Traffic in the Netherlands 2016

Taale, Henk; Wilmink, Isabel

Publication date
2016

Document Version
Final published version

Citation (APA)
Taale, H., & Wilmink, I. (2016). *Traffic in the Netherlands 2016*. TrafficQuest.

Traffic in the Netherlands 2016

TrafficQuest

CENTRE FOR EXPERTISE ON TRAFFIC MANAGEMENT

Contents.

Foreword.

This is TrafficQuest's third annual review: Traffic in the Netherlands 2016. As in the previous editions, we present you with an overview of the current situation and the developments in traffic and traffic management. We disentangle the spaghetti of information on traffic and look in detail at what is changing in traffic and transport. And as you will learn, many things are changing!

As is customary, we begin our annual review in Chapter 1 with an overview of all the statistical trends related to accessibility, safety and the environment. We zoom in on a number of specific cases, namely the opening (after all those years) of the A4 Midden-Delfland motorway and the bottlenecks to be expected on the A2 between Deil and Empel.

Then, in Chapter 2, we discuss the themes of 2016. What is the traffic world focusing on and what is TrafficQuest particularly interested in? We ourselves worked on drawing up an inventory of traffic management functions and their relationship to C-ITS.

Another important theme involved data sources and unlocking those sources. The focus was also on traffic management in the event of a calamity and on how C-ITS can play a role in this. Last year, we dealt with urban traffic management in detail, but it continues to be a subject that deserves attention. The same applies to evaluation: what is the impact of automated driving on traffic flow and what does an evaluation framework for C-ITS and automated driving actually look like? Important questions to which we still don't have clear answers, so they will continue to be relevant in the time to come.

Needless to say, our annual review wouldn't be complete without an overview of the relevant professional and scientific literature. Once again, a wide range of interesting dissertations and articles was published, and we list them for you in Chapter 3. We hope that the short descriptions stimulate you to further explore a number of the subjects!

The subject for the coming years is smart mobility. The Netherlands wants to play a leading international role in this field – amongst other things, by testing smart mobility solutions in practice. For example, a number of trials are being held with coordinated network-wide traffic management in the Amsterdam region; systems for cooperative and automated driving are being tested on the A58; platooning trials are being held with freight traffic; and the use of innovative data sources is also receiving attention. Chapter 4 deals with these subjects in detail.

The Netherlands is also the country of cooperation – we are good at solving problems using dialogue. And that's good, because many different parties are needed for the complex solutions that we are looking at in the field of smart mobility. The Government, market parties and knowledge institutes are working together to get systems that show potential up and running. Chapter 5 discusses a number of these partnerships. Perhaps you are already a member, or perhaps you would like to join?

With this annual review, we hope to make all the knowledge in the Netherlands in the area of traffic management a little more accessible. This is one of the ways in which we are realising our mission to "collect, combine and disseminate knowledge". Incidentally, we do the latter in our reports, articles and recommendations.

See **www.traffic-quest.nl** for an overview.

The TrafficQuest-team, *september 2016*


KETHELTUNNE


A4 RING-W
Bergen op Zoom
Europoort
A20 RING-N
Utrecht
Schiedam
A20
Hoek v.Holland
Vlaardingen
1800m
2 km
1

Traffic statistics in the Netherlands.

In 2014, congestion in the Netherlands increased after slightly easing for a number of years. This trend continued in 2015 – quite strongly, in fact. But which increase are we actually referring to? What are the causes? Which urban regions are doing well and which are doing less well? And how are road safety and air quality coping under the increasing pressure of traffic? Based on figures and cases, we outline the Dutch traffic situation over the past year.

1.1. Traffic related statistics

2008 was the start of a long period of fewer traffic jams and less delay. That decline only came to an end in 2014. At the time, it was no great surprise: the economy was doing well again and that type of development translates almost automatically into more traffic on the road. But the speed at which the Dutch road network continued to fill up in 2015 was really quite remarkable. All the gains made in the preceding years seemed to disappear into thin air.

We now know that the rising trend is continuing in 2016 [1]: in the first four months of 2016, the number of traffic jams in the Central (Midden) region rose by 2% and by as much as 32% in the region of Amsterdam. It was only around Rotterdam that the number of traffic jams decreased, by 16% – see also section 1.2. The 2008 peak has not yet been reached, but it probably won't take very long.

How can that rapid increase be explained? In this section, we use a number of graphs to examine the main traffic indicators in 2015. We look at the main road network and at the urban road network in Amsterdam, Rotterdam, The Hague, Utrecht, Groningen and Eindhoven.

Developments in the main road network

The number of traffic jams on the main road network underwent a significant increase in 2015. But what does significant mean? We compiled the data in Figure 1 [2] on the basis of public reports issued by Rijkswaterstaat. The figure displays the indicators distance travelled, congestion severity and delays over the past few years. The growth in distance travelled (blue line) continued in 2015 at a rate of

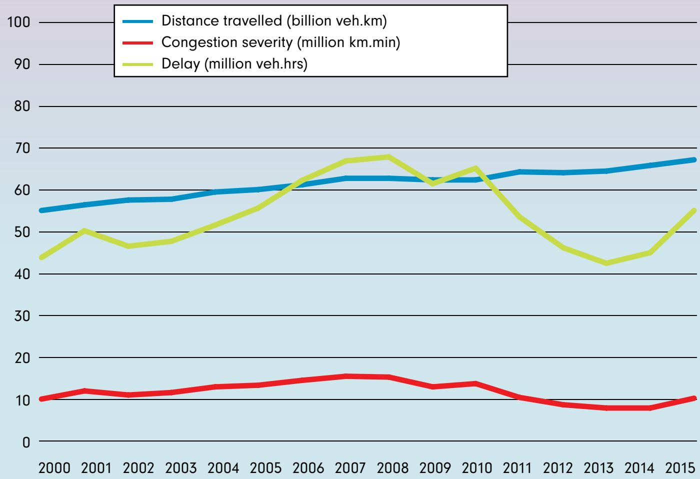


Figure 1: Indicators main road network (source: Rijkswaterstaat).

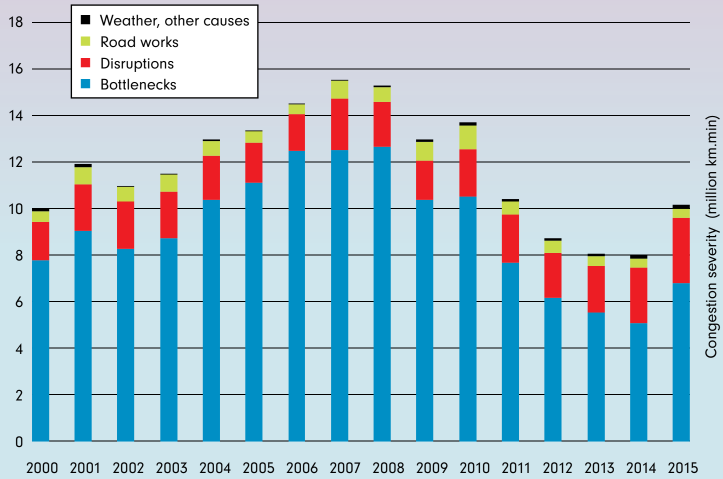


Figure 2: Congestion severity by cause, absolute (source: Rijkswaterstaat).

2.2%. That can be termed uniform, but those few percent did result in an increase of 27% in the amount of congestion, the congestion severity[1] (red line) and a growth of 22% in vehicle hours lost[2] (green line). And that can justifiably be called significant.

How can that increase in congestion severity be explained? Figure 2 classifies the congestion according to the cause. It is clear that most traffic jams are still caused by capacity bottlenecks (regular, recurring traffic jams), but also that this factor becomes more and more predominant: after all, the number of 'capacity traffic

[1] Congestion severity is calculated by multiplying the length with the duration of a traffic jam, expressed in kilometre minutes, as a consequence of traffic jams and other restrictions in road capacity.

[2] Vehicle hours lost are the number of hours of travel delay suffered by vehicles (compared to travel times in free flow) as a consequence of traffic jams and other restrictions in road capacity.

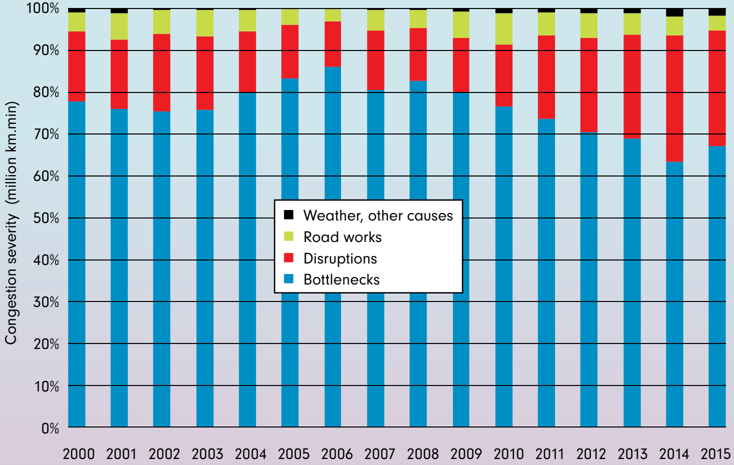


Figure 3: Congestion severity by cause, relative (source: Rijkswaterstaat).

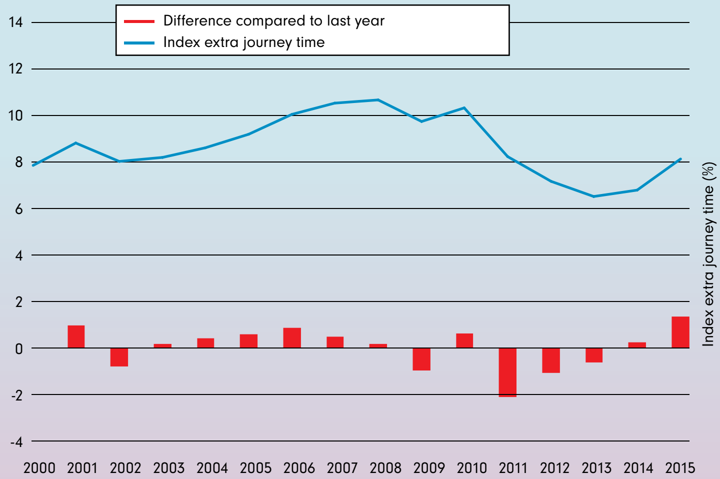


Figure 4:
Journey time index for the main road network (source: Rijkswaterstaat and TrafficQuest).

jams' increased by 35%. The number of traffic jams caused by disruptions (incidents and accidents) increased by 16% in 2015. The congestion caused by 'roadworks' and 'bad weather' also grew, but their share in the total amount of congestion remained limited.

Figure 3 also classifies the congestion according to cause, but now the focus is on their relative share. The importance of the 'disruptions' factor diminished in 2015, and that is a break with the rising trend that started in 2010. But there is still no cause for satisfaction, because the number of disruptions continues to increase in an absolute sense by the abovementioned 16%. A recent analysis by Rijkswaterstaat shows that that growth is mainly due to stranded cars and lorries [3]. That underlines the need for incident management, which must be firmly anchored in the organisations of the various road authorities and must continue to develop.

An increase in congestion also means an increase in journey times, as can be deduced from Figure 4. TrafficQuest's journey time index rose by 1.4 points in 2015 compared to 2014 and ultimately came to 8.2. That means that an average trip in 2015 took 8.2% longer than a trip in free-flow traffic. A trip over the main road network that would take 60 minutes in free-flowing traffic therefore took 64.9 minutes in 2015.

Developments in the urban road network

Naturally, more traffic on the main road network has an effect on the traffic situation in the city: a great deal of traffic starts or ends its journey on the urban road network. How has the traffic developed on those networks?

Figure 5 displays the TomTom congestion index on the roads in and around Amsterdam, Rotterdam, The Hague, Utrecht, Groningen and Eindhoven. What is clear is that only the traffic jams in Rotterdam and Groningen have remained more or less the same. In the other areas, congestion has increased. When we zoom in further and make a distinction according to the network type, the situation is slightly more nuanced – see Figure 6. The increase in 2015 was mainly on the main road network around the cities. In the cities themselves, the delays actually decreased compared to 2014, except in Eindhoven.

For that matter, in this issue of 'Traffic in the Netherlands' we were only able to use the data from TomTom [4] and not the data from INRIX.

INRIX switched to another indicator in 2015: the average number of hours that motorists spend in traffic jams [5]. That indicator cannot be compared with the INRIX figures of previous years. Any trends will only become visible some years from now. Apart from that, the INRIX figures are remarkable: according to INRIX, the amount of traffic in the Netherlands and the number of hours spent in traffic jams should have decreased in 2015, while all other data sources actually point in the other direction. It remains to be seen how that will turn out next year.

Conclusion

We can conclude that traffic congestion has increased significantly in 2015. If we consider this strong growth in relation to the trend-based growth of kilometres travelled, it looks as if in many respects our road network has reached its maximum capacity – and that this became very clear in 2015. The case of the A2 Deil-Empel motorway that we discuss below is a good example of that. With the current growth, we can expect to encounter those capacity problems in many more locations in 2016.

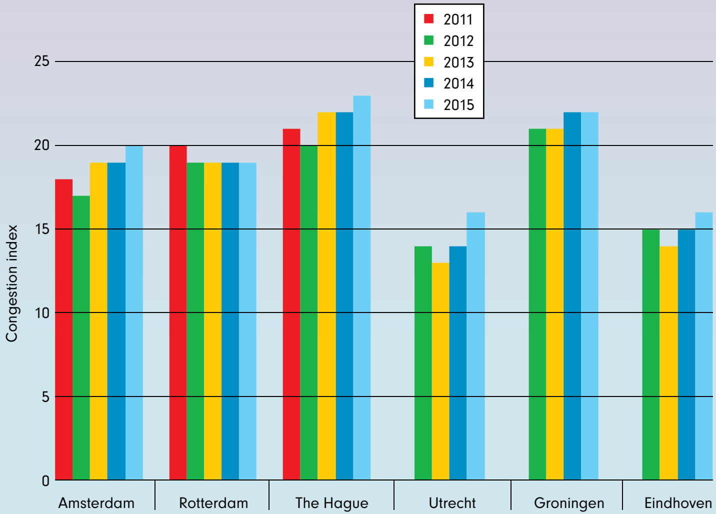


Figure 5: Congestion indices for urban networks (source: TomTom).

