for the driver. This results in searching behaviour, so that the driver’s attention is no longer concentrated on the vehicle and the road. This is also the cause of queues, traffic accidents and casualties.

8.5 Test certificate for TomTom on-board navigation system

Stichting Onderzoek Navigatiesystemen Muzenstraat 89, 2511 WB The Hague NL Email: secretariaat@stichtingonderzoeknavigatiesystemen.nl		**Test certificate**
This certificate relates to the following systems tested: TomTom Go, TomTom One, TomTom Rider, TomTom One XL, TomTom Go 720T		**Test date: November 2007** **Test protocol: see this report**
Description	**Result**	**Error details**
Test investigation: finding the correct routes		
A – Avoid residential areas in route (kid killer test)	error	KILLING ERROR
B – Avoid residential access roads in route within built up area	error	KILLING ERROR
C – Avoid residential access roads in route outside built up area	error	KILLING ERROR
D – Avoid local roads when driving on motorways	ok	
Test investigation: preventing searching behaviour		
1 – Motorways		
A – Show number of lanes when motorway divides	error	dangerous manoeuvres, traffic jams, risk of accidents
B – Show number of lanes at exit	error	dangerous manoeuvres, traffic jams, risk of accidents
C – Show exits close together, warning	error	dangerous manoeuvres, traffic jams, risk of accidents
D – Lane instructions at motorway junctions	error	dangerous manoeuvres, traffic jams, risk of accidents
E – Warning when slip road turns into exit	error	dangerous manoeuvres, traffic jams, risk of accidents
2 – Non motorways		
A – Indicate sorting lane	error	slowing of traffic flow
B – Warning ahead of lane selection	error	dangerous manoeuvres
3 – Various		
A - Tunnel navigation	error	dangerous manoeuvres, traffic jams, risk of accidents
B – Road signs – motorways	error	false information, traffic jams, risk of accidents
C – Road signs – exits	error	false information, traffic jams, risk of accidents
4 – Display		
A – No superfluous data	ok	
B – Data easy to read	ok	
C – Symbol qualityt	ok	

If you see KILLING ERROR, the Stichting Onderzoek Navigatiesystemen advises you not to use the navigator.

The TomTom systems were included in the investigation at a later date because the results of the off-board systems tested, with the exception of Nav4All, were so bad. The Stichting Onderzoek Navigatiesystemen was interested in seeing how TomTom, as a major market player (market share 52%), would perform when tested against the criteria. The conclusion is that TomTom fails against the most important test criteria. TomTom does fulfil the display criteria with its large display.

TomTom fails to find the ring roads and consequently uses roads through residential areas and other roads that are not intended for through traffic. Navigation systems that direct drivers through residential areas where children play are popularly known as “kid killers”. The Stichting Onderzoek Navigatiesystemen blames this problem on software errors, which could have been prevented by using good testing procedures.

On motorways and multi lane roads TomTom gives no lane instructions and drivers are not correctly warned about difficult situations ahead. In view of the high traffic density and high driving speed, TomTom puts the driver and other road users in danger. This causes traffic queues, congestion and accidents. TomTom fails to read the correct direction from a sign at a motorway exit, thus confusing the driver.

TomTom’s complaint that it is the government’s fault that TomTom cannot find the ring roads is incorrect. This failure is caused by software errors, which are also to blame for the fact that traffic trying to escape queues is directed along the wrong roads. This increases the number of traffic accidents and casualties, disturbs the peace and quiet, and damages the environment in residential areas.

9. Discussion

A navigation system must, first and foremost, calculate the correct route. The correct route is the optimal route for the driver, taking into account his social responsibility. All navigation systems – with the exception of Nav4All – use as through routes roads in areas designated as low traffic and residential. These systems are therefore popularly known as “kid killers”. They make the same error on residential access roads, both in and out of built up areas. These navigation systems purposely cause drivers to behave in a socially unacceptable fashion. These navigation errors represent a threat to residential environments, specifically due to the increases they cause in the number of traffic casualties, noise and environmental pollution.

