Field Trials with a (Dynamic) Speed Limit of 130 km/h

Final Version

Issue: 4th edition
Version: 1.0
Date: December 31st, 2012

Issued by: Rijkswaterstaat (NL)
Authors:
Niels Beenker, ARCADIS
Arnold van Veluwe, Rijkswaterstaat
Henk Taale, Rijkswaterstaat
PREFACE

An alternative to fixed speed limits is dynamic speed limits. By a dynamic speed limit we understand one that is imposed temporarily and that deviates from the permanent speed limit, depending on current traffic- and situation-related circumstances. Dynamic speed limits are intended to increase traffic safety, to improve traffic flow, to reduce environmental impact or to increase acceptance among road users. Combinations of these objectives may also be aimed at.

To gain more knowledge about dynamic speed limits, the project “Dynamax” has been conducted in the Netherlands. The aim of the Dynamax project was to gain more insight into the effects (including safety, traffic flow and the environment) and the behavioural aspects of dynamic speed limits, and to obtain a picture of the consequences for road and network management. Practical trials have already been conducted on the A1, A12 and A58 with different applications of dynamic speed limits, and a new trial started on the A20 in mid-2010. The effects on traffic flow, traffic safety, air quality and noise impact are investigated in these trials. At the same time, the operational experiences, effects on road user behaviour and the road user’s support for dynamic speed limits are studied.

The present Dutch cabinet indicated in its coalition agreement that it intended to increase the current speed limit (dynamically) on the motorways to 130 km/h where possible. In order to gain insight into the effects of 130 km/h, it is desirable to experiment with a (dynamic) speed limit of 130 km/h on a number of routes. In the experiment, insight is gained into the effects on traffic flow, compliance, perception, the surrounding area and traffic safety of a speed limit dynamically increased to 130 km/h on certain routes. The experiment is defined in the “Experimenteerverkeersbesluit ten behoeve van een experiment met een dynamische maximumsnelheid tot 130 km/h op enkele wegvakken onder beheer van het Rijk” (“Experimental traffic decree for the purposes of an experiment with a dynamic speed limit up to 130 km/h on some road sections managed by the national government”).

The implementation and evaluation of the 130 km/h trial routes is accommodated in the Dynamax project. The Dynamax 130 project, along with the other Dutch Dynamax projects, has the aim, by means of an experiment on eight routes, of introducing a dynamic speed limit of 130 km/h and investigating what the effects are on aspects including traffic flow, traffic safety and the environment.

The ‘Dynamax 130 project’ comprises two tracks:

- By means of an experiment on eight routes, to introduce a dynamic speed limit of 130 km/h and investigate what the effects are on aspects such as traffic flow, traffic safety and the environment.
- To conduct a study for the steps needed to implement an increase of the national dynamic speed limit.

The present evaluation study is targeted at the first track: to investigate what the effects are of a dynamic speed limit increase. The results of the evaluation will be used in the elaboration of a national implementation (track 2).

The eight trial routes have been evaluated during the experiments. The following key question is answered in this evaluation:

“What effect does the application of a dynamic increase of the speed limit to 130 km/h has on the traffic on the road (in terms of traffic flow, compliance with the speed limit and safety), what is the road user’s appreciation of it, and what effects occur for the environment (in terms of noise and air quality)?”
For each trial route, this key question is answered in a comparable way. The evaluation of the trial routes consists of two evaluation rounds:

- Overall evaluation by route: results in broad terms from the eight trial routes.
- Integral detailed evaluation: in this evaluation, account is taken of the route-specific characteristics and external influences.

For the evaluations the focus is on five themes: Traffic Flow, Perception, Safety, The Environment and Compliance. For each theme, a number of study questions and hypotheses are formulated which are answered in the overall and detailed evaluation.

The hypotheses are answered by comparing data from before and after measurements. The data comprise flow and speed loop data per minute, individual vehicle data, incidents, weather conditions and driver surveys.
# TABLE OF CONTENTS

**REPORT TEMPLATE** .................................................................................................................. 6

1. **Key Evaluation Results** ........................................................................................................ 7
   1.1. Impact on Traffic Flow ........................................................................................................ 7
   1.2. Impact on Safety ................................................................................................................ 7
   1.3. Impact on Environment ...................................................................................................... 9
   1.4. Other Key Results ............................................................................................................. 10

2. **Description of the Problem** .................................................................................................. 11
   2.1. Sites .................................................................................................................................... 11
   2.2. Issues Addressed ............................................................................................................. 13

3. **Description of the ITS Project** .............................................................................................. 15
   3.1. Service Area .................................................................................................................... 15
   3.2. Key Words ...................................................................................................................... 15
   3.3. Objectives ....................................................................................................................... 15
   3.4. Systems and Technologies Applied ................................................................................ 16
   3.5. Costs ............................................................................................................................... 17
   3.6. Status of the Project ......................................................................................................... 17

4. **Evaluation Planned** .............................................................................................................. 18
   4.1. Timing and Type of Evaluation ....................................................................................... 18
   4.2. Objectives for the Evaluation ......................................................................................... 18
   4.3. Research Questions ......................................................................................................... 18
   4.4. Study Area for the Evaluation ....................................................................................... 19
   4.5. Expected Impacts ............................................................................................................ 21
   4.6. Methods Used .................................................................................................................. 22
5. The Impact of the Project - Results

5.1. Technical Performance

5.2. Results

5.3. Reliability of Results

5.4. Research Questions Answered

5.5. Overall Assessment

5.5.1. Safety

5.5.2. Efficiency

5.5.3. The Environment

6. European Dimension: Transferability of the Results
REPORT TEMPLATE

Project Name: Field Trials with a (Dynamic) Speed Limit of 130 km/h in The Netherlands

Project Code: CEN48

Area Code: CS212

EasyWay Region: CENTRICO
1. Key Evaluation Results

This section presents a brief summary of the key results related to the EasyWay objectives and any other key results.