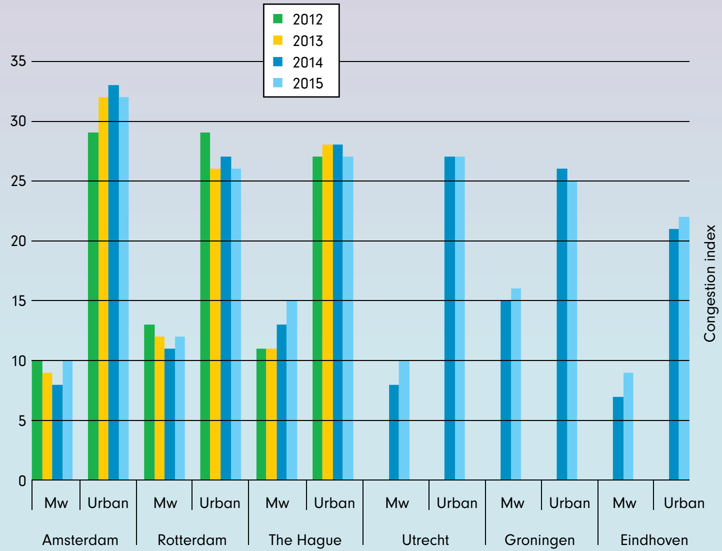


Figure 6: Congestion indices for motorways and urban networks (source: TomTom).

1.2. Case: Opening of the A4 Midden-Delfland motorway

Of course, the average figures in the previous section do not do justice to all the interesting developments that took place at individual locations. That is why we will explore that issue in more depth in this section and focus on the (long expected) opening of the A4 Midden-Delfland motorway between Schiedam and Delft in late December 2015. After years of squabbling, the missing link in the Rotterdam-The Hague corridor – and more widely, in the Amsterdam-Antwerp corridor – was finally filled in. How has this link influenced traffic flow in the region?

To answer that question, at 18 locations we compared the traffic volume data from January 2015 with that from January 2016, just after the opening of the A4 Midden-Delfland motorway. The data relates to volumes for all traffic lanes in one direction of travel. Figure 7 displays the absolute difference in traffic volumes for the different locations, both on national roads and on provincial roads.

The Figure shows that one month after being opened, the new route attracted 63,000 vehicles per day. Three months after being opened, the daily traffic volumes have increased further to 70,000. Slightly more vehicles drive in a northerly direction than in a southerly direction. The increase of traffic on the A4 mainly seems to be due to traffic that used to drive on the A13. After all, the volumes on the A13 have dropped substantially, by 22% (northerly direction) and 20% (southerly direction), at the chosen traffic count location. The traffic volumes on the A20 between the interchanges with the A4 and the A13 are also much lower than in the past: 14% (westerly direction) and 18% (easterly direction). This is because the use of the A13 between the Benelux Tunnel and The Hague is now a less obvious option.

On the section of the A20 between the A16 and the A13 the traffic volumes have scarcely changed. One possible explanation for this is that the volumes on the A20 were already approaching capacity level and are now still close to that level. The number of vehicle hours lost on this route has actually decreased – for example, by more than 40% in the northerly direction. The traffic now seems to be travelling more along the southern side of Rotterdam on the A15, and here the volumes have increased by 3% and 8% in both directions. This assumption is reinforced by the fact that there is 13% (northerly direction) and 15% (southerly direction) more traffic using the Beneluxtunnel.

The increase in flow in the Beneluxtunnel, the extra traffic over Haringvlietbridge (around 10%) and the unchanged traffic volumes on the Moerdijkbridge and Van Brienenoordbridge are evidently the consequence of extra long-distance traffic between Brabant and Rotterdam. This is plausible because an extra route is now available via the A4/A29 motorway between Antwerp-Havens and Rotterdam-Havens.[1]

[1] On this route, the missing link between A4 Dinteloord and Halsteren was opened in November 2014.

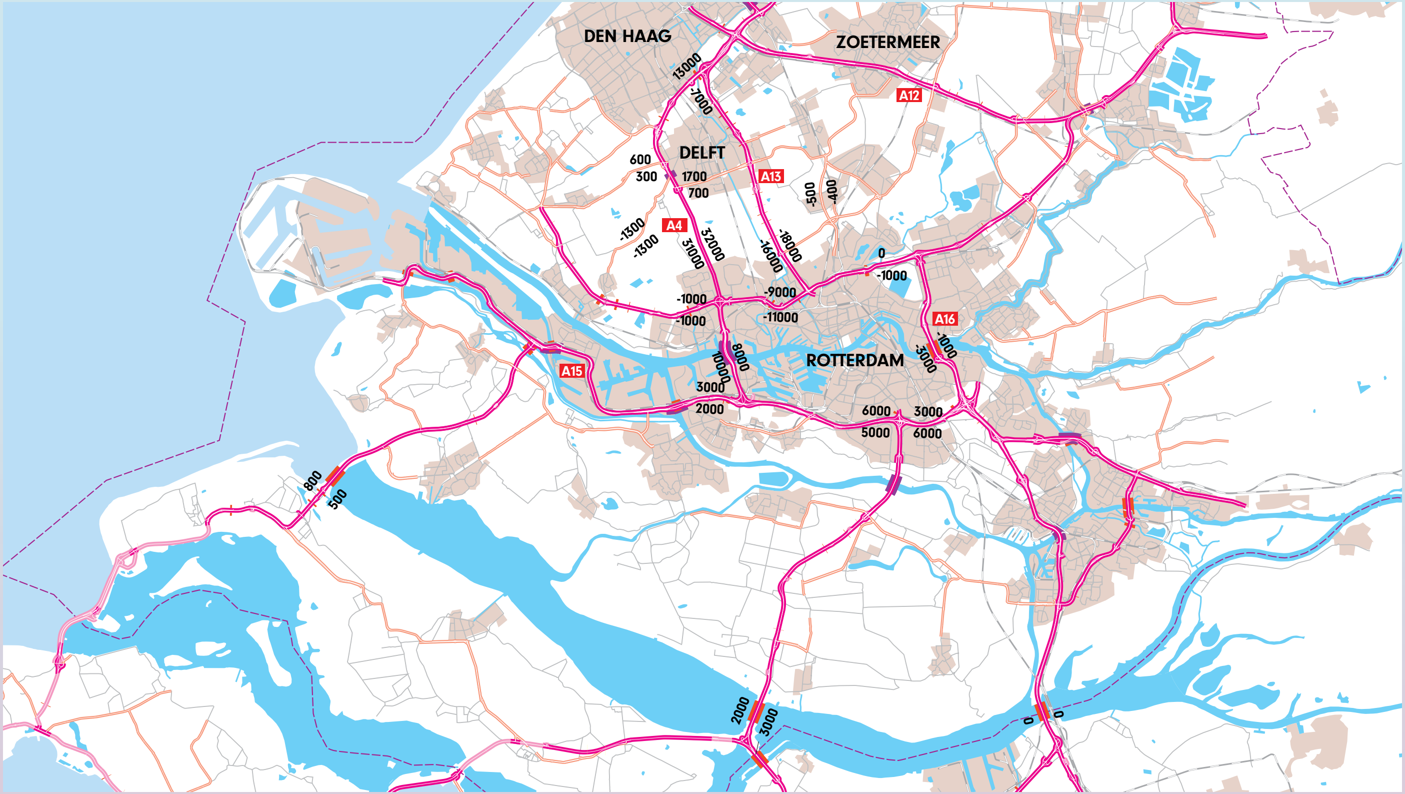


Figure 7: The difference in average workday traffic volume. To measure this, the traffic volumes of January 2015 were compared with those of January 2016 at 18 different locations (source: NDW, TNO).

More traffic is entering the A4 Midden-Delfland motorway form the provincial roads. From the N470 there is as much as 19% more traffic. On the N471 near Berkel and Rodenrijs, which is a road that is often used as an alternative to the A13, the traffic volume has actually dropped. On the N468, which was the only road between Delft-South and the A20 before the A4 was completed, the flow has decreased by as much as 30%. Here, too, the traffic will now take the A4.

There are also huge changes on the A4 between The Hague-South and Leidschendam. Here, more traffic has been measured in both directions. Besides the original traffic flows – especially local traffic – long-distance traffic is now also using the new A4 corridor between The Hague and Rotterdam.

What is the effect of these shifts in volumes? For a number of routes in the region Rotterdam-The Hague, Figure 8 displays the difference between the vehicle hours lost and the traffic performance[2] on working days (morning rush hour and evening rush hour) in January 2016 compared to working days in January 2015. This clearly shows that on most routes the vehicle hours lost are decreasing, often by tens of percent at the same time. On the A13, for example, which, as indicated above, benefits most from the new A4 route, the delays have decreased by over 80%.

[2] The traffic performance indicates how many vehicles were processed by a particular road section. This indicator is calculated by multiplying the traffic volume on the road section by the length of the road section. The traffic performance is usually expressed in vehicle kilometres per hour.

On a number of other routes, however, the vehicle hours lost are increasing. The extra (long-distance) traffic between The Hague-South and Leidschendam, for example, is leading to large percentage increases in lost vehicle hours in both directions on this route. There new bottlenecks are appearing. The route Beneluxplein-Kleinpolderplein is now also experiencing problems during the evening rush hour. That is mainly due to the increase in traffic on the A4.

To determine the consequences of the opening of the A4 between Schiedam and Delft, we looked at the complete ring around Rotterdam: the routes in Figure 8, plus the A15 Beneluxplein-Ridderster and the new section of the A4. The results are displayed in Table 1.

This table shows that between January 2015 and January 2016 the amount of kilometres driven and therefore the amount of traffic increased by 10%. Nationally, the growth in 2015 was 2.2%, so the opening definitely had a ‘pull factor’ on traffic in the region – in any case as far as the main road network is concerned. When we examine the delays, we can see they decreased by 31% in the area: the opening of the A4 increased capacity and also increased the number of possible routes. So for the moment, that translates into less delay. In itself, less delay with more kilometres is a positive development, but of course at the same time those extra kilometres also result in higher emissions, higher energy consumption and possibly more accidents.

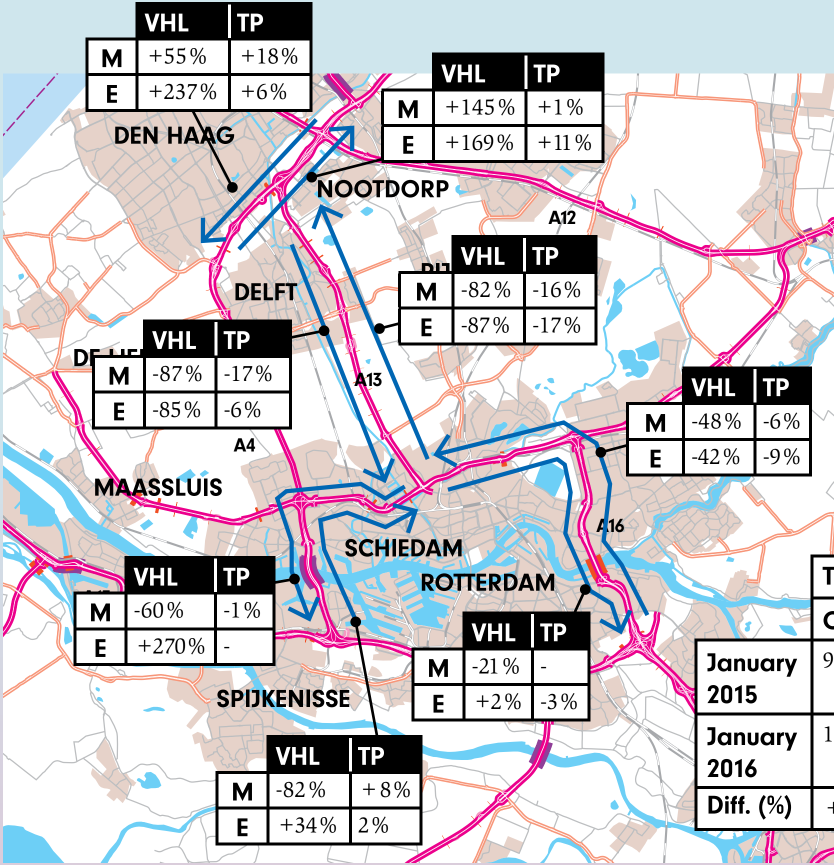


Figure 8: Difference in vehicle hours lost (VHL) and traffic performance (TP) in the morning rush hour (M) and evening rush hour (E) on working days between January 2015 and January 2016 (source: Rijkswaterstaat).

	Traffic performance (veh.km)			Delay (VHL)		
	OS	AS	24 hrs	OS	AS	24 hrs
January 2015	988.003	1.030.490	6.584.640	3.991	4.882	15.098
January 2016	1.108.880	1.161.742	7.229.393	2.540	3.607	10.358
Diff. (%)	+ 12%	+ 13%	+ 10%	-36%	-26%	-31%

Table 1: The traffic performance and the delay for the Rotterdam Ring Road plus the A13 and A4 Midden-Delfland.

1.3. Case: Analysis A2 Deil-Empel

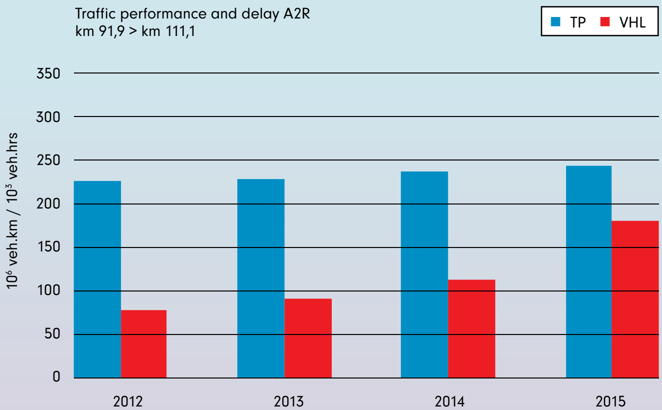
Many routes on the main road network have become much busier over the past year. This has caused many new, structural bottlenecks. TrafficQuest has analysed the available data for fourteen routes that are at a tipping point – that is, getting busier and even experiencing the occasional traffic jam. For the complete analysis of these 'tipping-point routes', we refer you to the TrafficQuest memo on our website [6]. As an example, below we zoom in on the A2 between the Deil and Empel interchanges.

The traffic performance and the delays on this route are displayed in Figure 9. In 2015, the amount of traffic increased by 3% in both directions compared to 2014. However, the delays increased by much more: in the direction of Empel by 61% and in the direction of Deil by 19%. This route therefore seems to be quite saturated.