The second basic ability a navigator must have is to give clear instructions so that the driver can concentrate on the traffic. The quality of the navigation was tested against 13 criteria, adherence to which should prevent searching behaviour. Only Nav4All fulfils all the test criteria. Most navigation systems do not provide adequate information about the number of lanes, so that the driver drives on the left without needing to or switches lanes frequently. Navigation instructions for sorting lanes and in tunnels are usually inadequate. Presentation of navigation instructions on the display is partly or completely illegible in nearly all systems and this is a factor that prompts searching behaviour. “Unpredictability, uncertainty and doubt will not benefit road safety, according to the principles of the Sustainable Safety policy (CROW, 1997) [11]. These basic principles are explained in more detail in the publication by the Stichting Wetenschappelijk Onderzoek Verkeersveiligheid (SWOV) [Institute for Road Safety Research] entitled Naar een duurzaam veilig wegverkeer (1992) [Towards a sustainably safe road traffic].” (quote) [57].

Residential areas and residential access roads
Tomtom recently contended that navigation systems do not have access to the data needed to avoid residential areas and residential access roads.[ref] According to TomTom, the government should provide better road coding. The investigation shows that this assessment is incorrect. Even with conventional data (Navteq), one navigation system (Nav4All) at least is able to avoid residential areas and residential access roads. One reason for navigation systems making these kinds of errors is that they do not embody adequate procedures for correctly detecting the type of road. This lack results in TomTom being unable to avoid these errors. The detection involves very complex calculations, in which integrating more than 250 existing characteristics determines how a road may be used.

Alternative routes to avoid queues
The SON is concerned about the rapid growth in the number of navigation systems that calculate alternative routes in order to avoid traffic queues. This investigation does of course show that all the systems tested – with the exception of Nav4All – use as through routes roads in residential areas, residential access roads and secondary connecting roads. These roads are not designed to be used to avoid traffic jams on the motorways. Research by the SWOV has shown that the number of traffic casualties per kilometre is greater on these alternative routes.[ref] Moreover, the living environment in residential areas is adversely affected by traffic congestion, air pollution and noise. The Stichting Onderzoek Navigatiesystemen considers that the government needs to step in to prevent navigation systems from subjecting Dutch residential neighbourhoods to a reign of terror.

Accident figures
Research shows [58] that navigation systems lead to fewer kilometres being driven and to a reduction in searching behaviour in a number of situations. Both these factors bring about a drop in the number of traffic accidents and casualties. This research, however, is (implicitly) based on the assumption that navigation systems function properly. It thus takes no account of the inability of navigation systems to find the correct route.

This report deals specifically with the shortcomings of navigation systems which threaten road safety. In order to find shorter routes, drivers are unnecessarily turned into ‘kid killers’ by being directed through residential areas and onto roads not intended for through traffic. In addition, the incorrect navigation instructions cause search behaviour just when the vehicle is travelling at high speed. Finally, an increase in the number of accidents is to be expected due to the ‘queue optimisation systems’. Because of an inability to find the correct route, such systems fill minor roads, which are less safe, with traffic that is not intended for them. These roads already have a higher accident rate, which will increase as a result of the added congestion. The final conclusion of the Stichting Onderzoek Navigatiesystemen is that navigation systems that do not fulfil the criteria laid down in this report actually reduce road safety. The advantages mentioned in earlier investigations are overshadowed by the unsafe situations caused by systems that do not function properly.

10. Summary and conclusions

1. In this investigation, examintion criteria are defined in order to evaluate navigation systems. These criteria are based on the "Sustainable Safety" policy, which is applied in nearly all countries when designing the road infrastructure. This policy is based on substantial scientific research. Navteq and Teleatlas have put these infrastructures on to the computer and supply them to cartographers and navigation systems.

2. A navigation system must have two basic abilities:
a) the ability to find the correct route in order to drive from A to B.
b) the ability to prevent searching behaviour while driving by giving the correct instructions clearly and in good time.

3. The investigation shows that the data from Navteq and Teleatlas is sufficient for finding the correct route.

4. Only Nav4All fulfils all the examination criteria. Nav4All finds the correct route and prevents searching behaviour by providing clear spoken instructions backed up by a clearly legible screen display.