The effects of the (dynamic) speed limit 130 km/h were evaluated in eight field trials with different main objectives. The detailed results below are described according to the five main objectives involved.

1.1. Impact on Traffic Flow

With regard to the theme ‘Traffic Flow’, the effect of introducing 130 km/h was positive. On average, the speed of the passenger traffic increased with about 2 to 3 km/h, which means a reduction of the journey time. The increase in the speed limit had no effect on the speed of trucks or on traffic jams.

Average speed
On the test routes with two lanes in each direction, the average speed (of the passenger traffic) increased with 2 to 3 km/h during the 130 km/h regime. An exception to this was the A17/A58. Here, an increase of 2 km/h was measured. On the A16, with 2x3 lanes, the speed increase on the section where 100 km/h was the old speed limit, was larger, approximately 8 km/h. On the A2 test section, where there are four lanes and 120 km/h applied in the prior situation, the average increase was effectively equal to that on the road sections with two lanes. On the A6 (where driving at 130 km/h is only allowed in the evening and during the night), the average speed during the day did not increase.

Trucks
The average speed of trucks remained unchanged by the introduction of 130 km/h. The effect on roads with and without an overtaking prohibition for trucks was also investigated. No difference in the effect on speed was observed between these situations.

Congestion
As well as the effect on speed, the effect on congestion was studied. It was shown with a quantitative analysis that the 130 km/h measure had no influence on the number or seriousness of traffic jams.

Journey time
The journey times reduced on all routes, varying from approximately 10 to 60 seconds, depending on the length of the route. The values mentioned are an average that may vary for vehicle type and individual.

1.2. Impact on Safety

Based on the indicators studied, a limited negative effect on traffic safety was observed. The average speed increased, which increases the probability of accidents. The speed differences between passenger vehicles mutually and between passenger cars and trucks also increased, which could lead to additional hazardous situations. On road sections with two lanes, the introduction of 130 km/h
led to more events in which vehicles with a shorter interval in combination with a higher speed approached each other. The increase in the probability of accidents was limited, about 1 to 2%. Given the relatively brief evaluation period, it is not yet possible to draw a justified conclusion about the actual change in safety in terms of increase or decrease in the number of accidents.

**Speed per lane**
As well as the increase in average speed per route, the speed per lane was also investigated. In general, it can be concluded that on routes with two lanes, the speed increase on the left lanes was larger than the increase on the right lanes. The exception here was the night window on the A6. Here, the speed on the right lane increased more than the speed on the left lane. This is a result of the quiet road situation during the night. In that situation the majority of the traffic drives on the right lane.

**Distribution of speed**
On all routes, the mutual differences in speed between passenger cars and trucks increased. The increase in this dispersion varied between 0.5 and 2.5 km/h. This increase could be seen mainly on the right lanes where the trucks continued to move at roughly the same speed, while the passenger car moved with a higher speed on average. The variance on the left lane decreased particularly on routes with three or four lanes. Only passenger cars drive on these lanes, so the speed became more homogeneous.

Particularly on routes with two lanes, it was shown that not all passenger car drivers increased their speed, so that mutual speed differences between passenger cars also increased.

In the daytime on the A6, when no 130 km/h limit is used, then almost no difference in the speed distribution was observed.

**V85 and V95 (85th and 95th percentile of speed)**
On most routes, the V85 and V95 increased by 2.5 to 3.5 km/h. On a number of routes (A7 and A2), increases of 5 km/h in the V85 and V95 were observed. On the road section of the A16, where previously a speed limit of 100 km/h was applied, the V85 and V95 increased by 10 and 7 km/h respectively.

**Discontinuities**
In the evaluation, attention was paid to a number of specific locations on the trial routes. This concerned locations where there are discontinuities in the road situation, or road sections where the traffic hazard level was relatively high before the introduction of 130 km/h. It proved that the average speed increase at many of these locations was less than on the ‘normal’ road sections, where an average increase of 2 to 3 km/h was measured. The speed increase on the Ketel bridge (A6) was 1 km/h on the section where a speed reduction to 100 km/h applied (on the rest of the route, 120 km/h applied). In the Vlakte tunnel (A58), an average speed increase of 1.5 km/h was measured. The road section on the A17/A58 between De Stok interchange and the Heerle junction was designated as critical from a traffic safety viewpoint. On this route, the speed increase was smaller than on the other road sections of the A17/A58. Opposite the locks on the Afsluitdijk (A7), the speed decreased after the introduction of 130 km/h.

**Transitions**
Downstream of the trial routes, a speed measurement was also conducted to create a picture of the progression in driving speeds after the trial routes. It can be concluded from this analysis that speed
downstream of the trial routes on average increased by around 1 km/h. Where there is a natural barrier, such as the Zoomland interchange on the A58 or the Lorentz locks in the Afsluitdijk, there was hardly any speed increase on the downstream route. The downstream measurement points were between 1 and 10 km from the trial routes. Most locations were situated within 6.5 km of the trial route.

**Interactions**

It was investigated whether the 130 km/h measure had an effect on the mutual distances and intervals between vehicles. It may be concluded that on motorways with two lanes, the number of short vehicle intervals increased slightly. For motorways with three or four lanes, no increase in the number of short vehicle intervals was observed. When the combination of high speed and short vehicle interval was checked, it proved that the number of hazardous combinations of high speed and short vehicle intervals increased by 1 to 2% on motorways with two lanes. On motorways with three or four lanes, with a speed limit of 120 km/h in the before measurement, the number of hazardous situations did not increase. Evidently, the traffic on three- and four-lane motorways distributes itself more over the road than on road sections with two lanes. The number of hazardous combinations increased by 1 to 2%, which implies an increase in the probability of accidents (particularly rear end shunts). If this is translated into actual accidents, it may be deduced that the increase to 130 km/h had a limited effect on the number of serious accidents as a result of shorter intervals in combination with higher speeds.