That is also evident from the traffic volume figures. We have calculated the annual average hourly volume for the road section where the problems are largest, or rather: where a bottleneck seems to have developed. The traffic volumes throughout the day are displayed per 15 minutes. This is based on data over the period 2012-2015, as well as on an extrapolation for 2016-2020 – see Figures 10 and 11. The extrapolation assumes an annual growth of 2%, which is a conservative estimate based on the annual growth throughout the Netherlands.

No account was taken of possible shifts, such as expansion of the rush hour, that can occur when congestion is really severe.
The capacity of the road section is also plotted in the graph [7]. That line is just an indication that at that point a bottleneck can occur. After all, it relates to an annual average flow in which the daily fluctuations are not included, even though they are very important for determining the level of congestion on a road section [8].

For the A2 Deil-Empel, over the past two years the traffic volumes have increased significantly and there is congestion during both the morning and evening rush hours. Figure 10 shows that this can become a structural bottleneck from 2017 onwards. In the other direction, Empel-Deil, there are many traffic jams during the morning rush hour: there is a broad peak in traffic volumes in the morning. The traffic jam usually occurs near the Zaltbommel connection, but sometimes also downstream of this location. During the evening rush hour, congestion is still limited, but with the current growth in volumes the chance of traffic jams will increase correspondingly in the years to come.



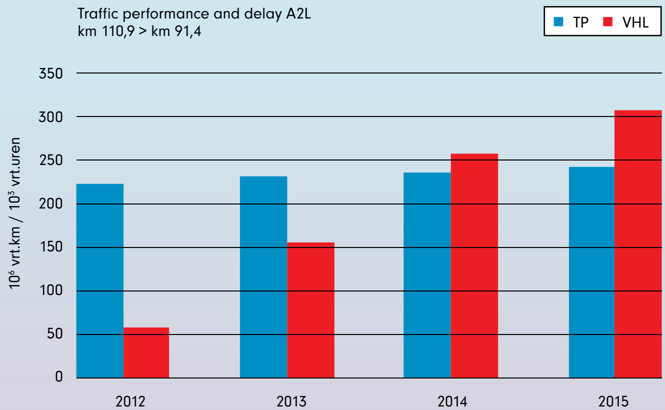
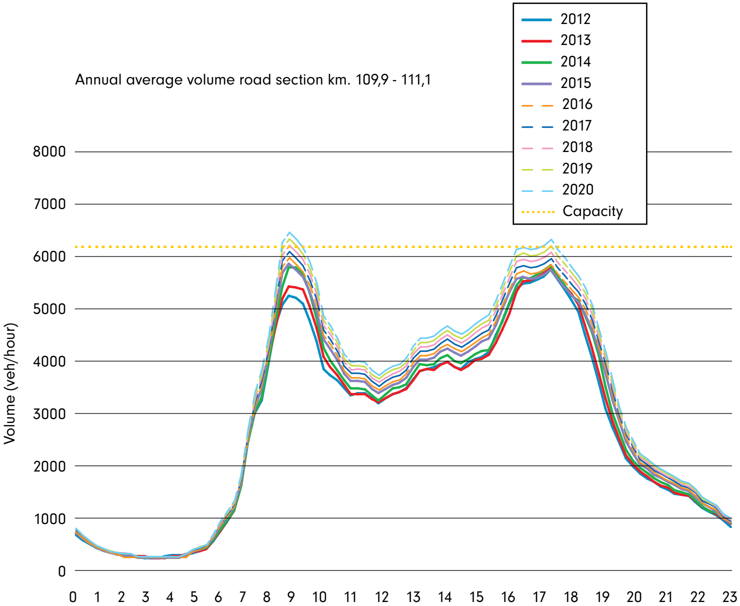


Figure 9: Traffic performance and delay A2 Deil-Empel
(source: Rijkswaterstaat and TrafficQuest).



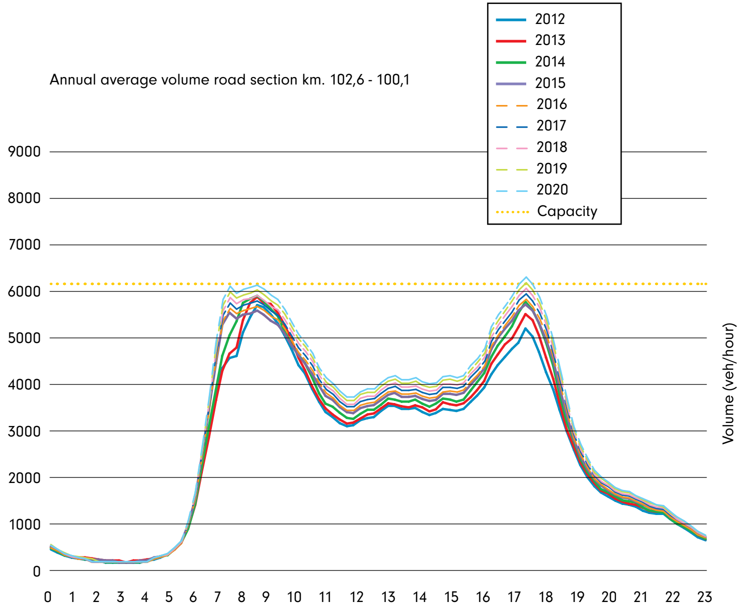


Figure 10: Measured and estimated traffic volume A2 Deil-Empel (source: Rijkswaterstaat).

Figure 11: Measured and estimated volume A2 Empel-Deil (source: Rijkswaterstaat).


ZJ-DP-84

1.4. Road safety in figures

The number of traffic deaths in the Netherlands in 2015 was published in April 2016. That number had risen from 570 in 2014 to 621 in 2015 [9]. There had been no increases since 2003, so this gave much food for thought. Which groups are most affected and on which type of road?

When we examine the accident data, the increase mainly relates to men and then particularly men aged 80 and older. When we classify the data according to means of transport, we find that the number of fatalities in passenger cars and in motorised vehicles for the disabled has increased, while the number has stayed the same for, for example, cyclists.
The majority of the casualties occurs on the provincial and urban road networks, but the number of traffic fatalities has risen most on the national network (mostly motorways). While the number of victims rose by 6% from 507 to 539 on the other road networks, on national roads the number rose by 30% from 63 to 82. As a result, the discussion about the safety of motorways on which motorists may drive 130 km/hour flared up again [10].

The number of casualties is also rising again: in 2014 it was 10% higher than in 2013 (no figures are yet available for 2015).
Figure 12 displays all the relative numbers together: the number of traffic fatalities (national network and all roads) and casualties (all roads) per billion of vehicle kilometres driven.

Internationally, the Netherlands is still doing well, but we should mention that the country tables contain figures from 2013. If we look at the number of traffic fatalities per million inhabitants [11], the Netherlands is in 3rd place with 28, after Malta (26) and Sweden (27), ahead of Great Britain (29) and well ahead of Belgium (67). On the IRTAD ranking that ranks countries on the basis of the number of traffic fatalities per billion driven kilometres, the Netherlands rose from 8th place last year to 7th place now.

Given the disappointing 2015 figures, however, there is every reason to start paying more attention to road safety.

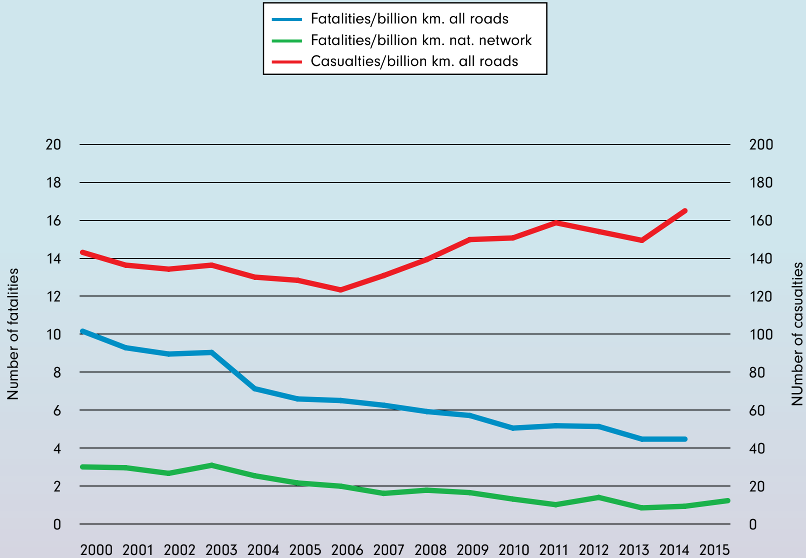


Figure 12: Development of the relative number of traffic fatalities and casualties in the Netherlands (source: Rijkswaterstaat and CBS).

1.5. Air quality in figures

As far as the air quality is concerned, we must rely on figures from 2014. Despite the fact that the amount of traffic and the number of kilometres driven increased in 2014, emissions continued to decrease that year, both in absolute terms per kilometre driven. Figure 13 displays the emissions per million kilometres driven.

Particularly the emission of PM_{10} dropped significantly, by 13 % in 2014 compared to 2013, both absolutely and relatively. For NO_x this decrease was 8 %. The decrease in CO_2 was not as significant, just 1 % for the entire road network, but still 3 % for the national network. We should add that these figures are based on the official statistics. It is not clear how the emissions scandal (the ‘Dieselgate’ software) will affect these figures.

The fact that emissions are decreasing while the number of kilometres driven is increasing can largely be attributed to the replacement of the vehicle fleet. Cars are becoming increasingly cleaner and are emitting increasingly lower amounts of harmful substances.

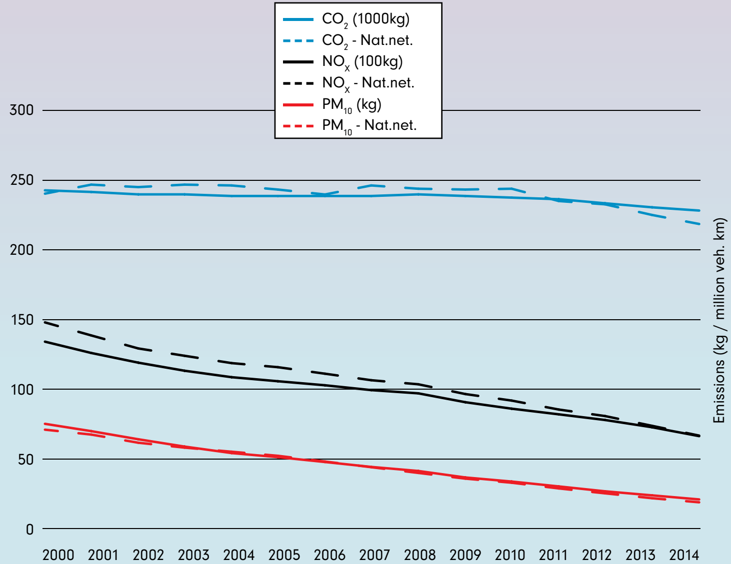


Figure 13: Development of emissions (source: CBS).

1.6. Summary

All in all, again there were many developments in traffic in 2015. The increase in congestion that began in 2014 continued in 2015. That led to much more delay. Disruptions are an important cause, but the regular traffic jams as a consequence of capacity bottlenecks are still the reason for most of the delay. That will not change in the coming years: more and more routes are being used to their full capacity and are at a tipping point, such as the A2 Deil-Empel.

Road safety is also under pressure: the number of traffic fatalities and casualties has risen. Therefore, extra measures seem to be necessary. Developments in the area of emissions are still positive, even though the decrease in CO_2 emissions is slow.

Main findings

- Like last year, congestion is on the rise, but this year's increase of 27% is considerably higher.
- Among the causes of congestion, the absolute and relative increase of incidents and accidents is striking.
- The opening of the A4 between Delft and Schiedam has resulted in less delay in the Rotterdam region as a whole. On other routes, however, new bottlenecks are developing.
- Road safety diminished to an alarming extent, but it is still too early to describe this as a trend.
- As far as emissions are concerned, there is still a downward trend, but it is developing slowly. We should note that the consequences of 'Dieselgate' software have not yet been accounted for in these figures.

References

[1] **ANWB (2016)**
www.anwb.nl/verkeer/nieuws/nederland/2016/april/filezwaarte-april, visited on 3 June 2016.

[2] **Rijkswaterstaat (2016a)**
Operational Target Availability HWN. Memo drawn up by RWS WVL, 3 March 2016.

[3] **Rijkswaterstaat (2016b)**
Operational Target Availability HWN. Memo drawn up by RWS WVL, 3 March 2016.

[4] **TomTom (2016)**
www.tomtom.com/nl_nl/trafficindex, visited on 11 May 2016.

[5] **INRIX (2016)**
inrix.com/press/scorecard-nl, visited on 11 May 2016.

[6] **TrafficQuest (2016)**
Analysis possible future bottlenecks. Memo drawn up for Rijkswaterstaat, 29 April 2016.

[7] **Rijkswaterstaat (2015)**
Handbook Capacity Values Infrastructure Motorways, version 4, Grontmij, July 2015.

[8] **S.C. Calvert (2016)**
Stochastic Macroscopic Analysis and Modelling for Traffic Management, PhD Thesis, Delft University of Technology, TRAIL Research School, May 2016.

[9] **Central Government (2016)**
www.rijksoverheid.nl/actueel/nieuws/2016/04/21/aantal-verkeersdoden-gestegen-in-2015, visited on 11 May 2016.

[10] **De Volkskrant (6 juli 2016)**
www.volkskrant.nl/binnenland/limiet-van-130-km-leidt-grotere-kans-op-dodelijk-ongeval~a4334125, visited on 6 July 2016.

[11] **European Commission (2016)**
europa.eu/rapid/press-release_IP-16-863_en.htm, visited on 11 May 2016.

2

The themes for 2016.

Every year, there are a number of themes that are paid an above-average amount of attention in research studies, in the trade press and in corridor talk. In this chapter, we discuss a number of those 'hot items'. We look at innovations such as cooperative ITS and automated driving, but also at data sources and 'good old' traffic control systems.

2.1. Traffic functions in relationship to C-ITS

In 2013, an informal round table consisting of representatives of road authorities, service providers, industry and research institutes drew up the ‘Better Informed on the Road’ roadmap. This Roadmap sets out the route to a new approach to traffic management and traffic information. The approach involves a total of six “transition paths”, which are the main changes that are necessary for the new approach – see Figure 14.