5. All other systems fail the exam, namely KPN op Weg (Appello), Wayfinder, Active pilot (Jentro), Webraska, AmazeGPS, Telmap, Nokia navigator, and the five TomTom systems. They use residential areas where children play as through roads and are therefore popularly known as "kid killers". The same error occurs on residential access roads within and outside built up areas. None of the systems succeeds in finding ring roads.

6. The navigation systems mentioned purposely put the driver into a situation of unacceptable social behaviour. The increase in traffic accidents and casualties resulting from these navigation errors has been demonstrated statistically and, because this increase is caused by the software failings, manufacturers and suppliers of navigation software can be held directly responsible. In the literature these errors are considered to demonstrate a lack of social responsibility. This is particularly true as it can be assumed that the manufacturers and suppliers are aware of these software errors. Reference is also made to the Ford Pinto affair, in which defects were hushed up in order to maintain profits.

7. There are many public complaints about the inability of navigators to find the correct route. As a result, vehicles drive through residential areas (kid-killers) and other roads not intended for through traffic. The management of TomTom (52% market share) says that these deficiencies are the fault of the government. The Stichting Onderzoek Navigatiesystemen has established that TomTom's view is incorrect as the free navigation package Nav4All is able to find the correct routes, including ring roads.
On the basis of these findings by the Stichting Onderzoek Navigatiesystemen, the government can save billions of euros throughout Europe because the upgrading demanded by TomTom is not necessary. The only thing that TomTom and the other suppliers who failed the test have to do is to correct the relevant software errors. They should, of course, quickly inform their customers and warn them about the possible consequences of the errors. It is a matter of responsibility relating to serious errors that will result in more casualties on the roads.

8. In the case of queue optimisation it is essential that the navigation software be able to distinguish between the different road types. The software failings shown in relation to finding the correct route leads to traffic that is trying to escape queues also being sent along residential access roads in rural areas, towns and residential areas, as well as through the centres of villages and housing estates. Roads in these areas are not designed for such use, so that more traffic accidents and casualties result. The resulting misery is nowadays a frequent topic of conversation in many areas. The remark by TomTom that only 15% of drivers own such a navigation device can only lead to the conclusion that, in view of the growth in this market, a disastrous situation will rapidly develop. This situation should prompt government action to introduce certification of navigation systems as this would make it possible to ban systems with these errors.
It is socially unacceptable that as a result of failings in navigation software, motorway congestion is shifted to residential areas where it has a negative impact on the environment and the quality of life.

9. A navigation system must also have the basic ability to give correct instructions so that the driver can concentrate as much as possible on the road and on the vehicle. The quality of the navigation as tested by checking how well it performed in preventing searching behaviour by the driver.

Only Nav4All fulfilled all the test criteria set by the Stichting Onderzoek Navigatiesystemen for the various navigation elements. None of the other systems tested did so. They failed to instruct the driver on the choice of lane and failed to direct the driver to change lanes correctly and in good time. Most noticeable is that they are not even capable of correctly interpreting the direction signs along the motorway, so that the wrong place name is chosen from the sign, which contradicts the navigation instructions given. This actually brings about searching behaviour instead of preventing it. The presentation of navigation instructions on the display is partly or completely illegible in virtually all systems (except for TomTom), which can cause searching behaviour in exactly those situations where it should have been prevented.

11. Recommendations to manufacturers, consumers and government

These recommendations concern all issues surrounding the failure to fulfil the test criteria. They are thus not relevant to Nav4All as it meets all the test criteria.
The report strives to give appropriate advice to manufacturers, suppliers, consumers and the government immediately after supplying details of the errors and a description of their seriousness. This makes the report more readable, as observation, evaluation and advice are close together.

11.1 Recommendations to manufacturers and suppliers

This report thoroughly examines the software errors that mean the correct route (often ring roads) is not found and through traffic is directed along residential access roads. Because the software errors cause an increase in the number of traffic accidents and casualties, manufacturers and suppliers of navigation software can be held directly responsible. In this context, the literature points out that these kinds of errors are considered to demonstrate a lack of social responsibility. Reference is also made to the Ford Pinto affair, in which defects were hushed up in order to maintain profits.