**Risk figures**

On locations with a high risk figure, a slightly lower increase in the maximum speed (approximately 2 km/h for passenger cars) could be observed compared with the locations with a low risk figure (approximately 3 km/h for passenger cars).

### 1.3. Impact on Environment

On most routes, the air quality reduced slightly while the noise emissions increased a little. The dynamic speed reduction on the A2 did ensure that the air emissions were compensated for. Seen over a day, the emissions were not larger than in the before measurement. All differences are in fact small.

**Air quality and noise emissions**

In this evaluation, the effect on air quality and noise emission was investigated overall. The effects were determined overall, based on the increases in speed. Due to the increases in the average speeds on the routes, the noise emission increased slightly and the air quality diminished somewhat. The values are in fact very small. For noise, the differences lie between 0.2 and 0.4 dB. For air quality, the increases are in general 1 to 2%. On the A16, the increases were a little larger (3.4%), because here the speed limit was changed from 100 to 130 km/h.

A special measurement site on the A16 was set up for this evaluation to determine the effect on the noise level. This site was located near the road section that previously had a limit of 100 km/h. It proved from the noise measurements that the speed increase on this road section lead to an increase of the noise emissions of 0.4 dB. This effect is comparable to the overall analysis that was conducted in this evaluation.
Compensation from 100 km/h
For the A2, it was investigated whether the dynamic speed reduction to 100 km/h (formerly 120 km/h) provided compensation for the period in which the speed was increased to 130 km/h. It can be concluded that the speed reduction to 100 km/h on the A2 did not lead to a full compensation of the air emissions on this route. Also, the temporary 100 km/h limit is not able to compensate fully for the extra noise impact in the 130 km/h periods. But the differences are small.

1.4. Other Key Results

Compliance
With regard to the theme ‘compliance’, the effect of introducing 130 km/h was positive. The number and proportion of speeders (driving faster than the speed limit) and offenders (driving faster than the speed limit + a tolerance gap of 6 to 9 km/h) reduced. However, on the routes where a lower speed limit of 100 km/h was imposed dynamically, the proportion of speeders was large, around 75%.

On the majority of the routes, the proportion of drivers exceeding the legal speed was reduced by around 15 to 20% after introduction of 130 km/h. The A16 was an exception. On the road section where 100 km/h applied previously, the number of speeders was reduced by 60%.

For the proportion of offenders (exceeding the legal speed + legal margin), it applies that it decreased on almost all routes by around 15%. The dynamic speed limit of 100 km/h on the A2 and A16 was poorly complied with. On the A2 and A16, only 25% kept to the speed limit of 100 km/h.

Perception
On the first four trial routes (A2, A6, A7 and A16), a perception study was conducted separately from this evaluation. The most important conclusions related to the evaluation are listed here. Drivers gave the most (very) positive assessment to the trial on the A7, followed by the A6 and then the A16 and A2. The very positive evaluation varied from 72% on the A7 to 64% on the A2. In this same study, drivers indicated that an increase of the speed limit in relation to the amount of traffic is the most ‘efficient’ and most positive for traffic flow. A permanent increase was assessed as being the clearest and not as hazardous. It was indeed indicated that it is undesirable to keep to a dynamic speed when it does not feel appropriate to the amount of traffic.

Habituation
It was found that there is no ‘habituation’. The effects found in the second after measurement are almost equal to those in the first after measurement (in comparison with the before measurement).

For the first four trial routes (A2, A6, A7 and A16), two after measurement periods were used: one just after the introduction of 130 km/h limit in the spring, and the second after the summer period. In the second after measurement, it was apparent that the speed increase on the four routes had not become larger. The increase was equal to the first after measurement or somewhat lower by a maximum of 1 km/h. The relative speed differences in traffic in the second after measurement were in general somewhat lower than in the first after measurement. The number of offenders and speeders was equal to or somewhat lower (max. 2%) than that of the first after measurement.
2. Description of the Problem

2.1. Sites

In the Dynamax 130 project, eight field trials were carried out on eight locations. The background of the field trials was not specifically to solve a problem, but the overall objective was to gain more insight into the impact of increasing the (dynamic) speed limit to 130 km/h.

The eight experiments differed in implementation form and introduction date. Below, there is an explanation of the routes. A map of the eight motorway routes is included in Figure 1.2.

- **A7 between Wognum and Friesland.** On this route, the speed was permanently increased to 130 km/h. This has been applied since 1 March 2011.

- **A6 between Almere and Joure.** On this route, the introduction of 130 km/h was implemented in the form of a time window. It is made clear to the road user by means of signs what speed limit applies at a given time. This comes down to the fact that the speed limit is 130 km/h in the evening and at night (between 7 p.m. and 6 a.m.). This time window was introduced on 19 May 2011.

- **A2 between Nieuwegein and Deil.** The increase to 130 km/h on this section is implemented dynamically using signs. If the I/C value (intensity/capacity ratio) exceeds a given limit, the speed limit is reduced to 100 km/h. The implementation takes place on two route sections (the break is at the Culemborg junction) given that the traffic demand on the two sections differs significantly. This therefore means that the speed limit, which was 120 km/h in the before situation, varies dynamically in the after situation between 130 and 100 km/h. The dynamic speed has been applied on this route from 31 May 2011.

- **A16 between Breda and Moerdijk.** The increase to 130 km/h on this route is implemented dynamically using signs, just as on the A2. If the I/C value exceeds a given limit, the speed limit is reduced to 100 km/h. In the first period of the trial (until 19 July 2011) this was still 90 km/h in connection with technical limitations. The switch of the speed happens on two separate routes (to the north and south of Princeville interchange) given that the traffic demand on the two sections differs significantly. On this route, the introduction of 130 km/h started on 31 May 2011.