The Netherlands want to innovate and has therefore worked hard on the planned changes in various projects and pilots. Particularly for transition paths 1 and 2, it is good to know which traffic functions are now available on and beside the road and how they can change in the long term. This mainly involves the question of how those functions can be implemented in the future using cooperative ITS, or C-ITS for short. Once that is clear, those C-ITS applications can be developed in a more targeted way and the transition can be made faster.

At the request of Rijkswaterstaat TrafficQuest drew up an inventory of all of Rijkswaterstaat’s signs and measures on the road and translated them into traffic functions [1]. TrafficQuest examined which functions can be realised by C-ITS applications and which functions Rijkswaterstaat wants to continue providing itself whatever the circumstances.[1] Below, we briefly describe the structure and results of the research.

[1] Because this type of elaboration is also useful for other road authorities, the results of the inventory have been discussed with the Optimising Use Follow-up programme.

Functions, goals and types

We first identified all the traffic functions that Rijkswaterstaat is now using. It turned out that there are more than forty of them, including detecting height of vehicles, monitoring traffic, supervising rush-hour lanes, signposting (other than speed limit), automatic incident detection, providing information about lane configuration, warning for disruptions (such as incidents or open bridges), recommended speeds, overtaking prohibition for freight traffic, etc.
See Table 2.

These functions are subdivided according to type: monitoring, informing, advising, warning or controlling. The goal is also indicated: to improve accessibility, increase safety, good for the environment/quality of life or information supply. Many functions serve multiple objectives.

Data

To make it possible for these functions to be offered in the vehicle, the correct data must be available. That is why, in a second step, it was determined which data is used by the different functions. It is also indicated whether this involves data from the so-called Data Top 8. The Data Top 8 are sources that the government makes accessible to market parties on a priority basis [2, 3]. This relates to the following:

1. *Data about roadworks*
2. *Location references*
3. *Maximum speeds*
4. *Indication of the remaining duration of incidents*
5. *Operational control scenarios*
6. *Parking information*
7. *Event information*
8. *Traffic signal control data*

For example, the functionality ‘Informing motorists about lane configurations’ requires data about roadworks and about the remaining duration of incidents.

Implementation design now and in the future

All functions have a current implementation design (beside or above the road) and some also have an implementation design such as C-ITS. These are C-ITS services that already exist or at least are under development. In a third step, all known and expected implementation designs are described. An example: the function ‘Informing motorists about lane configurations’ now uses static signs; in the future, that function can be implemented with In-vehicle signage and a Merging assistant.

Requirements

When functions are offered in the vehicle, they will have to comply with certain requirements, just as guidelines are now specified for the layout of the road and the positioning of signs. The C-ITS requirements will have to be defined for each function. In the research, we have already worked out five types of requirements [4] –

see Table 3. There are more types of requirements conceivable, such as enforceability and visibility and frequency of information updates, but they will probably only become important when the in-car applications actually start replacing the roadside systems.

In the Beter Benutten[2] programme on optimising the use of the infrastructure, which is an initiative of the Ministry of Infrastructure and the Environment, market parties have worked out a set of use cases in which one or more functions are deployed for each case. Even during this early development phase it is important for road authorities to define minimum requirements for the aspects displayed in Table 3. That is now being done, with the benefit that market parties can take those requirements into account when developing a service. Where possible, the requirements are functionally expressed so that market parties are not restricted and have the space they need to propose innovative applications that still comply with the minimum requirements – and that may have much more to offer.

The elaboration of the requirements has produced useful insights into how information, recommendations, rules and restrictions can be supplied safely and efficiently in the vehicle. With an increase in C-ITS applications in the years to come, the requirements will have to be elaborated in more detail and requirements for aspects other than the five displayed in Table 3 will probably also be necessary.

[2] See www.beterbenutten.nl/en.

Accessibility · Safety · Quality of life and environment · Information supply

TRAFFIC FUNCTIONS

Function	Accessibility	Safety	Quality of life and environment	Information supply
MONITORING				
Detecting hazardous situations (bad road surface, slippery conditions, etc.)		●		
Detecting weight of trucks		●		
Detecting height of vehicles	●	●		●
Detecting disruption (including standstill detection)		●		●
Monitoring traffic	●	●	●	●
Supervising rush-hour lane		●		
PROVIDING INFORMATION				
Signposting (other than speed limit)				●
General communication				●
Informing motorists about alternative routes	●			●
Informing motorists about the network situation (traffic jams, bridge openings, incidents, etc.)	●			●
Informing motorists about parking and P+R	●		●	●
Informing motorists about journey times	●			●
Informing motorists about the lane configuration		●		●
Informing freight traffic (parking spaces, slots)	●		●	
MAKING RECOMMENDATIONS				
Recommending a traffic lane	●	●		
Speed recommendations		●		
Recommendations about headways	●	●		
Routing hazardous cargo		●		
Reducing traffic demand (weather, rush hour avoidance, other info)	●	●	●	
Recommending alternative route	●			
ISSUING WARNINGS				
Automatic incident detection (queue tail warning)		●		
Warning for tailgating		●		
Warning for dangerous situation (poor road surface, slippery conditions, etc.)		●		
Warning approaching an intersection (green wave, etc.)	●	●		
Warning for disruptions (bridge open, incident, etc.)		●		
CONTROL				
Queue tail warning with reduced speed limit		●		
Flexible lane layout	●			
Homogenisation (including reducing shock waves)	●			
Processing a vehicle which is too high	●	●		
General overtaking prohibition	●	●		
Overtaking prohibition trucks	●			
Lane open/closed	●	●		
Speed limit (static)	●	●	●	
Speed limit (variable)	●	●	●	
Stopping traffic		●		
Temporary capacity expansion (rush-hour lane, plus lane)	●			
Prohibition of trailers		●		
Buffering traffic	●			
Metering traffic	●			
Improving traffic flow	●			
Shortening disruption duration	●			
Prescribing alternative route	●			

Table 2: The more than forty traffic functions that Rijkswaterstaat now uses, subdivided according to type. The goals are also indicated for each function.

Requirement type	Explanation
Importance	Should the information be given priority (in processing and displaying)? What are the consequences if the information is not made available?
Promptness	How quickly must the information be received?
Accuracy	How important is it to display the information at the correct location and at the correct time (including legal consequences)? This aspect is more absolute than reliability.
Reliability	How important is the correctness of the information (not restricted to location and time)? This aspect is more personal for the receiver: how can trust be maintained in the service/ information?
Standardised	Do standards already exist for the information communicated to the road user?

Table 3: Five types of requirements for C-ITS functions. These requirements must be specified in detail for each function.

Figure 14: The six transition paths of the Roadmap ‘Better Informed on the Road’.

2.2. Data sources for traffic management

The main developments in terms of data relate to *opening up existing data sources*. As far as ‘roadside data’ is concerned, traffic light data particularly stands out. One important driver for the road authority for providing this data more effectively is the improvement for the services it provides to road users: the data can be used to handle traffic on the intersection and in the network more efficiently. But the data can also be used to enable private service providers to develop additional traffic information services for road users.

The Netherlands as a test site

The abovementioned ‘Beter Benutten’ (Optimising Use) programme is the national overarching programme in which many of the regional initiatives related to data are being developed. However, internationally operating parties such as Google are also becoming active and opting for the Netherlands as a test location. Because the Dutch main road network is equipped with a fine-meshed, high-quality measurement network – particularly from an international perspective – the Netherlands is a good location to analyse the quality of traffic information that has been obtained in an alternative way. The next step involves determining how these alternative data sources can be deployed to fuel existing and future traffic management measures. Here, the alternative sources are not used to emulate the current data source; instead, the work is based more on the specific characteristics of the relevant data source.

In this context, Google commissioned TNO to determine the usability, coverage and possible cost savings of traffic statistics for traffic management that are possible using Google data [5]. In this research study, TNO worked with depersonalised, aggregated historical traffic data from Google. The study compared this data with the measurements made using 3,000 loop detectors in the Dutch road network. The quality and usability of the data were determined on that basis. The average speeds determined with the Google data deviated by 5 to 10% from the speeds measured using traditional loops. That is a deviation of a maximum of 5 km per hour at an average speed of 50 km per hour. The indicators calculated in this way produce a very cost-effective additional data source for traffic managers, particularly given the relatively high costs of measuring traffic flows with loops. TNO therefore believes that there are excellent opportunities for alternative and additional data sources, particularly when they are aimed at understanding important traffic flows. Cities and road authorities can use new data sources to develop high-quality, reliable traffic statistics and in that way manage their traffic more effectively.

NDW and DiTTlab

NDW, the National Data Warehouse for Traffic Information, has launched projects to test 'mobile data', such as data on the basis of smartphones. In our previous annual review, we described a pilot with data fusion [6]. However, new developments are taking place all the time. For example, NDW and DiTTlab[1] are now working together on an intelligent historical database in which users can search for information much more intuitively using traffic characteristics or keywords. This should make it much easier to search for and process data for a research project [7].

However, DiTTlab is no longer focusing just on databases. It is aiming to become a laboratory that combines (big) data and (open-source) simulation tools. The data can be used to monitor developments in the field of traffic and transport and the measures that have been taken in the area. The data combined with algorithms can be used to predict the traffic situation and in that way improve operational traffic management. And, lastly, data combined with traffic models is useful for determining the effects of (programmes of) measures. The effects can therefore easily be up-scaled to the desired level.

In order to use data as broadly as possible, DiTTlab is working on new simulation models that can deal with more modes of transport (including automated driving) and more aspects (such as charging points for electric vehicles) than the current models and that can be used for both planning and operations. An open-source simulation toolbox is being developed for this purpose, and the first version is now ready.

Traffic Signal Control

Data from traffic signal control systems (TSCSs) will be an important source for the urban environment. TSCSs can supply information about the amount of the traffic. For many intersections a distinction between the different modes is also possible, and information about the throughput, thanks to the data about delays and the length of queues. What makes TSCS data so attractive is that the data is already available – it just needs to be accessed. See also the next section.

[1] DiTTlab stands for Delft Integrated Traffic & Travel Laboratory. See dittlab.tudelft.nl.

2.3. Developments in TSCS

Road authorities have been deploying traffic signal control systems (TSCS) for decades. Still this instrument is being improved and developed all the time. In the Netherlands, the Optimising Use programme in particular is currently focusing on TSCS innovations.

Many of the current innovations are based on the fact that information can now be shared between roadside systems and road users more easily and more rapidly. Most relevant for the road authorities and road users are the new measures that are ultimately possible on the road. However, in the framework of the Optimising Use programme, the preparatory work that is being carried out is at least as important and is something that we may be able to reap the benefits of for even longer. One excellent example of this is the open architecture on which Optimising Use is currently working.

Architecture

The aim of the new architecture is to make it easier to develop and roll out new services. That is now still difficult. A TSCS must be able to do its work smoothly day in day out for fifteen to twenty years – and given that requirement, implementing innovations is a risk. However, the new architecture is tackling that problem. It basically means that all (new) traffic control systems are fitted with a basic interface that can be used to safely control the lights. All extra functionality has been added separately (in software and/or hardware), such as the control programme or the hardware and software to communicate with the road user and the road authority. The common architecture uses open and international standards as much as possible, which makes it even easier to develop and roll out new services. This substantially increases the market for innovative measures in terms of both the sales market (geographical scope) and the providers.

The regional road authorities have since indicated which new functions they would find interesting and which are interesting for the road user. The market is now being challenged to set up new services on the basis of this input that are commercially viable.

2.4. Traffic management in the event of calamities

An extreme weather situation, a terrorist attack, an explosion at a chemical factory, a power failure or a burst (main) water pipe – the events that we call calamities are very diverse. They usually have an enormous impact on their surroundings, and therefore also on traffic. In such cases, traffic management can play an important role in maintaining the traffic flow during such a calamity. This could include evacuating the disaster area, directing the vehicles of emergency services and local authorities to the disaster area, supervising the other traffic in and through the area and (depending on the seriousness of the disaster) diverting traffic around the disaster area.

Road authorities are generally well prepared for calamity situations. But there are developments in smart mobility that can affect traffic management and traffic information when calamities occur. That is why TrafficQuest organised a workshop in early 2016 at the Innovation Centre in Helmond with representatives of road authorities, emergency services, service providers and research institutes to take a close look at the role of traffic management and how it is organised.

The existing cooperation between the emergency agencies and the road authorities seems to be working well, certainly as far as the Police-Rijkswaterstaat combination is concerned. The parties involved are well trained to deal with crises and are usually very experienced (more so than in the case of incident management). Although the harmonisation with other road authorities could probably be better in some regions. The service providers ('market parties') that attended the workshop said they need the Government to be more 'directive'. The road authority is responsible for traffic safety. The government should therefore be clear about what information may or indeed must be shared with the general public. The service providers do not always want to make these decisions themselves. The Government should therefore share unambiguous information with the relevant emergency services, traffic control centres and service providers.

The question was how smart mobility can be used to improve crisis management. Because what will happen if the effectiveness of the current approach diminishes in the future, when road users are increasingly better informed by in-car systems such as (dynamic) navigation systems and smartphone apps that are not controlled by the Government? In-car systems and apps can offer a number of advantages:

- *Better data about the current traffic situation will make it possible to define better diversion routes that can also be communicated to road users more effectively (and in a personalised way). The reasons for the diversion can be specified, which will have a positive effect on compliance.*

- *Smart mobility apps can help to make people more alert, to warn them about potentially dangerous situations.*

To make optimal use of these possible advantages, knowledge of the human factors is very important. What way of communication with road users will make them display appropriate behaviour in a crisis? And how can it be ensured that drivers are not too distracted by the information presented to them? Another point is: if everybody has data, and perhaps even information, who then determines what will be done with that information and how it will be interpreted? This is a question that will become increasingly relevant as more road users become ‘connected’. Unambiguous information will have to be derived from all the available data, which can then be shared with all the relevant parties. For example, information indicating that particular roads or areas must be avoided due to a calamity. A distinction can be made here between ‘need to know’ and ‘nice to know’ information.

The conclusion of the workshop participants was that the market can tackle the monitoring, but that the Government must intervene and take control in the case of a calamity. When calamities occur, traffic management is facilitating and not leading. It must be clear who is responsible for the messages communicated to road users – and that must in any case be a Government organisation. The use of smart navigation systems and apps can help give road users the right options for their trips. Multiple recommendations to choose from and justification for the recommendations are important here.