The Stichting Onderzoek Navigatiesystemen points out that the consumer has the right to expect a product to work properly. They should be able to be confident that the warning given when the navigation system starts up is not aimed at shifting responsibility for the consequences of errors found during this investigation. The Stichting Onderzoek Navigatiesystemen advises manufacturers and suppliers to warn their customers about the consequences of the errors found in this investigation and inform them about a call back campaign to have them corrected. To limit the damage, including claims for damages, the Stichting Onderzoek Navigatiesystemen advises that the sale and delivery of these systems be stopped temporarily until the errors have been corrected, including the correction of navigation systems that have already been delivered.

11.2 Recommendations to consumers regarding products with these errors

The Stichting Onderzoek Navigatiesystemen advises the consumer to read this report. If they have bought a system, they should ask in the shop for the errors to be corrected or insist on a refund on the basis of the conformity principle. They are not restricted to the warranty period in this case. This is EU law. The consumer should not forget to claim any damages, including for physical injury, from their supplier.

11.3 Recommendations to the government regarding products with these errors

The Stichting Onderzoek Navigatiesystemen advises the government to ban the sale and use of navigation systems with these errors, because they will cause the number of traffic accidents and casualties to increase, and will have a negative impact on the living environment of children and of residential neighbourhoods. Moreover, the errors found are at odds with the government's "Sustainable Safety" policy and the associated "Prevention of Searching Behaviour". It is a primary task of government to protect the living environment created for children and residential neighbourhoods from undesirable external influences.

The Stichting Onderzoek Navigatiesystemen draws the government's attention to the "TomTom consultation" on the subject of freight and other traffic being directed along residential access roads, as well as the failure to find ring roads and all the problems caused by this failure. These problems are the result of the software failings in the TomTom navigation systems. In this regard the government can thus save billions of euros throughout Europe.

The Stichting Onderzoek Navigatiesystemen demands that particular attention be paid to the threat of a "reign of terror" by navigation systems. A direct consequence of the software errors is that the automatic queue avoidance systems used by TomTom and others fill local roads with vehicles escaping traffic jams, although these roads are not designed for it. This increases the number of traffic accidents and casualties and destroys the peace and quiet of residential areas. It is also at odds with the government's "Sustainable Safety" policy.

12. Questions to the sounding board group

Question 1. Why is reference made to the Ford Pinto affair and to the literature about organisational criminality when discussing the errors made when finding the correct route (test items 1, 2 and 3)?

When categorising an error we address the social responsibility of organisations.

1. Companies and organisations often bear great responsibility when carrying out their work. They must not only meet the needs of their customers but also take account of social expectations. In their decision making they should take into account external effects such as the environment and public safety. It is also in the interests of companies to pay attention to social expectations as this helps them to gain a good reputation. A good reputation is financially important but also has intrinsic value, because both employers and employees like to be proud of their organisation.

2. The individual citizen is increasingly dependent on companies and organisations. It is thus very important to be able to have confidence in social institutions and companies. The difference between the power of citizens on the one hand and that of companies on the other is continuously growing.

3. The central concept relating to meeting social expectations is social responsibility. This means "the capacity of the organisation adequately to take into account the feelings and expectations of the external surroundings". The best known example of a low level of responsibility is the Ford Pinto affair. Because of financial considerations Ford decided to do nothing about a construction fault that had already been recognised during tests of the prototype. The construction fault led to fatal accidents and injuries. The Ford Pinto affair is an example of organisational criminality. The assessment made here is not in accordance with social expectations. Van de Bunt [11,12] understands organisational criminality to be "the misdeeds (…) committed individually or as a group by members of a respected and bona fide organisation within the context of performing organisational tasks". A low level of social responsibility leads at worst to organisational criminality.

4. In the report by the Stichting Onderzoek Navigatiesystemen errors were picked up in the test items 1, 2 and 3, which recall the Ford Pinto affair, in which Ford failed to deal with known construction faults for financial reasons. We maintain that the software errors in test items 1, 2 and 3 are more or less comparable with the Ford case. The errors are known to the developers of these navigation systems, or at least they should be known. Having such an error present in a product is a sign of low social responsibility. Using traffic accident statistics one can calculate that around the world such errors will ultimately result in hundreds of serious traffic accidents causing physical injury and death. Therefore the Stichting Onderzoek Navigatiesystemen advises developers, manufacturers and suppliers to remove the defective navigation systems from sale immediately and to inform their customers about a call back campaign to correct the errors. Government is advised to forbid the use of navigation systems with the faults described above because their use conflicts with the "Sustainable Safety" policy.