- **A17/A58 between Moerdijk and Bergen op Zoom.** On this route, the speed has been permanently increased to 130 km/h. The permanent increase was introduced as of 7 July 2011.

- **A32 between Steenwijk and Heerenveen.** On this route, the speed has been increased permanently to 130 km/h. The permanent increase was introduced as of 7 July 2011.

- **A37 between Hoogeveen and Klazienaveen.** On this section, the speed has been increased permanently to 130 km/h. The permanent increase was introduced as of 7 July 2011.

- **A58 between Rilland and Middelburg.** On this section, the speed has been increased permanently to 130 km/h. The permanent increase was introduced as of 7 July 2011.
Figure 2.1: Locations of the (dynamic) 130 km/h speed trials
2.2. Issues Addressed

This paragraph describes, for each of the eight field trials, the essentials and the issues addressed. In the next chapter, the policy objectives and systems and technologies used are described.

On eight trial routes, the speed was increased (partly dynamically) to 130 km/h. In the following table, the most important aspects for each route are listed. It may be seen from this table that on five routes the speed of 130 km/h has been introduced permanently, on two routes dynamically, and on one trial route a fixed time window is used.

It is indicated in Table 3.1 what specific aspects were investigated on each route. These aspects are in addition to the general aims that apply to all routes:

- Effect on journey time;
- Road user’s experience;
- Effects on air quality, noise and safety.

The specific aspects for each route are dealt with in the detailed evaluation. The general aims are addressed in both the overall and the detailed evaluation. Besides these evaluations, other studies were carried out by various parties. It is indicated below what parts of the themes were conducted separately.

Perception
The perception study was carried out separately by Rijkswaterstaat. The summarised results from this study are included in this report.

Control algorithms
During the period of the overall evaluation, also attention was paid to the operation of the control algorithms on the A16 and A2. The conclusions that came out of this research, and their consequences, are included in the analysis for the A16 and the A2.
<table>
<thead>
<tr>
<th>Road number</th>
<th>‘Old’ speed</th>
<th>130 Regime</th>
<th>Specific aims</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Impact of transition from 120 km/h to 130 km/h</td>
<td>Difference between busy and quiet section</td>
</tr>
<tr>
<td>A2</td>
<td>120 km/h</td>
<td>Dynamic 100/130 based on I/C ratio</td>
<td></td>
</tr>
<tr>
<td>A6</td>
<td>120 km/h</td>
<td>Window times 120/130 (night 130 km/h)</td>
<td></td>
</tr>
<tr>
<td>A7</td>
<td>120 km/h</td>
<td>Permanent</td>
<td></td>
</tr>
<tr>
<td>A16</td>
<td>100 km/h</td>
<td>Dynamic 90/130 and 100/130 based on I/C ratio</td>
<td></td>
</tr>
<tr>
<td>A17/A58</td>
<td>120 km/h</td>
<td>Permanent</td>
<td></td>
</tr>
<tr>
<td>A32</td>
<td>120 km/h</td>
<td>Permanent</td>
<td></td>
</tr>
<tr>
<td>A37</td>
<td>120 km/h</td>
<td>Permanent</td>
<td></td>
</tr>
<tr>
<td>A58</td>
<td>120 km/h</td>
<td>Permanent</td>
<td></td>
</tr>
</tbody>
</table>

Table 2.1: Issues addressed per field trial
3. Description of the ITS Project

3.1. Service Area

The EasyWay Service areas are:
- Traveller Information Services,
- Traffic Management Services,
- Freight and Logistics Services,
- ICT Infrastructure.

In the Dynamax 130 project, the field trials were intended to gain more insight into the impact of a (dynamic) 130 km/h speed limit. So, the main focus was on Traffic Management Services.

3.2. Key Words

The following key words (highlighted) describe the nature of the Dynamax project and the applications used.

<table>
<thead>
<tr>
<th>Traveller Information Services</th>
<th>Traffic Management Services</th>
<th>Freight and Logistics Services</th>
<th>ICT Infrastructure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-trip Traveller Information</td>
<td><strong>Variable Speed Limits</strong></td>
<td>Freight Management</td>
<td>Data Management and Exchange</td>
</tr>
<tr>
<td>On-trip Traveller Information</td>
<td>Speed Control using ANPR</td>
<td>Vehicle Safety Systems</td>
<td>Traffic Management Plans</td>
</tr>
<tr>
<td>Variable Message Signs</td>
<td>Use of Hard Shoulder</td>
<td>Parking Areas</td>
<td>DATEX II</td>
</tr>
<tr>
<td>Highway Advisory Radio</td>
<td>Automatic Incident Detection</td>
<td>Hazardous Goods Monitoring and Tracking</td>
<td>Traffic Monitoring</td>
</tr>
<tr>
<td>Driver Behaviour</td>
<td>Use of CCTV</td>
<td>Transport Security</td>
<td>Control Centres</td>
</tr>
<tr>
<td>Comprehension and Compliance</td>
<td>Ramp Metering</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Traffic Management using Rerouting</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3.1: Services involved in the Dynamax 130 project

3.3. Objectives

The overall objective of the project was as follows: To gain experience with a dynamic speed limit up to 130 km/h and to investigate the effects on traffic flow, the environment and traffic safety in practice. By using different time windows and techniques in the experiment, a broad view on the effects and possibilities of a dynamic speed limit is obtained.
3.4. Systems and Technologies Applied

On five of the eight trial routes, the speed limit was increased to 130 km/h permanently. This is indicated by traffic signs.