2.5. Urban traffic management

Cities are growing again and as a result the urban mobility problem is also increasing. The use of urban traffic management can alleviate this, but how should that be done? Given the major differences between urban and national transport systems, urban traffic management should not be regarded as a copy of traffic management on the national and regional road network. For example, the urban environment has its own specific problems, namely the presence of mixed traffic, the robustness of networks, intersections and priority, urban distribution and events. The study trip to Austria and Switzerland that TrafficQuest made in 2015 showed that not only technical aspects, but also administrative, financial and organisational aspects have a major role to play [8]. If urban traffic management is to be successful, a target-oriented approach geared to the nature of the problem and intensive cooperation between all the parties concerned are absolute preconditions.

To plot the right course, TrafficQuest has set up the SVM-NL workgroup together with the Platform WOW, CROW and the National Traffic Management Council (LVMB). The goal of this collaboration is to:

- *Combine and exchange knowledge and expertise.*
- *Implement joint study projects and research studies.*
- *Make agreements about national uniformity.*
- *Make the effectiveness of urban traffic management known to and understandable for policy and decision-makers.*

In the first half of 2016, a number of regional meetings were organised in order to draw up an inventory of the technical, administrative, financial and organisational aspects for the application of urban traffic management. This was aimed at identifying the main subjects and the relevant questions for each subject. There was particular interest in the subjects ‘visibility and effectiveness of traffic management’, ‘C-ITS’ and ‘bicycle’. In the autumn, the workgroup will determine which subjects and questions should be given priority and which follow-up activities will be required.

2.6. Impact of automated driving on traffic flow

Interest in automated vehicles is growing all the time. The number of vehicles with driver assistance, level 1 of automated driving, is growing steadily: cars with Adaptive Cruise Control and Lane-Keeping Assistance are no longer a rare occurrence. There are also level 2 vehicles with partial automation, in which steering, accelerating and decelerating can be taken over. And there are also experiments with vehicles with even higher levels of automation.

It is mainly the automotive industry that is taking the initiative in this area, but many road authorities are closely monitoring developments. After all, the automation of traffic raises quite a number of questions. For example, what are the expected consequences for traffic flow, traffic management and road design? To explore this subject, TrafficQuest has written a memo about the possible obstacles that an automated vehicle can encounter when driving on the motorway in the Netherlands [9]. This has produced a list of challenges for road authorities and the manufacturers of cars and lorries, and a set of research questions to which TrafficQuest would like to draw attention. Below are some of the findings.

In the study, the main focus was on motorway traffic, because it is there that automated vehicles are first expected to drive. Figure 15 shows what an automated vehicle can encounter on a motorway journey in the Netherlands. It is clear that an automated vehicle must have the capacity to deal with merging and diverging lanes, weaving sections, rush hour lanes, dedicated lanes, on-ramps and narrow lanes with speed restrictions. Apart from that, an automated vehicle will also regularly have to deal with roadworks, incidents and extreme weather conditions. And of course with other vehicles, which in the coming years will still largely be manually driven.

We then zoomed in on one specific situation: a busy weaving section on which the automated vehicle must change lanes. We assume that the vehicle has automation level 3, conditional automation, which means that it has the capacity to drive independently in a traffic lane with or without a vehicle in front, to independently switch lanes and to follow a pre-programmed route.

The analysis of a number of difficult weaving section situations – no suitable gap in which to merge, several vehicles moving towards the same merging gap, human driver 'too quick for' the automated vehicle, human driver makes an awkward or illegal manoeuvre, human driver manipulates the behaviour of the automated vehicle – a number of aspects came to the fore in which automated vehicles may come up short in regular traffic. This relates to the following:

- **Situation and behaviour recognition**
  To be able to anticipate, automatic vehicles must be able to recognise situations and behaviour. That is a problem, because up to now they have mainly learned to detect objects.

- **Capacity to anticipate**
  Autonomous automated vehicles do not look as far ahead as most drivers and are therefore not good at anticipating. They often drive reactively rather than proactively.

- **Flexibility in (safety) protocols**
  The interaction between regular vehicles is characterised by a certain degree of flexibility in driving behaviour. From a safety perspective, however, automated vehicles are conservatively oriented and do not have that flexibility or have it to a much lesser degree.

- **Taking other vehicles into account**
  Automated vehicles are by definition not social because they do not yet have the capacity to interact with other drivers or vehicles. They therefore probably lack a certain degree of courtesy – for example, giving another road user space to which he may not necessarily be entitled, but that he can use for late merging. It is also not easy to programme 'courtesy' into vehicles.

- **Equality with regular vehicles**
  Should an automated vehicle be treated in the same way as a regular vehicle and may it claim the same rights? A situation in which an automated vehicle demands right-of-way sketches how difficult this is, especially as far as the choice between desirability and safety is concerned.

These aspects do not yet signify an immediate problem with a level 3 automated vehicle if it is assumed that vehicles on this level return control to the driver quite often and quite quickly [10]. However, it is not yet known where this boundary lies, so it is good to identify all of these aspects – also because they will become more relevant for higher levels of automation. On the one hand, the above aspects are challenging the automotive industry to come up with smart solutions to tackle the problems. On the other hand, road authorities are facing challenges to make agreements about how automated vehicles should behave and which standards they must comply with so that they are automatically allowed to drive on their roads.

Another point is that nobody yet knows how the participation of automated vehicles in traffic will affect traffic flow. The above challenges mainly relate to traffic situations in which the traffic is in a critical situation: it is very busy on the road, but the traffic is still flowing and there is not yet any congestion. For that critical traffic situation, the specified challenges indicate that there are various activities that an automated vehicle initially probably cannot do as efficiently as an ordinary driver.

How does the conventional road user deal with this? And how does it affect traffic flow? This and other questions have been formulated into a number of research questions that are also included in the memo.

TrafficQuest will continue to work on this subject and will work together with other parties in the Netherlands that are also focusing on the subject. We are already exchanging knowledge with specialists in the area of automated driving in other countries. In addition, we still want to examine how impacts can be quantified. One possible solution involves micro-simulations, which then provide input for macroscopic models such as the National Model System.

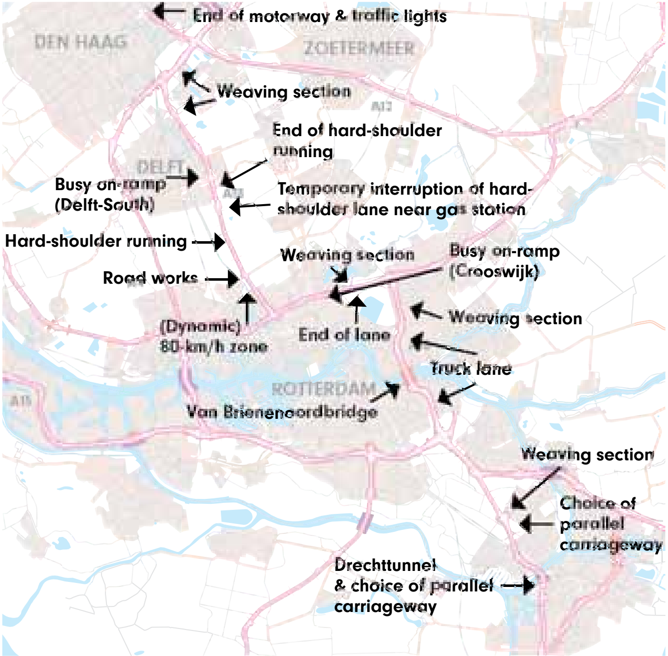


Figure 15:
Sample route Dordrecht-The Hague with a number of challenging road sections.

2.7. Evaluation framework for C-ITS and automated driving

In the Netherlands, a large number of trials are being held with C-ITS and automated driving. In order to learn from these experiences, a good evaluation is required [11]. But which evaluation framework must we use to do that? Numerous evaluation guidelines and methods are being used for traffic measures, but they often focus specifically on the evaluation of (existing) traffic management measures. Would that be sufficient for C-ITS and automated driving?

DITCM – an 'open innovation organisation' for cooperative technology (see www.ditcm.eu) – drew up an inventory of available evaluation methods and their suitability for the evaluation of C-ITS [12]. The conclusion is that none of the existing methods are sufficiently compatible with C-ITS. Amongst other things, that is because existing methods are based on measures that affect a large section of the traffic at once – and this does not happen with a service that is rolled out gradually. There is another problem that is in principle separate from C-ITS, but it is a flaw nonetheless: no single evaluation method covers the entire chain of evaluation steps. Of all the known methods, the so-called FESTA method[1] is still the most suitable for C-ITS.

[1] FESTA stands for Field Operational Test Support Action.
See also wiki.fot-net.eu/index.php/FESTA_handbook_Introduction.

Evaluation in-car track Practical Trial Amsterdam
There have already been positive experiences with the FESTA method – for example, in the in-car track of the Practical Trial Amsterdam. In this track, market parties provided road users with two types of traffic information services: for the day-to-day situation (regular traffic) and for events. This involved a large-scale practical trial that was aimed at achieving a visible effect and had two objectives: to provide reliable individual traffic information in order to influence behaviour and to improve cooperation between the market and the Government. The consortia were themselves responsible for setting up the information service, for recruiting the participants and keeping them on board, and for the evaluation.

The in-car trial for the Practical Trial Amsterdam involved 'C-ITS', where in this case the C stands for 'connected': on-trip route advice was given by means of smartphone apps (amongst other things). The FESTA method was prescribed for the evaluations of the in-car trial. The parties were also provided with a number of research questions and indicators that in any case had to be dealt with so that the results of the two trials with regular traffic and the two trials with event traffic could be compared. The FESTA method gave the evaluation a good structure and worked very well for this trial. When aspects specific to C-ITS – penetration rate, measuring with and inside the vehicle, scaling/adding up impacts – are examined, it is clear that this did indeed involves a typical C-ITS evaluation, with all the associated complexity. The penetration rate was high enough, for example, to evaluate whether the recommendations were being followed, but not high enough to be able to see the effects on the road (expressed in vehicle hours lost, to be measured with roadside systems). And it was indeed possible to measure what the users did (was the route driven the same as the recommended route?), but not what they originally intended and why they had or had not followed the recommendations. Surveys were held to ask people to explain those reasons. In addition, it was difficult to scale up the effects because no effects could be demonstrated on the road (even though small effects may have existed).

After the trials, the two consortia reported on all of their findings. On that basis, the client wrote an overall report to which the insights of the consortia have also been added. For the main results, see section 4.1.

What's next?

In DITCM, participants in the Round Table 'Effects' are examining ways in which C-ITS and automated driving can best be evaluated. Aspects such as human factors will play an important role, as will their integration into traffic models.

Specific aspects for the evaluation of C-ITS

- **Penetration rate:** With C-ITS, just a small part of the traffic is influenced by the C-ITS service or measure. After all, the current pilots are small-scale in terms of both the number of vehicles and the area in which the trial was held. This means that the penetration rate is low and has little or no effect on the total traffic flow.

- **Measuring with and in the vehicle:** It is difficult to determine how the measured vehicle behaviour comes about. Was the behaviour clearly based on the use of and compliance with the C-ITS function, or was it (also) based on other causes? In order to evaluate this properly, we need detailed and accurate measurements of the behaviour of drivers as well as vehicles that do not use the function. Then the problem is that these types of effects occur over a short period, under dynamic circumstances. The interaction with the surroundings is therefore decisive.

- **Evaluation structure:** It is difficult to keep the ex-ante and ex-post evaluation separate because C-ITS measures are usually introduced gradually. Moreover, the effects of different C-ITS functions may not simply be added together, because the functions may influence each other.

- **Scaling up:** It is difficult to translate the effects of a trial to a higher scale (more vehicles or a larger area). That could be possible using a model in which measured local effects are simulated on network level. However, those local effects largely depend on penetration rate, traffic conditions, compliance, etc. In addition, the current models are not really suitable for simulating these types of measures.

Specific aspects for the evaluation of automated driving

- **Behaviour:** A number of aspects of the ‘behaviour’ of automated vehicles are unknown or require further research, such as the way automated vehicles merge and weave in the traffic flow. But questions about route choice and the possible extra traffic due to empty runs also still need to be studied and answered.

- **Mixed traffic:** During the transition from manual to automated driving, there will be a changing mix of automated and other vehicles. In particular, the possible reactions of the other road users to automated vehicles are unknown and require further research.

References

[1] **H. Taale (2015)** *Description of overview with classification in functions.* [In Dutch.] TrafficQuest, 19 August 2015. Belongs with the overview 'Indeling_verkeerskun-dige_ functies_20151209.xlsx'.

[2] **Optimising Use Programme (2016a)** beterbenutten.nl/data-top-5, visited on 11 May 2016.

[3] **Optimising Use Programme (2016b)** www.beterbenutten.nl/assets/upload/files/ITS/FACTSHEET-PBB-DATA-NL.pdf, visited on 11 May 2016.

[4] **S.C. Calvert, A. Soekroella and M. Duijnisveld (2016)** *Elaboration requirements to traffic applications C-ITS.* [In Dutch.] Report TNO 2016 R10351, March 2016.

[5] **TNO (2015)** *Google and TNO research traffic statistics for traffic management.* [In Dutch.] Press release, 18 November 2015. www.tno.nl/nl/over-tno/nieuws/2015/11/google-en-tno-onderzoeken-verkeersstatistieken-voor-verkeersmanagement, visited on 4 July 2016.

[6] **E. Felici, I. Wilmink and D. Vonk Noordegraaf (2015)** *The NDW data fusion project: pilot description and results.* 22nd ITS World Congress, Bordeaux, France, October 2015.

[7] **H. van Lint and A. Verbraeck (2015)** *DiTTlab: (big) data meets simulation.* [In Dutch] NM Magazine, volume 10 (2015), no. 3, pp. 24-26.

[8] **B. Immers, I. Wilmink, H. Taale, R. van Katwijk, H. Schuurman, Y. Yuan and V. Knoop (2015)** *Study tour Austria – Switzerland May 31 – June 5, 2015. Report of the tour and main findings.* Report TrafficQuest, October 2015.

[9] **S.C. Calvert, I. Wilmink, A. Soekroella and H. Schuurman (2016)** *Knowledge gaps of automated driving in regular traffic.* [In Dutch.] Memo TrafficQuest, March 2016.

[10] **S. E. Shladover (2015)** *Road Vehicle Automation History, Opportunities and Challenges.* [In Dutch.] Presentation for Connekt/ITS Netherlands, Delft, 9 November 2015.

[11] **P. van Beek, S. van Lieshout and K. Malone (2016)** *The development of Connected ITS.* [In Dutch.] NM Magazine, volume 11 (2016), no. 2, pp. 8-13.

[12] **D. Vonk Noordegraaf, F. Faber and T. Blondiau (2016)** *Inventory of evaluation methods for C-ITS.* Memo for TrafficQuest and DITCM, January 2016.