Question 2. Can the Stichting Onderzoek Navigatiesystemen explain why only Nav4All performs well and the other systems investigated failed. Is the investigation not too strongly concentrated on Nav4All?

Answer: at the outset the investigation was directed at off board telephone navigation systems. When it transpired that only Nav4All fulfilled all the set criteria, we decided to include in the investigation the Nokia navigator 6110 and all the top of the range TomTom systems. As the report has shown, these systems also failed to meet the test criteria. The Stichting Onderzoek Navigatiesystemen is fully aware of the impact of this investigation's results, as now two leading companies, Nokia and TomTom, do not meet the requirements set by the Stichting Onderzoek Navigatiesystemen. It is also significant in this respect that TomTom emerges as the winner in nearly all magazine tests. The magazine tests were a direct cause of this scientific investigation being set up to test the quality of navigation systems. It was key to this investigation that the tests could be reproduced. The Stichting Onderzoek Navigatiesystemen's primary objective was to draw up a list of requirements that navigation systems would have to meet, based on the "Sustainable Safety" policy followed by many governments. This policy is based on principles that are supported by science and aimed at developing an infrastructure that is inherently safe.

It also aims to minimalise searching behaviour by road users as this behaviour distracts attention away from the road, which increases the likelihood of accidents.

According to the Stichting Onderzoek Navigatiesystemen a navigation system must have four basic abilities in order to be able to calculate the correct route from A to B (see chapter 7). The tests that are performed feature many complex algorithms for calculating networks paths using at least 250 variables per link in order to be able to find the correct route.
Failing the test shows that the algorithm has not been mastered by the producers concerned or that the algorithm they use has failings.
Neither Nav4All or the Stichting Onderzoek Navigatiesystemen should be thanked for the fact that only Nav4All passed the tests. The real issue is that there are navigation system producers who did not manage to test their software properly even though science offers enough techniques for solving this sort of problem.

Question 3. Speed camera warning devices are components of navigation systems, which are done well by many companies, whereas Nav4All does not support them. Why did the Stichting Onderzoek Navigatiesystemen not investigate this aspect? It could have provided plus points for all the other systems and a negative result for Nav4All.

The Stichting Onderzoek Navigatiesystemen thinks that speed camera warning devices are at odds with the government's "Sustainable Safety" policy. The Stichting Onderzoek Navigatiesystemen is therefore of the opinion that the use of such "camera alerters" should be banned. These are the reasons why the investigation did not pay any attention to such devices.
The Stichting Onderzoek Navigatiesystemen would like to draw people's attention to the fact that the use of these devices is already banned in a number of countries.

Question 4. Why did the Stichting Onderzoek Navigatiesystemen not include in the investigation the possibility of providing information about traffic queues and subsequent automatic adjustments to routes?

The Stichting Onderzoek Navigatiesystemen is currently looking intently at the questions of queue information and the automatic recalculation of routes. This research was prompted partly by complaints from the market, which came to our attention through comments on the internet. These complaints can be summarised as being a feeling among members of the public that automatic re routing by navigation systems is causing a nuisance. They see cars with navigation systems driving on roads that are only intended for local traffic. People also notice that this causes traffic jams in villages, which they attribute to the automatic detours directed by navigation systems. This re routing means that the traffic queues from motorways often cause congestion on minor roads.
Based on scientific research it can be said that the number of serious traffic accidents and casualties will rise as a direct result of this automatic re routing. On this issue we can refer to the SWOV, which records and publishes figures on serious traffic accidents and casualties, linked to the type of road [61] (see also publication by SWOV) [60].

Partly on the basis of the results of this investigation report, The Stichting Onderzoek Navigatiesystemen is already expressing its concern at the rapid growth of systems that automatically calculate a new route in order to avoid traffic queues. This investigation shows that all the navigation systems investigated, with the exception of Nav4All, have so many software errors that they are incapable of avoiding those roads on which only local traffic is allowed.