![Permanent speed limit signs](image1)

**Figure 3.1: Permanent speed limit signs**

On the A6, 130 km/h is implemented using a time window for the night. This is indicated by speed and motto signs.

![Time frame signs](image2)

*[only 7 p.m.-6 a.m.]*  
*Daytime 6 a.m.-7 p.m.]*

**Figure 3.2: Time frame signs**

On the A2 and the A16, the speed limit of 130 km/h is imposed dynamically, so that the speed limit is shown based on the I/C ratio. Algorithms have been developed for this in such a way that in the rush hour periods, if the traffic is heavy, the speed is reduced to 100 km/h, and when it becomes quiet again, the speed is 130 km/h.

![Dynamic speed limit signs](image3)

*[A dynamic limit applies here]*

**Figure 3.3: Dynamic speed limit signs**
3.5. Costs

The costs of these experiments are relatively low, given that the existing motor traffic management system could be used for the dynamic application. For the static and time-dependent speed limit indications normal traffic signs have been installed. Besides this, a number of motto signs were required to make various things clear to the road user.

3.6. Status of the Project

At the time of writing this report, the evaluation of the field trials is finished. The installed systems and measures are still operational and work properly.
4. Evaluation Planned

4.1. Timing and Type of Evaluation

The ex-post evaluation study was carried out in 2011. The evaluation included an analysis of traffic data to determine effects on traffic and questionnaires among road users to gain knowledge about the perception of the road users.

4.2. Objectives for the Evaluation

The overall objective was as follows: To investigate the effects on traffic flow, the environment and traffic safety of a (dynamic) speed limit of 130 km/h. By using different time windows and techniques in the experiment, a broad view on the effects and possibilities of a dynamic speed limit is obtained.

The most important key question reads:
What effect does the application of a dynamic increase in the speed limit to 130 km/h have on the traffic on the road (in terms of traffic flow, compliance with the speed limit and safety), what is the road user’s appreciation of it, and what effects occur for the environment (in terms of noise and air quality)?

4.3. Research Questions

The initial research questions were as follows:

Traffic flow
- What is the influence of the (dynamic) speed limit increase to 130 km/h on journey times?
- What is the influence of the (dynamic) speed limit increase to 130 km/h on the (average) speeds realised?
- Are there any effects observable on adjacent road sections?
- Do traffic problems (jams) on the trial route as a consequence of a higher speed limit?
- Do any traffic problems (jams) occur at the transition to and from the 130 km/h zones?
- How is the interaction with the overtaking prohibition for trucks from a traffic viewpoint?
- What are the effects on the speed differences between the lanes?

Perception
- How does the user experience the fact that 130 km/h is permitted?
- What is the road user’s perception of the traffic safety?
- Does the road user understand the intention of the speed limit increase and the restrictions on it?
- Does the user understand the transition when driving into and leaving the 130 km/h zone?
- How does the user deals with the time windows? How does the user deals with an interruption in the 130 km/h zone?
Traffic safety

- Do the average speed and the speed differences increase through the introduction of a higher speed limit and what influence does this difference have on traffic safety?
- Is there any increase in ignoring the speed limit?
- How do the V85, V95 and % compliers with the speed limit develop at multiple measurement points?
- How do the team headways develop with a higher speed limit?
- How does the time-to-collision develop with a higher speed limit?

Environment

- What are the effects of the speed limit change on noise production?
- What are the effects of the speed limit change on air quality?
- Is there sufficient compensation during 100 km/h for noise and air quality in order to compensate for the increased emission during 130 km/h?

Compliance

- Does the dynamic increase in the speed limit have an effect on the percentage of drivers going faster than the speed limit?
- Does the dynamic increase in the speed limit have an effect on the percentage of speed limit offences?
- What is the effect of the enforcement on the speed limit offences?

4.4. Study Area for the Evaluation

The study areas for the evaluation are shown on the map of the Netherlands in figure 2.1 and in more detail in the figures below.

The measurement sites are also shown on the maps.
4.5. Expected Impacts

The study questions were translated into the following hypotheses:

**Traffic flow**
- Through the increase of the speed limit, the average speed along the route will increase and therefore the average journey time will decrease.
- Through the increase of the speed limit, the average speed realised at each location and on the route will increase.
- The speed limit increase will only have an effect on the routes selected and no effects will occur on adjoining routes.
- The traffic flow on the routes will not be affected by an increase in the speed limit. It is supposed that disruptions (traffic jams) occur at higher intensities. When disruptions occur, the traffic is self-regulating in such a way that the speed would then already be less than 130 km/h.
- During speed-switching on the routes with a dynamic speed limit regime, disruptions may possibly arise, because the traffic has to adapt itself to the regime newly in force.
- No disadvantageous effects will arise from the combination of an overtaking prohibition and a time window in connection with a speed limit increase.
- The speed differences between lanes will increase, given that the goods traffic will maintain the same speed and the rest of the traffic will adopt a higher average speed.

**Perception**
- The speed limit increase on the routes will be appreciated by the user.
- The road user will not perceive a dynamic increase as a more hazardous situation.
- The user will have to become used to a transition to 130 km/h and back again. Initially, probably not every road user will adopt the desired speed in good time.
- The user will have to get used to transitions in time, when what speed is permitted. Initially, probably not every road user will adopt the desired speed at the right time.
- The user will consider it undesirable to have to maintain a lower speed dynamically if this is not necessary in his view. It is probable that not every user will keep to the dynamically reduced speed limit.
Traffic safety

- The increase in the speed limit will lead to greater speed differences and therefore will make the road more hazardous.
- The average speed in each carriageway will increase as a result of the (dynamic) speed limit increase to 130 km/h.
- The average speed for traffic other than trucks in each carriageway will increase as a result of the (dynamic) speed limit increase to 130 km/h and exceed the total average.
- The average speed in each lane will increase with a (dynamic) speed limit increase, and the increase will be larger in the left than in the right lanes.
- The standard deviation of the speed in each carriageway will increase with a (dynamic) speed limit increase.
- The standard deviation of the speed in each lane will increase with a (dynamic) speed limit increase.
- The V85 and V95 will attain a higher value with a (dynamic) speed limit increase.
- The number of offenders will be lower with a higher speed limit.
- In places where the speed limit is made lower than 130 km/h dynamically, more road users will probably contravene this.
- The average speed at transitions to 130 km/h will also rise as not all users will remain exactly within the route or time window with their speed adaptation.
- The vehicle time intervals will be shorter with a higher speed limit given that people will likely maintain the same separation distance.
- The number of ‘unsafe’ combinations of short vehicle headways with high speeds will increase.