Sorbo.nl
3-KSJ-74


3
Houten (A27)
RING A12

New developments in research.

Thorough scientific research is a precondition for progress. It often appears to be about minor details, but one little bit of extra insight brings us to another – and that is how the field of traffic and transport keeps improving itself. In this chapter, we make a selection from the (doctoral) research studies of the past year and examine the papers presented during scientific conferences and other meetings.

3.1. Relevant PhD research

In our previous annual reviews, we dealt with the PhD studies of Gerdien Klunder and Simeon Calvert. Both research projects were partly financed by TrafficQuest. Below, we briefly look at the latest results of Klunder and Calvert. We also discuss other relevant PhD studies that were recently completed.

Relationship between data quality and traffic management

In her research, Gerdien Klunder examines the relationship between the quality of the data that we use for traffic management measures and the ultimate effect of those measures. Over the past few months, she has concentrated on the use of floating car data (FCD) for the generation of route choice recommendations during the trip. How do those 'FCD-fuelled' recommendations affect traffic flow in a network?

Route advice

FCD is used in this application to gain a more accurate picture of the current situation in the network in order to generate more up-to-date (and therefore better) route advice. One condition for this is that the penetration level to FCD must be sufficiently high. In her research into FCD, Klunder used an easy but effective network model and speed data that has been measured in reality.

Road users normally select their route on the basis of experienced travel times. Based on experience, they know where there are delays on their route every day and what is the fastest route for them under normal cir-

cumstances. What they do not know, however, is which route is the best if unexpected conditions occur. Would road users then benefit from up-to-date route information? Klunder set up the network model so that some of the road users followed recommendations based on real-time journey times and speeds. Traffic flow with real-time route recommendations is then compared in models with traffic flow where the road users only know about 'historical' journey times.
The penetration rate was varied (how many people receive the recommendation based on FCD?), as was the time of day and also the amount of available FCD (a measure of the quality). It was found that with a penetration level of 10% a minor effect of 1% less delay can be achieved. That appears to be minimal, but on an annual basis and converted to the value of time for the region of Amsterdam alone this means a saving of around € 20 million. If 90% of the vehicles are equipped with this type of advice/recommendation, the savings add up to 5%-8%.

OD matrix

Another application in which FCD could play a major role is in estimating of an origin-destination matrix, or an OD matrix for short. This matrix contains the amount of traffic that wants to travel from one area to another – and this is essential input for several types of traffic and transport models. However, estimating the OD matrix is a difficult and time-consuming task. In many cases, a transport model is used to generate a matrix, which must then be calibrated using counts.

In principle, FCD could be the solution: the routes of individual road users can be followed so that it can be determined where the travellers are coming from and where they are going. The problem with FCD, however, is that the penetration rate is usually low and unknown. Therefore, the extent to which the available FCD is representative of the entire population of road users is not clear.

Klunder examines how the quality of FCD data affects the quality of the estimated OD matrix. Definitive results are not available yet, but the provisional results of the study show that the use of FCD in estimating OD matrices has great potential. Even without calibration with the detector data, the matrices estimated in this way display good consistency with the original (fictitious) matrix.

Modelling variations in traffic

Simeon Calvert studied the influence of variations in traffic and how they can be modelled for traffic management. He has completed his study and on 26 May 2016 he successfully defended his thesis Stochastic Macroscopic Analysis and Modelling for Traffic Management at Delft University of Technology.

Analysis

The first part of his research involved a thorough analysis of the stochastic characteristics of variables that influence traffic flows. Calvert developed two methodological frameworks to derive the stochasticity of road capacity and traffic demand from data. It turned out that the best way to do this was to consider demand and capacity not separately but together: in that way, the total effect of variation on traffic systems was easier to understand.

Modelling

Based on the analysis of the variations in traffic, it was possible to start modelling it – which is the second part of the study. The study made a distinction between variation due to uncertainties in a traffic system and variation due to fluctuations in traffic flows. This is because the two types turned out to be inherently different, even though the source of the stochasticity can be the same. For that reason, Calvert also developed different modelling approaches.

As far as the modelling of uncertainty is concerned, two model types were examined. The so-called *Advanced Monte Carlo* simulation models repeatedly extract input variables from probability distributions and use those variables to perform a simulation. By using algorithms that more effectively distribute the drawings, a representative distribution is possible with a relatively small sample size. The other model type was developed specially for the study: the *Core Probability Framework*. This is an analytical framework with which uncertainty can be modelled using one model run ('one-shot'). Experiments performed on simple networks have shown that the calculation times are significantly reduced with this model. For larger networks and a greater degree of stochasticity, the savings in calculation time were found to be even larger.

The *First Order Model with Stochastic Advection* was developed to model fluctuations in traffic. This model has a high level of accuracy and can also include driving behaviour in the macroscopic modelling.

Besides the above models, Calvert also developed a method for identifying vulnerable road sections where throughput is expected to benefit most from traffic management or other measures. This *Link Performance Indicator for Resilience* resembles the sensitivity of road sections to withstand congestion and to recover after a ‘congestion event’.

Visualisation

The final part of the study involved the visualisation of uncertainties. It is important to communicate model results: it is only when that is done properly that the results of model studies will actually be used effectively. Calvert analysed various graphical representations of uncertainty in traffic. To do this, he used what is called a cognitive task switching experiment to test the display of results from a macroscopic traffic model for clarity of information transfer.

Conclusion

In a test case, Calvert demonstrated the importance of monitoring stochasticity, both for the aspect of uncertainty and for fluctuations between vehicles. The frameworks and methods that he developed make it possible to evaluate the effects of traffic management or other traffic measures in advance with a high degree of accuracy. In this way, traffic management measures can be deployed more effectively, which in turn leads to better utilisation of the road network, less congestion and less delay. The final conclusion of Calvert’s research is therefore that uncertainties and traffic fluctuations should always be included when planning new traffic management measures.

Other relevant PhD research

Diana Vonk Noordegraaf

Road Pricing Policy Implementation

On 8 June 2016, Diana Vonk Noordegraaf obtained her PhD at Delft University of Technology. Her research focused on the implementation of various types of pricing strategies. Earlier research studies had mainly focused on the economic effects of pricing policy. But in her thesis, Vonk Noordegraaf analysed the factors that influence the implementation process. To do this, she drew up a list of the factors that played a role in the (now abandoned) implementation of the kilometre-based charge in the Netherlands and the implementation factors in a number of other countries. She also studied the role of employers in Rush Hour Avoidance projects. After all, those projects also worked with a pricing strategy (in this case a reward). A final part of her research involved the frameworks for the implementation of transport policy: how suitable are they for the analysis of road pricing implementations?

Her main conclusion is that the implementation of pricing strategies must always be custom-designed. That is due on the one hand to the low usability of the existing frameworks in assessing policy and on the other hand to the large number of factors (including political factors) that play a role in pricing strategies.

Bernat Goñi-Ros

Traffic Flow at Sags: Theory, Modeling and Control

On 21 March 2016, Bernat Goñi-Ros defended his thesis on traffic flow at so-called sags at Delft University of Technology. A sag is the part of the motorway in which the slope changes from downward to upward, or rather: the part past the deepest point of a valley. The capacity of sags is substantially lower – up to 30% – than the capacity of road sections without a slope – in any case as far as motorways are concerned. In some countries, sags are therefore typical bottlenecks. In Japan, approximately 60% of traffic jams on motorways occur in the vicinity of sags. Goñi-Ros studied the traffic flow and the existence of traffic jams in relation to these bottlenecks. He also developed a simulation model to describe the traffic flow and used this model to examine which traffic management measures are most effective against sags. His conclusion: speeding up traffic at the right place and in the right way can substantially reduce the number of traffic jams.

Jaap Vreeswijk

The Dynamics of User Perception, Decision Making and Route Choice

In February 2015, Jaap Vreeswijk published and defended his thesis The Dynamics of User Perception, Decision Making and Route Choice at the University of Twente. Vreeswijk studied an important aspect of traffic, namely the perception of time. He focused on the empirical measurement of the perception of time in traffic and on the factors that influence that perception (amongst other things, routes and traffic lights). He includes an extensive overview of the similarities and differences in the findings of the empirical research, the relationship to decision-making behaviour and the day-to-day dynamic, and the consequences for traffic and transport policy and traffic management.

One important conclusion of his research is that the perception of time often deviates from the measured time: on average, the perception is reasonably accurate but is very variable among motorists. Furthermore, perception plays an important role in day-to-day decision-making behaviour, and this is an important observation for the decision-making models in the traffic and transport models.

3.2. Interesting literature

Year after year, a wide range of scientific conferences and meetings produce a rich harvest of interesting papers. In this section, we describe a number of papers from the past year that are relevant for traffic management and the development of the field.

IEEE-ITSC 2015

The IEEE Conference on Intelligent Transportation Systems, abbreviated to ITSC, is an annually recurring event held by the IEEE Intelligent Transportation Systems Society. In 2015, the ITSC was held in Las Palmas de Gran Canaria.

Every year, the IEEE awarded prizes for the best papers and dissertations. This year, for the field of road traffic, the prize was awarded to the thesis *Traffic Modelling, Estimation and Control for Large-Scale Congested Urban Networks* written by Mohsen Ramezani Ghalenoei of École Polytechnique Fédérale de Lausanne. His study subjects were traffic state estimation methods based on probe vehicle data, and a hierarchical control strategy for large urban networks. Amongst other things, that involved perimeter control and cooperative (or coordinated) regulations. Meng Wang of Delft University of Technology was awarded the second prize for his thesis *Generic Model Predictive Control Framework for Advanced Driver Assistance Systems*.

The first prize for the best paper went to Toru Seo, Takahiko Kusakabe and Yasuo Asakura of the Tokyo Institute of Technology for their paper *Traffic State Estimation with the Advanced Probe Vehicles using Data Assimilation*.

See also www.itsc2015.org.

TRB 2016

The 95th edition of the Annual Meeting of the Transportation Research Board, TRB, was held as usual in Washington DC from 10 to 14 January 2016. TrafficQuest was at the meeting and mainly attended the sessions about automated driving, managed lanes and active traffic management, the terms used in the US for traffic management as we know it on our roads.

At the sessions dealing with automated driving, participants spoke at length about developments on the vehicle level and ongoing field trials. The focus was also on human factors. However, there were (as yet) no presentations about the impact of automated driving on traffic flow and traffic management. But there were plenty of opportunities to discuss the subject with colleagues from all over the world.
As far as managed lanes are concerned, it was striking that pricing measures are being deployed on many of those lanes. In the US, pricing is now commonplace.
Of the prizes awarded during the TRB, the Green Shield Prize on the

theme of traffic flow was probably the most interesting. This year's prize was awarded to the paper submitted by TNO and Delft University of Technology titled *Real-Time Travel Time Prediction Framework for Departure Time and Route Advice* by Simeon Calvert, Maaike Snelder, Taoufik Bakri, Bjorn Heijligers and Victor Knoop.

See also amonline.trb.org.

CVS 2015

The 41st Transport Planning Research Colloquium (Colloquium Vervoersplanologisch Speurwerk) was held in Antwerp on 19 and 20 November 2015. The theme was 'Colouring outside the lines'. This year, two papers were awarded first prize. One first prize went to the paper *Value of experience colours the quality of public transport hubs* by Laura Groenendijk. The other first prize was awarded to *Don't turn the cycle path into a motorway*! A plea for an opportunistic approach to long-distance routes for cyclists by Stephan Valenta and Martijn Sargentini. Both papers are in Dutch.

See also www.cvs-congres.nl.

NVC 2015

The National Traffic Engineering Congress (Nationaal Verkeerskunde Congres) is an annual congress where researchers and practitioners meet to discuss the latest developments with each other. In 2015, the NVC was held in Zwolle in the Netherlands. TrafficQuest gave two presentations: one about urban traffic management and the other about the impacts of automated driving.

The prize for the best paper went to a contribution from Alex van Loon, René Walhout and Benjamin van der Velden: *Traffic considerations when unbundling on motorways and helping road users find their way*.

See also www.nationaalverkeerskundecongres.nl.

Photograph: Daimler

4

Pilots smart mobility and traffic management.

Nothing is as unruly as reality. Therefore, pilots are an indispensable instrument for estimating the value of new insights, ideas and services. In the Netherlands, a number of pilots for smart mobility and traffic management are currently active. In addition, a number of interesting demonstrations and challenges were held on the public roads. In this chapter, we discuss the main pilots, grouped according to the sub-topics.[1]

[1] Other sources of information about ongoing and completed pilots include the ITS Overview on the Connecting Mobility website and the WiKi of FOT-Net, on itsoverzicht.connectingmobility.nl and wiki.fot-net.eu, respectively.

4.1. Coordinated network-wide traffic management

Practical Trial Amsterdam

In the Practical Trial Amsterdam the Amsterdam City Council, the City Region of Amsterdam, the Provincial Government of North Holland and Rijkswaterstaat are working together with the industry and universities to develop, test and evaluate innovative technologies for coordinated network-wide traffic management. The aim is to utilise the combined road network more effectively by integrating roadside measures and in-car services and deploying them in a coordinated way. One important secondary objective involves creating a practical basis for the use of coordinated network-wide traffic management in other urban areas, inside and outside the Netherlands, based on the experiences in the Practical Trial.

The Practical Trial Amsterdam consists of three phases:

Phase 1: The coordinated use of roadside systems (traffic signal control systems and ramp metering systems) along the A10 West, and the supply of smart, personalised in-car advice for regular circumstances and events. During this phase, roadside and in-car are still separate tracks. This part of the trial has since been completed.

Phase 2: The partial integration of the 'roadside track' and the 'in-car track'. When using roadside measures, information from the in-car track will now also be included. On the other hand, roadside measures will be shared with the in-car systems so that the advice can be more effectively harmonised with those measures (closures, speed restrictions, etc.). In this phase, the area of operation is larger: other areas in the region of Amsterdam are also being introduced to coordinated network-wide traffic management.

Phase 3: The actual merging/integration of traffic management systems along the road and the systems inside the vehicle.

We wrote extensively about the Phase 1 roadside track in previous editions of 'Traffic in the Netherlands'. In this issue, we focus on the in-car trials during Phase 1 and Phase 2.

Practical Trial Amsterdam

Phase 1: In-car

The trials with in-car systems started in 2015. The two consortia *Amsterdam Onderweg* and *Amsterdam Mobiel* each developed two smartphone apps: one for 'regular traffic' (routine daily trips) and one for 'event traffic'. Using these apps, the participants received information and recommendations about the optimal route and parking options. Amsterdam Onderweg's apps are called Superroute and Superticket, while the apps developed by Amsterdam Mobiel are called ADAM and EVA.