The Stichting Onderzoek Navigatiesystemen foresees a horror scenario in which the queue information systems of TomTom and many other navigation software suppliers clog up roads with vehicles that do not belong there. These are roads that are not intended to take the traffic from congested motorways, thus the added traffic damages the living environment in residential areas with air pollution, noise and an increasing number of traffic accidents and casualties.
In addition, regional economies are damaged by the congestion of their road networks, networks that were not designed as an overflow for the congestion problems of motorways. In view of the rapid developments, the Stichting Onderzoek Navigatiesystemen believes that government action is now essential. The government must prevent navigation systems from creating a reign of terror in Dutch residential areas with their queue optimisation systems. It is really five minutes to midnight in this respect.

Question 5. Why is there such an emphasis on the direction signs on motorways? Surely if a navigation instruction has been given the road sign no longer plays a role.

Within the framework of the government's "Sustainable Safety" policy, navigation must be aimed at the "prevention of searching behaviour". In this context there is added certainty if the main destination drivers see on the signs agrees with the direction the navigation system puts on the display.
It is noteworthy that, apart from Nav4All, none of the systems tested was able to select the correct name from a sign at a motorway exit, which showed several names. The name must agree with the direction in which drivers are going to go after taking the exit. This name is shown at the top of the screen. In the relevant tests all but one system chose the wrong direction.

The Nokia navigation system and many others have not mastered the technology for selecting the main direction from the road sign at all. They often put on the display all the names that appear on the sign. Due to the small letters on the display, this method of providing information leads to extra searching behaviour, with all its consequences. There can no longer be any question of taking in the information on the screen "in a flash". The eye must adjust itself to reading, which means that the eye is no longer on the road.

13. Address list of manufacturers of the systems tested

Nav4All
Nav4All BV
Keizersgracht 62-64, 1015 CS Amsterdam NL
Email: info@nav4all.com

KPN op weg (Wisepilot)
Appello
Kungsgatan, SE-411 19 Götenborg
Email: info@appello.se

Wayfinder
Kungsgatan 5, 2nd floor, S-111 43 Stockholm, Sweden
Email: dan.haneklint@wayfinder.nl

Jentro (Activepilot)
Jentro Technologies GmbH
Rosenheimerstrasse 145e, 81671 München
Email: www.activepilot.de/contact

Webraska
Webraska Mobile Technologies
22, rue Guynemer BP 107, 78602 Maisons-Laffitte cedex, France
Email: info@webraska.com

AmazeGPS
London Office
5 Warren Mews
Warrenstreet, London W1T GAP
Email: www.amazegps@locationet.com

Telmap (Vodafone)
Telmap Ltd
11 Bareket ST, P.O. Box 12888, Herzlia 46733, Israel
Email: sales@telmap.com

Nokia
Nokia Head Office
Keilalahdentie 2-4, Fin-02150 Espoo, Finland
Email: www.nokia.com

TomTom
TomTom BV
Rembrandtplein 35, 1017 CT Amsterdam
Email: tomtom.pr@tomtom

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Appendix 1

Wegcategorisering

Bron: http://nl.wikipedia.org/wiki/Duurzaam_Veilig#Categorisering

Het uitgangspunt van functionaliteit van wegen is in de Duurzaam Veilig visie vertaald in een éénduidige categorisering van wegtypen. Er worden drie categorieën wegen onderscheiden met een verschillende functie:

- Stroomwegen;
- Gebiedsontsluitingswegen;
- Erftoegangswegen.

Bijna alle wegbeheerders hebben de wegen inmiddels in deze drie typen *gecategoriseerd*. Meestal is dit opgenomen in een categoriseringsplan, dat vaak onderdeel uitmaakt van het verkeersbeleid van bijvoorbeeld de gemeente of de provincie.