Compliance

- There will be fewer cases of breaking the speed limit with a (dynamic) speed limit increase.
- There will be fewer offences of the speed limit with a (dynamic) speed limit increase.
- The effect of enforcement of the speed limit will not be different from the current situation.

Environment

- The increase in the speed limit will lead to an increase in noise emission.
- The increase in the speed limit will lead to a worsening of the air quality.
- Sufficient compensation will be possible to compensate for the growth in noise emission and the worsening of the air quality during a speed limit increase with the reduction in these emissions during a speed limit reduction.

4.6. Methods Used

To be able to test the hypotheses, a number of indicators have been defined for each hypothesis for both the overall and the detailed evaluation. The indicators used are indicated in the table below.

<table>
<thead>
<tr>
<th>Theme</th>
<th>Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic flow</td>
<td>Journey times</td>
</tr>
<tr>
<td></td>
<td>Average speeds</td>
</tr>
<tr>
<td>Perception</td>
<td>Experience of 130 km/h</td>
</tr>
</tbody>
</table>
Field Trials with a (Dynamic) Speed Limit of 130 km/h

<table>
<thead>
<tr>
<th>Traffic safety</th>
<th>Speed differences</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average speed per carriageway</td>
</tr>
<tr>
<td></td>
<td>Average speed per carriageway except trucks</td>
</tr>
<tr>
<td></td>
<td>Average speed per lane</td>
</tr>
<tr>
<td></td>
<td>Standard deviation (SD) speed per carriageway</td>
</tr>
<tr>
<td></td>
<td>Standard deviation (SD) speed per lane</td>
</tr>
<tr>
<td></td>
<td>V85 and V95</td>
</tr>
<tr>
<td></td>
<td>Number of offenders</td>
</tr>
<tr>
<td></td>
<td>Speed at transitions</td>
</tr>
<tr>
<td></td>
<td>Number of interactions</td>
</tr>
</tbody>
</table>

| Compliance                      | Number of drivers breaking the speed limit (speeders)                             |
|                                 | Number of offenders (speed limit + 6 to 9 km/h)                                  |

| Environment                     | Noise emissions                                                                   |
|                                 | Air quality                                                                       |

Table 4.1: Indicators

The evaluation was mainly conducted by comparing measurement data from the situation before 130 km/h with the situation after the introduction of 130 km/h. On four trial routes (A2, A6, A7 and A16), two after measurements were done in order to gain insight into the development in behaviour as well. A perception study was carried out separately on the trial routes A2, A6, A7 and A16, and a noise measurement was conducted on the A16.

Data from various sources were combined to get a detailed and complete view of the changes in the traffic situation. The data used were:

- Aggregated traffic data per minute (speeds and volumes) from loop detectors in the road (“MoniCa data”). These data were collected from all loop detectors on the road sections;
- Traffic data at vehicle level (“RESI” data): loop detector data from which speed, variation in speed, traffic volumes and time headways could be determined on lane level, for three vehicle types. These data were collected at specific locations, usually three to four per trial;

Besides these measurement data, use was made of various other sources:

- Bridge openings on the A6 and A7
- Weather information
- Traffic data from TomTom.

The basic data from each measurement point, each route and each measurement period are presented on the analysis sheets developed. An example is presented in Figure 4.2.
Figure 4.2: Example of standard analyses for each location.
5. The Impact of the Project - Results

5.1. Technical Performance

For the trials on the A16 and A2 algorithms were developed to ‘translate’ the traffic monitoring data into actions to activate the dynamic speed limits according to the specific purpose per trial. Shortly after the first activation of the algorithms, it was evaluated whether the algorithms functioned well, by means of interviews with traffic management centre operators and quick scan analyses of traffic data. Minor changes were made to several of the algorithms on the A16 and A2.

5.2. Results

In this section, the results of the overall and the detailed analysis are presented. In the first instance, the most important conclusions are included in summary table 5.1. Then the results of the overall and detailed evaluation are presented.

Summary table 5.1 gives the main results for the average speed and the 85-percentile speed on all trial routes.

<table>
<thead>
<tr>
<th>Route</th>
<th>average speed (*)</th>
<th>V85 (**)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>before</td>
<td>after</td>
</tr>
<tr>
<td>A2 Everdingen – Deil</td>
<td>118.1</td>
<td>121.1</td>
</tr>
<tr>
<td>A6 Almere – Joure (day)</td>
<td>116.2</td>
<td>115.9</td>
</tr>
<tr>
<td>A6 Almere – Joure (night)</td>
<td>119.9</td>
<td>122.9</td>
</tr>
<tr>
<td>A7 Wognum – Lorentzsluizen</td>
<td>118.1</td>
<td>120.7</td>
</tr>
<tr>
<td>A16 Klaverpolder – Galder (100 – 130)</td>
<td>110.8</td>
<td>119.0</td>
</tr>
<tr>
<td>A16 Klaverpolder – Galder (120 – 130)</td>
<td>117.9</td>
<td>121.1</td>
</tr>
<tr>
<td>A17/A58 Klaverpolder – Bergen op Zoom</td>
<td>117.8</td>
<td>119.9</td>
</tr>
<tr>
<td>A32 Steenwijk – Heerenveen</td>
<td>116.2</td>
<td>118.4</td>
</tr>
<tr>
<td>A37 Hoogeveen – Klazinaveen</td>
<td>116.2</td>
<td>118.5</td>
</tr>
<tr>
<td>A58 Rithern – Vlissingen</td>
<td>114.5</td>
<td>117.3</td>
</tr>
</tbody>
</table>