The trial in Phase 1 has already been completed: the consortia have analysed all the data about the participants and the traffic on the road and drawn up an evaluation. On this basis, the client has written its own summarising report. [1]

Below, we briefly summarise the main and most eye-catching points in the evaluation:

- Around 1 in 12 participants adjusted their departure time on the basis of a pre-trip recommendation. Half of the participants also followed the recommendations during the trip (on-trip).

- With the in-car approach to events, a positive traffic effect could be demonstrated. The traffic was more effectively distributed over the approach routes and parking locations.

- The in-car service aimed at the regular situation was not used as often. Before the trip and when there was heavy congestion, the app was consulted frequently, but the users didn't express much need for information and support during the trip: just 1 in 5 participants used the app on-trip. Amsterdam Mobiel asked the participants of focus groups to explain this. It turned out that many participants do not consider on-trip information about regular trips to be very important: 'I know the route well enough, there are no alternatives anyway', and so on. Every effort to use the service (switch on app, place smartphone in the cradle) then feels like it is too much. That was unfortunate, because the focus of the trial was on on-trip recommendations – and theoretically there is a lot to be gained from that. Moreover, the participants that did use the app during the trip were satisfied with it. The conclusion is that user convenience must be increased in order to tempt more users to use the app on-trip.

- Both consortia found it difficult to determine the effect of the app on the journey times. For all kinds of reasons, the logged data was often difficult to interpret. This was due to both technical causes (missing/bad GPS data) and 'human' causes: for example, participants did not indicate that they had ended their trip in the app when they arrived at their destination, or they entered a generic destination such as 'city centre' instead of a specific address.

- The degree of compliance and the appreciation that Amsterdam Mobiel reported were somewhat higher than reported by Amsterdam Onderweg. However, the latter consortium did evaluate more trips and also had more survey data.

Practical Trial Amsterdam

Phase 2: Southeast

The object of the Practical Trial Amsterdam Southeast is to test whether the in-car approach of Phase 1 can be reinforced by combining it with (information about) roadside measures, particularly during events. In addition to the above, this part of the pilot also studied whether public-private cooperation is possible in the context of network-wide traffic management. Cooperation and harmonisation between government organisations and market parties could lead to traffic management that is more cost-effective for the road authorities, to better traffic conditions, and to better services for the road user. This relates to functional aspects (such as harmonisation of public and private services), technical aspects (integration of roadside and in-car, data fusion) and organisational aspects (strategy, roles and responsibilities).

The process of the Amsterdam-Southeast trial is unusual in the sense that the market parties themselves are bearing the costs for the implementation of the proposed plans. What also makes the Practical Trial Amsterdam-Southeast unique is the intention to jointly research whether there are options for private traffic management services, where service providers can use the Government's systems and implement traffic management before, during and after events. Meanwhile, the steering group of Practical Trial Amsterdam has decided to tackle this with two consortia of collaborating market parties. The first trial was performed during the first half of 2016. The second trial has started and the project parties have also started the preparations for Phase 3.

See also:
www.praktijkproefamsterdam.nl
www.amsterdamonderweg.nl
www.amsterdammobiel.nl

4.2. C-ITS and automated driving

Phantom traffic jams A58

In the Phantom Traffic Jams A58 project, around thirty public and private parties are working on the development and roll-out of cooperative technology. The A58 between Tilburg and Eindhoven is the ‘trial area’: the project first worked only with cellular communication using 3G/4G, but there are now also 34 roadside beacons for fast (Wi-Fi-P) communication with cooperative vehicles. In order to demonstrate the practical added value of the technology and infrastructure, a first cooperative service was immediately set up: the phantom traffic jam service. In this trial, participants receive in-car speed advice through the FlowPatrol and ZOOF apps as soon as they approach a shock wave (‘phantom traffic jams’). The idea is that if enough vehicles adapt their speed on time, the shock waves will be resolved.

Besides giving careful thought to the traffic concept (‘How do you solve a phantom traffic jam?’), the project parties also paid a great deal of attention to the aspect of security. For example, a PKI solution was elaborated and tested: this was a ‘certificate system’ to safeguard the integrity and authenticity of messages. In this way, the project parties have created a strong basis for future ‘security-sensitive’ applications.

For peers, a knowledge database was set up on the website. The database provides access to documents about the concept, the technical specifications and the legal integration. It also includes short videos that explain how the service works.

Automatically complying with recommended speeds

On the Phantom Traffic Jams A58 route, a demonstration was held in late May 2016 with self-driving cars that automatically complied with the speed advice given by the phantom traffic jam service. During the test, three cars drove in a platoon. The car in front was given a phantom traffic jam advice and automatically adapted its speed. The other cars then followed suit. In addition, the vehicles were given speed advice that they automatically complied with when they depart from the traffic jam.
In this demonstration, therefore, the self-driving vehicles interacted not only with each other but also with the roadside, based on roadside data about the traffic situation. That way, the vehicles could anticipate what was happening downstream (even though they could not yet observe it with their own sensors) and optimally react to it.

See also:
www.spookfiles.nl

Grand Cooperative Driving Challenge

Photographs GCDC

The second Grand Cooperative Driving Challenge – GCDC for short – was held in May 2016. The challenge involved innovative and competitive demonstrations with cooperative and automated driving on the A270 between Helmond and Eindhoven. GCDC 2016 was part of the i-GAME research programme supported by the EU, in which TNO, Eindhoven University of Technology, the Spanish IDIADA and the Swedish Viktoria are collaborating with each other.

After preparing at home, ten teams from all over Europe took their own automated vehicles to the Automotive Campus in Helmond to test their solutions. The GCDC was designed as a competition. Three assignments had to be completed on the public road: Merging vehicles or joining a line of vehicles, known as platoons, Automated crossing and exiting a junction, and Automated space-making for emergency vehicles in a traffic jam. The teams were assessed on the basis of teamwork, mutual communication and, of course, their performances (Was the merging successful? How smoothly did it go? etc.).

The Swedish team from Halmstad University won first prize, the German team KIT AnnieWay came second and the Swedish KTH (truck team) came third.

Read more:
www.gcdc.net/nl/event

Cooperative ITS Corridor

Over the past few years, the technology for cooperative services has been developed and built in separate research and development projects in a number of countries. With the Cooperative ITS Corridor project, the Netherlands, Germany and Austria are taking the first step towards working together internationally on the realisation of cooperative services. To start with, this involves two services on the Rotterdam-Frankfurt-Vienna route: Road Works Warning and Probe Vehicle Data.

With the Road Works Warning service, motorists receive detailed information about roadworks over a secure Wi-Fi connection. With the Probe Vehicle Data service, cars equipped with new in-car equipment pass on depersonalised information about current conditions on the road to traffic control centres. Rijkswaterstaat is representing the Netherlands in the project. In 2015, together with the market the project team developed the specifications for the two services. The participating market parties are also supplying the roadside equipment and the devices that can receive, send and process the signals.
The technology has since been tested in practice in a number of smaller demonstrations. In 2016, a number of large-scale tests will be performed on four different sections in the Dutch corridor. With these so-called pre-deployments, the project team, again in cooperation with interested market parties, will complete the current set of specifications for the services. In every individual pre-deployment, a particular characteristic of the intended system is tested. For example, attention will be paid to the further development of the requisite information supply in the chain.

Preparations for the tender procedure for the services in the Dutch part of the corridor are expected to start sometime in 2017.

Needless to say, Rijkswaterstaat and its German and Austrian counterparts are focusing not just on their own corridors: the countries are constantly harmonising and cross-border tests will also be organised.

4.3. Freight traffic and ITS

European Truck Platooning Challenge

In early April 2016, six convoys of semi-automated trucks drove from a number of European cities to Rotterdam, to the APM terminals on the Second Maasvlakte. The Netherlands had a world first with the European Truck Platooning Challenge, organised by Rijkswaterstaat. The challenge was unique because up to that point testing with platoons of semi-automated and highly-automated trucks had only been permitted inside national borders and because truck manufacturers, which are in competition with each other, had never before jointly taken part in a single initiative. As a neutral player in this market, Rijkswaterstaat was able to persuade the parties to commit themselves to the initiative. All the European truck manufacturers took part: DAF, Daimler, IVECO, MAN, Scania and Volvo. In addition, the Governments of Sweden, Denmark, Germany and Belgium were also involved. The initiative was staged in the framework of the Netherlands' EU presidency in the first half of 2016.

Photograph: Dutch Ministry of Infrastructure and Environment

During the Informal Transport Council meeting of 14 April 2016, which was attended by all the Ministers of Transport of the European Member States, the Declaration of Amsterdam [2] was signed. In this declaration, the Ministers pledge to invest in smart mobility and cross-border cooperation in the field of research and testing. The European Truck Platooning Challenge was an excellent test of that pledge.

Truck platooning is seen as a type of automated driving that can be implemented in a relatively short time. It involves trucks driving in a platoon, where the trucks pass on signals to each other about factors such as the speed and steering movements. In the European Truck Platooning Challenge, the minimum time headway between the trucks was 0.5 seconds. The truck platoons drove in normal traffic and no extra traffic measures were taken.

The Challenge was more than a technological challenge – it was a signal to start working on harmonisation and standardisation. In order to take part, the truck manufacturers had to apply for an exemption in each country – and this just showed how differently the vehicle authorities and the road authorities in the countries in question assess the safety of truck platooning on the public roads. It also became clear that all of the truck manufacturers technically resolve the safety issues related to the shorter time headway in different ways.

Truck parking

It is not always easy for truck drivers to find a suitable parking space. The service stations along and in the vicinity of motorways are often full and the drivers do not have much time to look for another parking space. And if a traffic jam unexpectedly materialises somewhere, it becomes very difficult for drivers to take their (obligatory) rest on time.

Recent research has shown that the Netherlands as a whole does have enough parking spaces for trucks. Rijkswaterstaat alone maintains 280 service stations throughout the country. In addition, there are many dozens of private truck parks, often with extensive amenities, that are (reasonably) close to the road.

To make these truck parks easier to find, the data – location, number of parking spaces, amenities – is now available centrally through the National Data Warehouse for Traffic Information data, NDW. App developers can easily include the NDW information in their apps. Examples of efficient apps include Truck Parking Europe and Parckr.

Read more:
nt.ndw.nu
www.truckparkingeurope.com
www.parckr.com

Reducing tyre failures for trucks

Tyre failures in freight traffic is a problem that affects the entire transport chain: the shipper, the transporter, the receiving party and the road authority. Even the tyre sector itself is not served by these problems: they often have to go out on the road at all hours of the day and night to change tyres in dangerous conditions.

Research from 2008 illustrates the scale of the problem [3]. According to the researchers, the road inspectors of the main road network had to go out 904 times in one year to repair tyre failures suffered by trucks. (They estimate that the actual number of tyre failures is higher, because many drivers keep driving until they reach a parking area.) In 68 of the 904 registered cases, this led to traffic jams. Fourteen of those traffic jams were longer than 6 kilometres. What is even worse is that blowouts cause 2-4 very serious accidents with traffic fatalities every year [4]. Good monitoring and keeping tyres properly inflated – low tyre pressure is often the reason behind tyre failures – are therefore very important and require constant attention.
In 2012, Rijkswaterstaat held a competition for the freight transport sector. From the fourteen entries, the jury selected eight solutions that were eligible for an incentive: systems that make it easy to test the tyre pressure, tyres that repair themselves, a solution that uses the truck's hydraulic system to keep the tyres under pressure, etc. Some of these solutions were later implemented successfully.

Due to the financial crisis, it took quite a long time for the transport sector to really start investing in systems to reduce tyre failures, but more and more transport companies are now becoming interested. Besides reducing the chance of tyre failures (and related accidents), good tyre pressure also helps transporters to reduce fuel consumption by 2%. It also ensures that tyres last longer.

Examples of transporters that have implemented safety measures include CargoBoss in Maasdijk, Bolk Transport in Almelo, APM Terminal Maasvlakte, Limkes Geleen, Vink of Barneveld (uses the Ventech system), Van der Lee in Delft (uses Tirco), DVS Roads (Ultra-seal) and De Rooy in Eindhoven (Pe-eye).

4.4. Data and data fusion

Earlier in this issue, we wrote about the importance of good data and of combining data sources to create more effective information. In section 2.2, we discussed alternative data sources for traffic management and the efforts being made to use them. The doctoral research of Gerdien Klunder (see section 3.1) also discusses data, but then in relation to the quality of traffic management. In addition to this, a number of pilots with data are taking place in the Netherlands.

FCD and AID

The traffic management system on the motorways provides queue tail warnings, also called Automatic Incident Detection (AID). This function uses data from loop detectors – with a loop every 500 metres on each traffic lane – to determine vehicle speeds and, on that basis, the location of traffic jams. In that way, vehicles can be warned in good time about congestion further downstream. Because loop detectors are relatively expensive instruments, Rijkswaterstaat commissioned Be-Mobile to study whether it is possible to supply the AID function with floating car data, FCD. This method uses the data of users of the well-known Flitsmeister app, which is used by an average of 6% to 8% of the passing vehicles.

In the first part of the study, the FCD was combined with the minute data of loop detectors (1 minute aggregation) to create an impression of the traffic flow. The conclusion was that the real-time fusion of data from the Rijkswaterstaat systems with other data sources can lead to new applications, but that the link with the minute data is less suitable for the AID function. That is why the second part of the study used FCD based on seconds rather than minutes.

The 1 Hertz FCD was used to generate an AID status for the A27, which was then compared with the AID status that had occurred in reality. Both AID systems generated the same result in up to 64% of cases. In the other cases, the AID status based on FCD seems to be more pro-active.

Needless to say, the penetration rate is a factor of importance. The effect of variations in penetration rate will be examined in a follow-up study.

FCD and OD matrix

In a number of projects, the NDW is studying the added value of FCD for traffic management applications. One of those applications involves determining origin-destination matrices (OD matrices). These are important for traffic research and are required as input for almost all traffic models. The NDW is therefore working on a proposal for a pilot. That proposal will focus on aspects such as time dependency, mode of transport and degree of detail (network versus intersection). The pilot is expected to be launched this year.

References

[1] **Practical Trial Amsterdam (2016)**
Overall final report In Car.
16 February 2016.

[2] **Declaration of Amsterdam on cooperation in the field of connected and automated driving (2016)**
Signed on 14 April 2016 in Amsterdam by the EU transport ministers during an informal meeting of the Transport Council.