Stroomwegen (SW) zijn bedoeld voor een betrouwbare afwikkeling van relatief grote hoeveelheden verkeer met een hoge gemiddelde snelheid. De maximumsnelheid van een stroomweg is 100 km/h (regionale stroomweg) of 120 km/h (autosnelweg). Stroomwegen hebben dus een primaire verkeersfunctie, waarbij de doorstroming centraal staat en zijn derhalve niet toegankelijk voor langzaam verkeer en landbouwverkeer en kennen in de Duurzaam Veilig visie geen gelijkvloerse kruisingen. Een ander essentieel kenmerk van duurzaam veilige stroomwegen is een fysieke rijbaanscheiding, bijvoorbeeld in de vorm van een middenberm, om het verkeer in beide richtingen te scheiden.

Voor veel enkelbaans autowegen die zijn gecategoriseerd als regionale stroomweg is echter de komende jaren nog geen budget beschikbaar om essentiële kenmerken als een fysieke rijbaanscheiding en ongelijkvloerse kruisingen te realiseren. Op deze enkelbaans autowegen wordt echter wel een een dubbele asmarkering met groene vulling toegepast om inhalen te verbieden en te ontmoedigen en de herkenbaarheid van dit type weg te vergroten.

Gebiedsontsluitingswegen (GOW) zijn wegen die zowel doorstroming als uitwisselen tot doel hebben. Gebiedsontsluitingwegen zorgen ervoor dat woonwijken, bedrijventerreinen, winkelcentra etc. bereikbaar blijven. Zij moeten voor het verdelen en het verzamelen van verkeer zorgen. Het is volgens de Duurzaam Veilig filosofie echter ongewenst om uitritten van erven op gebiedsontsluitingswegen te laten uitkomen. Buiten de bebouwde kom mag er 80 km/h gereden worden, binnen de bebouwde kom 70 of 50 km/h. Het homogeniteitsprincipe leidt ertoe dat langzaam- en snelverkeer van elkaar moet worden gescheiden. Binnen de bebouwde kom kan dit door fietsstroken of vrijliggende fietspaden aangelegd; buiten de bebouwde kom door parallele fietspaden of erftoegangswegen. Hierbij moet worden bedacht dat ook medegebruik van een gebiedsontsluitingsweg door langzaam landbouwverkeer ongewenst is. Bromfietsen vormen hier een aparte groep, binnen de bebouwde kom delen ze de weg met de auto's, buiten de bebouwde kom met de fietsers. Inhalen op gebiedsontsluitingswegen is ongewenst, met name buiten de bebouwde kom, hetgeen betekent dat het beste een dubbele asmarkering kan worden toegepast, eventueel gecombineerd met een moeilijk overrijdbare rijbaanscheiding.

Erftoegangswegen (ETW) zijn bedoeld voor het veilig toegankelijk maken van percelen, ze staan beter bekend als de 30km/h en 60km/h-zones. Op erftoegangswegen moeten alle verkeersdeelnemers (voetgangers, fietsers en automobilisten, etc.) van dezelfde rijbaan gebruik kunnen maken, waarbij voetgangers vaak wel een eigen verkeersruimte wordt geboden in de vorm van een trottoir. Manoeuvres als keren, draaien, het laten in- en uitstappen van passagiers, het laden- en lossen van goederen het oversteken moet veilig kunnen gebeuren. Omdat deze zogenaamde verblijfsfunctie het belangrijkst is, moet de snelheid van het gemotoriseerde verkeer omlaag om toch te voldoen aan de vereiste van homogeniteit van het verkeer. Om deze lagere snelheid (ten opzichte van de gebiedsontsluitingswegen) af te dwingen zijn de laatste jaren veel snelheidsremmende maatregelen getroffen. Door de lagere snelheid wordt doorgaand verkeer zoveel mogelijk geweerd, hetgeen weer beter past bij de functie van erftoegangswegen als weg voor bestemmingsverkeer. Naast het terugbrengen van de snelheid worden in principe geen andere verkeersmaatregelen zoals fietsstroken of zebrapaden toegepast.
Elk type weg heeft dus zijn eigen ontwerpeisen. Over deze ontwerpeisen wordt af en toe flink gediscussieerd, bijvoorbeeld over de vraag of fietsers op een rotonde wel of geen voorrang moeten krijgen. Over het algemeen geldt echter dat een positief veiligheidseffect wordt verwacht als Duurzaam Veilig in heel Nederland uniform wordt geïmplementeerd.