* average speed of all passenger cars
** V85, the speed that was exceeded by 15% of the passenger cars

Table 5.1: Overall results for the average speed and the 85-percentile
Results of overall analysis

Traffic conditions
• Average speed
  – On the test routes with 2x2 lanes, the average speed of the passenger traffic increased by 2 to 3 km/h during the 130 km/h regime.
  – An exception to this was the A17/A58. Here, a smaller increase was measured (between 0.5 and 1 km/h).
  – On the A16 (2x3 lanes), the speed increase on one section was somewhat greater, around 8 km/h. This concerned the road section that was previously 100 km/h. For the section where 120 km/h applied previously, an increase similar to that on the other trial routes was observed.
  – On the A2 (2x4 lanes), the average speed increase was equal to that on the 2x2 sections.
  – The average speed of the goods traffic remained roughly the same.
  – On the A6 (where a time window was applied), the average speed during the day did not increase.
  – Downstream of the trial routes, in general the speed increased. The increases were smaller than those on the trial routes themselves. On almost all downstream road sections, the increase was less than 1 km/h.
• Journey time
  – The journey times reduced on all routes and the reduction varied from approximately 10 seconds to a minute. The reduction depended on the length of the route.

Perception
• Opinion of the road user
  – On four routes, a perception study was carried out. Drivers gave the most (very) positive assessment to the trial on the A7, followed by the A6 and then the A16 and A2. The very positive evaluation varied from 72% on the A7 to 64% on the A2.

Traffic safety
• Speeds per lane
  – In general, it proved that on routes with two lanes in each direction, the speed increase on the left lanes was greater than that on the right lanes. The exception here was during the night window on the A6. Then the speeds on the right lane increased more than did those on the left lane. This is a result of the quiet road situation in the night, due to which the majority of the traffic drives in the right lane.
  – On the A16 (three lanes) and A2 (four lanes), the speed increase was the greatest on the middle lanes.
• Distribution of speed
  – On all routes, the variance in speed between passenger cars and trucks increased. The mutual speed differences therefore became larger. The increase in the spread varied between 0.5 and 2.5 km/h.
  – The increase in the variance could be seen mainly on the right lanes where the trucks continued to move at roughly the same speed, while the passenger cars moved at a higher speed (on average).
- On many routes, the spread on the left lane decreased. Only passenger vehicles drive in these lanes, so the speed became more homogeneous. This applied particularly on routes with more than two lanes (A2 and A16).
- It proved that not all passenger vehicle drivers increased their speed, so that mutual speed differences between passenger vehicles also increased. This applied particularly on the trial routes with two lanes.
- In the daytime on the A6, when no 130 km/h applied, no speed differences were observed compared with the before measurement.

**V85 and V95**
- On most routes, the V85 increased by 2.5 to 3.5 km/h. On a number of routes (A7 and A2), increases of up to 5 km/h were observed.
- The V95 increased on most routes by 2 to 3 km/h. On the A7, the increase was 4 to 5 km/h.
- On the road section of the A16 where previously a speed limit of 100 km/h applied, the V85 and V95 increased by 10 and 7 km/h.

**Discontinuities**
- The speed increase on the Ketelbridge (A6) was limited, namely 1 km/h on the section where a speed reduction to 100 km/h applied locally.
- In the Vlaketunnel (A58), an average speed increase of 1.5 km/h was measured. This is a little smaller than the speed increase on other parts of the A58.
- The road section on the A17/A58 between De Stok interchange and the Heerle junction was designated as critical from a traffic safety viewpoint. On this route, it was shown that the speed increase was smaller than on the other sections of the A17/A58.
- Opposite the locks on the Afsluitdijk (A7), the speed decreased compared to the before measurement.

**Compliance**

**Speeders**
- On the majority of the routes, the proportion of speeders was reduced by around 15 to 20% after the introduction of the 130 km/h speed limit.
- The A16 was an exception. On the road section where 100 km/h applied previously, the number of speeders was reduced by 60%.

**Offenders**
- For the proportion of offenders it applied that this fell on almost all routes by around 15%.
- The dynamic speed limit of 100 km/h on the A2 and A16 was poorly complied with. On the A2, only 25% kept to the speed limit. On the A16, this was even lower for the 90 km/h regime, 15%.

**Environment (noise emission and air quality)**
- Due to an increase in the average speeds on the routes, the noise emission increased slightly and the air quality diminished somewhat. The values concerned are in fact very small and did not lead to thresholds being exceeded.

**Habituation (applies only to the A7, A6, A2 and A16)**
- In the second after measurement, it was apparent that the speed increase on the A2, A6, A7 and A16 had not become larger. These were equal to the first after measurement or somewhat lower by a maximum of 1 km/h. On the A7 the speeds were slightly increased. On the A6, in the daytime, the differences increased by about 0.5 km/h.
The relative speed differences in the traffic in the second after measurement were in general somewhat smaller than in the first after measurement. On the A7, the differences on the right lane were slightly increased.

- The number of offenders and speeders was equal to or somewhat less (maximum 2%) than that in the first after measurement.
- The 100 km/h on the A16 was better complied with than the 90 km/h (30% compared with 15% offenders).