[3] **J. van Hattem, G. Visser and J. Fafié (2008)**
Inventory of truck tyres, Rijkswaterstaat Transport and Navigation Department.
[In Dutch.] Delft, 3 June 2008.

[4] **[4] Dutch Safety Board (2012)**
Truck accidents on motorways.
[In Dutch.] November 2012.

5

Programmes and partnerships.

Whether our traffic will really get smarter in the coming years will depend on more than just one or two parties. Road authorities, knowledge institutes, consultancy firms, service providers, hardware suppliers, car manufacturers and many more parties all have a role to play in the traffic domain. A great deal of cooperation and consultation is required to arrive at innovations that actually 'take off'. Where does that take place? In this final chapter, we take a tour along a number of relevant round tables, programmes and partnerships.

Round tables

Connecting Mobility, DITCM, the Optimising Use programme, AutomotiveNL and Connekt have set up a number of Round Tables to facilitate the substantive discussions about (C-) ITS and automated driving. There are now five of those round tables: Architecture & Interoperability, Effects, Human Behaviour, Legal aspects and Security.

The Round Tables participants are representatives of market parties, government organisations and knowledge institutes. They exchange knowledge and jointly devise solutions to the challenges related to (C-) ITS and automated driving. The Round Tables also sometimes provide support in specific projects.

TrafficQuest is taking part in two round tables that are focusing on Human Behaviour and Effects (of C-ITS and automated driving). For example, TrafficQuest has contributed to a presentation about the evaluation of C-ITS and automated driving and to a memorandum about driving task indicators for C-ITS.

Read more:
www.ditcm.eu/its-round-tables

CHARM

CHARM is an English-Dutch-Flemish joint venture between Highways England, Rijkswaterstaat and the Flemish Department for Mobility and Public Works.

In the framework of CHARM, Rijkswaterstaat and Highways England started implementing the DYNAC software in 2016. This is a commercial off-the-shelf traffic management system for traffic management centres (TMC). Both road authorities hope that their TMC operators can work more efficiently and uniformly with this system, at lower operating costs. The new software makes the traffic management centres future-proof and capable of incorporating new functions for road traffic management. By mid-2019, DYNAC will have replaced the many individual applications in all of the road traffic management centres of Rijkswaterstaat and Highways England. In the autumn of 2017, Helmond will be the first Dutch centre to switch to the system.

CHARM PCP is another CHARM project, where PCP stands for Pre-Commercial Procurement. In CHARM PCP, Rijkswaterstaat, Highways England, Mobility and Public Works, the Netherlands Enterprise Agency and Innovate UK are working on innovative modules for DYNAC. Three ‘challenges’ have been initiated in which eight companies and consortia are taking part. In the spring of 2016, they presented prototypes of their modules *Advanced Distributed Network Management*, *Detection and Prediction of Incidents* and *Support of Cooperative ITS Functions*. In September 2016, six of the eight participants will progress to Phase 3 of this project, which involves testing the prototypes on DYNAC.

Optimising Use programme

In the Optimising Use programme, the Government, the regional authorities and industry have been working together for a number of years on improving accessibility by road, water and rail in twelve regions. The programme delivered an initial package of more than 350 measures in the period 2011-2014.

The regional measures consisted of 149 supply measures, including expansion of the capacity of roads, bicycle paths and (bicycle) parking spaces. There were also 122 demand measures that made the traveller or transporter aware of their possible options in terms of the departure time, route or means of transport. And then there were 83 measures in the area of dynamic traffic management and intelligent transport systems, such as the optimisation of traffic signal control settings and network-wide traffic management.
In addition, cross-regional measures were implemented, including supporting and facilitating the growing demand for public transport by rail, ITS measures aimed at improving traffic data, and Lean & Green, a programme for sustainable (personal) mobility for companies and government organisations.

A ‘results book’ has been compiled about this initial package.
A selection from the results:

- The measures have led to 19% less delay during rush hours on specific routes in the Optimising Use regions (compared to situation without the programme).
- Thanks to Optimising Use, the regions have realised approximately 48,000 cases of rush hour avoidance per average workday.
- On an annual basis, the measures are leading to reductions of 70,000 tons of CO_2, 150 tons of nitrogen (NO_x) and 15 tons of particulate matter (PM_{10}).
- The Lean & Green approach reduced CO_2 emissions by 45,000 tons.

This year and in the coming years, the emphasis in the Optimising Use programme will be on smart mobility. In the Talking Traffic project, for example, market parties (the traffic industry and telecom, automotive and internet companies) and road authorities are working together on the large-scale deployment of new mobility services that inform the user not only before, but also during a trip. This concerns the following services:

- In-vehicle signage and recommended speeds.
- Personal supply of real-time information about potentially dangerous situations and roadworks further along the route.
- Prioritisation of groups of traffic participants in traffic signal control systems (TSCSs).

- Provision of up-to-date information from TSCSs to the road user (such as ‘time to green’).
- The optimisation of traffic flows using TSCSs.
- Bringing parking information in-car.

To make these services possible, data about roadworks, location references, maximum speeds, remaining duration indication incidents, measures in traffic management scenarios, parking, events and TSCSs must be available. This is the so-called Data Top 8 (called the Data top 5 at an earlier stage). In the summer of 2016, the industry worked on proposals to process this data in an appropriate way and offer services in the vehicle. They also worked on an approach for monitoring and evaluation. The first services are planned to be available for road users later this year, and the other services will be rolled out, tested and evaluated in the period after that.

Read more:
www.beterbenutten.nl

Conference of European Directors of Roads

CEDR is the Conference of European Directors of Roads.
The approach of this platform that was set up in 2003 is to encourage collaboration between the national road authorities in Europe. To achieve this, CEDR has initiated a number of different research projects, financed by the national road authorities of Belgium (Flanders), Germany, Finland, Ireland, the Netherlands, Norway, Austria, the United Kingdom and Sweden.

The subjects of the seventh ‘transnationally funded research programme’ in the call of 2014 were Asset Management and Maintenance and Mobility and ITS. The latter includes the sub-topics Mobility as a Service, The Journey to High and Full Automation and The Business Case for Connected and Co-operative Vehicles.

Interesting projects that stem from this call and are now up and running – with Dutch partners in the first two consortia – include:

- **ANACONDA**, which stands for Assessment of user Needs for Adapting Cobra including Online Database. This is a follow-up to the COBRA project. The aim is to help national road authorities to determine which cooperative services have the largest impact so that road authorities can work more cost-effectively. To achieve this, the COBRA tool for cost-benefit analyses of investments in cooperative systems is being developed further.

- **DRAGON**, which stands for Driving Automated Vehicle Growth on National Roads. This project is focusing on the potential effects of automated driving on the roads of the European national road authorities. It is also studying what road authorities can do to maximise the expected positive effects.

- **MAASiFiE**, which stands for Mobility As A Service For Linking Europe. The project is focusing on 'business and operator' models for Mobility as a Service (MaaS). The participating parties are also working on a European roadmap that focuses on the roles and responsibilities of the different stakeholders (road authorities in particular).

Later in 2016, the results of projects in the call of 2013 will also be available. This involves the following projects:

- **PRIMA**, which stands for Pro-Active Incident Management. This project worked on improving state-of-the-art incident management applications. The idea of proactive incident management is being elaborated in detail and now includes the following essential elements: anticipate, prepare, respond and monitor.

- **UNIETD**, which stands for Understanding New and Improving Existing Traffic Data. The goal was to provide drivers and road authorities with better information and in that way improve road traffic efficiency.

- **METHOD**, which stands for Management of European Traffic using Human-Oriented Designs. In this project, a human factors perspective on traffic management was developed. The approach is that road authorities can use this perspective to get more out of existing and new measures (better throughput and improved safety).

Read more:
www.cedr.eu

C-ITS Platform

C-ITS stands for cooperative intelligent transport systems. The technology has steadily evolved, but how do you ensure that C-ITS can also be introduced smoothly on a large scale? The *Platform for the implementation of cooperative intelligent transport systems in the European Union*, – in short, the C-ITS Platform – was set up in 2014 to develop a common vision for the interoperable implementation of C-ITS in the European Union. Members of the C-ITS Platform include national governments, industry and knowledge partners and various Directorates General of the European Commission. Five working groups have been formed around the following subjects: cost-benefit analysis, business cases, legal aspects, data protection & privacy and security & certification.

The first phase was completed with a Final report that became available in January 2016. The following are a number of highlights:

- A list of 'Day 1 services' was drawn up: these are services that will be available in the short term due to the expected social advantages and the maturity of the technology. The C-ITS Platform has also agreed on a list of the 'Day 1.5 services', that are regarded as mature and very desirable by the industry, but for which specifications or standards are not yet completely ready.
- A cost-benefit analysis based on the list of Day 1 services showed that the benefits ultimately far outweigh the costs on an annual basis – depending on the scenario – by a ratio of up to 3:1 based on the period 2018-2030.
- Various recommendations have been formulated for standardisation and interoperability, 'communication security' and communication systems and radio frequencies, for now and for the future.
- The report specifies the requisite technical solutions for access to data and resources in the vehicle: on-board application platform, in-car interface and the data server platform.
- The messages that vehicles transmit in the context of C-ITS services are regarded as personal data: users can be indirectly recognised. That is why is the C-ITS Platform believes that the EU legislation (Directive 95/46/EC) on data privacy and data protection is applicable in this case. Amongst other things, this means that drivers must be able to stop the transmission of data and must be informed about the possible detrimental consequences.
- The report includes a number of recommendations that relate, amongst other things, to a review of the European declaration of principles on Human Machine Interface and to the 'co-existence of equipped and non-equipped vehicles'. It also calls for more investment in education and in raising awareness.

The workgroups have therefore done a great deal of work and have even developed policy recommendations and proposals for measures developed for the Commission. But those recommendations still have to be implemented. In addition, further consultation is necessary for some issues, such as liability – for example, what happens if something goes wrong when using C-ITS services? A number of Phase 1 working groups will therefore continue into Phase 2, which started in 2016, and several new working groups have also started, focusing amongst other things on the physical and digital infrastructure and on traffic management. In addition.

Read more:
C-ITS Platform, Final report, January 2016.
See ec.europa.eu/transport/themes/its/doc/c-its-platform-final-report-january-2016.pdf

Connekt

Connekt is an independent network of more than 200 parties that are working on smart and sustainable mobility. Its main goal is to make knowledge accessible and to share experiences. For example, in the past year Connekt organised study trips for its members and set up a new taskforce together with Rijkswaterstaat, CROW and RDW.

Study trips to California

In November 2015, Connekt organised a fact-finding mission to California. Dutch government organisations and market parties visited a number of large and innovative companies such as Google and Tesla. What can the Netherlands learn from these companies? How do they 'organise' innovation? In January 2016, a second trip was organised, this time to Silicon Valley. The theme of the second trip was 'connected and self-driving vehicles'. Which start-ups are active in that field? And how do major map-makers such as HERE and TomTom deal with this? The results of these trips are being distributed inside Connekt and are being used as the basis for follow-up activities.

Read more:
www.connekt.nl/nieuws/connekt-to-california-fact-finding-mission

www.connekt.nl/nieuws/verslag-inspiration-abroad-ces-2016

Dutch Roads for Self-Driving Vehicles

In early, 2016, the taskforce *Dutch Roads for Self-driving Vehicles* was set up. This taskforce is an initiative of Rijkswaterstaat, CROW, RDW and Connekt and is charged with the task of stimulating and facilitating tests with self-driving vehicles. The parties in the taskforce are working together on the basis of equality. Regional, provincial and national road authorities are represented, but also TLN (Transport and Logistics Netherlands), safety regions and the National Police Corps (KLPD).

The taskforce is providing market parties with information about suitable test locations in the Dutch infrastructure. A uniform procedure has been set up for the submission of applications for tests. For the road authorities, the taskforce compiled a digital checklist that can be used to determine which steps are required to run tests safely and in compliance with the regulations. The taskforce is also dealing with liability issues.

Another product of the taskforce is the knowledge agenda: a website with an online overview of available and requisite knowledge in the field of automated driving. The overview is divided into the knowledge domains of Human Factors, Deployment, Legal, Impact, Technical. The library includes reports, papers and presentations. There is also an annual knowledge report about what was learned in 2015.

For TrafficQuest, the Impact knowledge domain is important. There are still many questions open in this area, such as 'What does current traffic look like (at bottlenecks) and how will automated vehicles influence that?', 'What is the added value of C-ITS for automated driving?' and 'How do automatically and manually driven vehicles interact with each other?'. For the latter question, a distinction can be made between self-driving (passenger) cars, robot taxis and truck platooning. In this framework, TrafficQuest is describing what is required in order to perform realistic simulations of mixed traffic with both manually and automatically driven vehicles.

Read more:
www.connekt.nl/initiatief/dutch-roads
knowledgeagenda.connekt.nl

Trilateral ITS Cooperation

The EU, the United States and Japan are the main driving forces behind automated driving. These parties therefore consult regularly, amongst other things in the *Automation in Road Transportation Working Group of the Trilateral ITS Cooperation*. In this cooperation, a sub-working group was formed in order to harmonise impact assessment approaches. TrafficQuest is taking part in this initiative. The sub-working group is working on an evaluation framework that can be used to determine the impacts of automated driving on the traffic and transport system. The framework is aimed at helping evaluation teams design meta-analyses, tests and effect studies properly (and comparably), so that as much as possible can be learned from all the trials that are being conducted worldwide with automated vehicles.

About TrafficQuest.

TrafficQuest

CENTRE FOR EXPERTISE ON TRAFFIC MANAGEMENT

TrafficQuest, the centre for expertise on traffic management, is a cooperation between Rijkswaterstaat, TNO and Delft University of Technology. A lot is going on in the field of traffic management; the three organisations work together in TrafficQuest to ensure that the existing knowledge does not get lost and is made accessible to practitioners. This is done by collection, developing and disseminating knowledge. The partners in TrafficQuest together cover knowledge on traffic management from science, applied science and operations. The activities consist of answering questions, giving advice in projects.

www.traffic-quest.nl

Colophon.

Text
Isabel Wilmink and Henk Taale.
With contributions from Aranta van den Broeke, Aad van den Burg, Simeon Calvert, Ben Immers, Ronald van Katwijk, Gerdien Klunder, Michèle Kroon, Henk Schuurman and Aroen Soekroella.

Production
Essencia Communicatie, Den Haag

Photography
Robert de Voogd

Notes

Notes