**Results of detailed evaluation**

**Traffic situation**
- The 130 km/h measure had no effect on the number of traffic jams.
- Dynamic switches mostly changed to 100 km/h on time, given the traffic situation.
- No differences were observed between roads with and without an overtaking prohibition for trucks.
- The average speed difference between the passenger cars and trucks in the after measurement(s) increased by around 2.5 km/h.

**Traffic safety**
- For two-lane motorways, the number of short vehicle headways increased slightly.
- For three-lane and four-lane motorways, no increase in the number of short vehicle headways was observed.
- The number of hazardous combinations of high speed and short headways increased by 1 to 2% on two-lane motorways.
- On three-lane and four-lane motorways, with a speed limit of 120 km/h in the before measurement, the number of hazardous situations did not increase.
- It may be deduced from this that the increase to 130 km/h had a limited effect on the probability of accidents.

**Perception**
- The road user does not perceive a dynamic increase as a hazardous situation.
- The road user understands that a dynamic adaptation is desirable, because otherwise problems arise for safety and the environment.
- The road user does not have to become used to a transition to 130 km/h and back again.
- The road user does not have to get used to transitions in time, when what speed is permitted.
- The road user finds it undesirable to maintain a lower speed dynamically while this is not necessary in his view. Not every user keeps to the dynamically reduced speed limit.

**Environment**
- The dynamic speed limit reduction to 100 km/h on the A2 cannot fully compensate for the extra air emissions. After introduction of the dynamic 130 km/h regime, a limited extra air impact remained compared with the before measurement.
- The dynamic speed limit reduction to 100 km/h on the A2 cannot fully compensate for the extra noise impact. After introduction of the dynamic 130 km/h regime, a limited extra noise burden remained compared with the before measurement.
Route-specific characteristics

- Signals and road lighting
  - Presence/absence of traffic signals had no influence on the effect of the 130 km/h measure.
  - Presence/absence of road lighting had a slight influence on the effect of the 130 km/h measure. On motorways with road lighting there was a slightly greater speed change between the before and after measurement during night hours than on motorways without road lighting.

- Type of regime
  - The effect of the 130 km/h measure at the activated times was equal for all types of regime (permanent, time window, dynamic).
  - On trial routes with a time window, a speed change was only observable within the 130 km/h window.

- Number of lanes
  - At carriageway level, the effects of the 130 km/h regime were equal for motorways with two, three or four lanes.
  - At lane level, differences were clearly observable between motorways with two, three and four lanes. These differences are present in both the before and the after measurements, and cannot thus be ascribed to the 130 km/h measure.

- Old speed limit
  - On motorways with a speed limit of 100 km/h in the before measurement, the average speed increased by an average of 8.5 km/h.
  - On motorways with a speed limit of 120 km/h in the before measurement, the average speed increased by an average of 2 to 3 km/h.

- Risk figures
  - On locations with a high risk figure, a slightly lower increase in the maximum speed (approximately 2 km/h for passenger cars) was observed compared with the locations with a low risk figure (approximately 3 km/h for passenger cars).

External influences

- Weekday versus weekend: no differences were observable in the effect of the 130 km/h measure between weekdays and weekends.
- Day versus night: at night, the average speed was higher than during the day in both the before and after measurements. On motorways with road lighting, the speed increase at night was equal to that during the day. On motorways without road lighting, the speed increase at night was less than that during the day (1 to 2 km/h).
- Quiet versus busier traffic situation: At quiet times (I/C < 0.6), the average speed was higher than at averagely busy times (0.6 < I/C < 0.8), although the increase in the average speed was greater at the averagely busy times. The average speed during busy and quiet times therefore came to lie closer together.
- Influence of rain: Rain does not appear to influence the effect of the 130 km/h measure. The number of observations in rainy conditions was however limited. For a final conclusion an analysis over a longer period is needed.
5.3. Reliability of Results

The evaluation of the trial routes took place based on a minimum set of 6 weeks of data. This was for the before measurement, the first after measurement as well as the second after measurement. The analysis conducted in the overall evaluations were based on large sets of observations (600,000 to 1,800,000 vehicles). Besides this, it proved that the results from the different routes were mutually comparable, so that data were used from two different sources. Based on these points, it may be stated that the results from the overall analyses are reliable.

In the detailed analyses, combined analyses were also worked with, and subgroups (for example ‘rain’) were made from the large group of data. A number of these specific analyses were based on a small group of data so that additional study is desirable.

5.4. Research Questions Answered

See section 5.2

5.5. Overall Assessment

The aim of the evaluation was to investigate the effects of the (dynamic) increase of the speed limit to 130 km/h on traffic situation, the environment and traffic safety in practice. By using different time windows and techniques in the experiment, a broad picture of the effects and possibilities of the (dynamic) change in speed limits could be obtained. This insight was obtained based on measurement data and the analysis methods developed. For this, data was researched to draw conclusions at the overall and a detailed level for each route and for specific circumstances.

The conclusions are dependent on the location and demonstrate that an increase of the speed limit on motorways from 120 km/h to 130 km/h leads to an increase of around 3 km/h in the speed actually driven. The effects on the traffic situation, perception and compliance are positive; on road safety and the environment they are slightly negative.

5.5.1. SAFETY

See 5.2

5.5.2. EFFICIENCY

See 5.2

5.5.3. THE ENVIRONMENT

See 5.2.
6. European Dimension: Transferability of the Results

In The Netherlands the maximum speed limit is increased to 130 km/h, like in many other European countries, such as Denmark, France and Italy. The evaluation study shows that the increase of the speed limit leads to somewhat higher driving speeds and slightly negative effects on safety and the environment. It is not obvious that these results are the same in other European countries due to different driving behaviour. That remains the main factor that determines the traffic situation and the consequences for safety and environment.