NorSIKT IP Final report
Recommendations and implementation plan

Photo: Knut Opeide, Norwegian Public Roads Administration
The main purpose of the NorSIKT IP project has been to ensure implementation of the main results in the previous NorSIKT I and NorSIKT II projects covering the following areas:

- Vehicle classification system
- Performance of different type of technologies for traffic data collection
- Procedures for testing traffic data collection equipment and vehicle detection systems
- Quality assurance of data collection equipment
- Specifications for purchase of equipment
- Harmonization of traffic parameters
- Nordic indexes for vehicle mileage and speed development

The project group has been working in close co-operation with the bodies responsible for the different topics mentioned above and has followed work carried out in those areas closely to ensure implementation of the NorSIKT “ideas” where it has been most appropriate and possible.

Within the Nordic countries there are different strategies and approaches when it comes to changes in the routines for collecting and presentation of traffic data. This has been recognized as a barrier within some areas and has been taken into account in the implementation process.

Even if many of the suggestions for harmonization already are implemented, there is still a need for co-ordination and knowledge exchange. The NorSIKT IP project group recommend that the Nordic co-operation within the traffic data area continue under the NordFoU umbrella.

**Keywords**
Traffic data, traffic parameters, traffic indexes, implementation
1 Introduction........................................................................................................................................... 4
  1.1 Background........................................................................................................................................ 4
  1.2 Working process .................................................................................................................................. 5
2 Summary of findings and recommendations ......................................................................................... 6
  2.1 Summary............................................................................................................................................. 6
  2.2 All estimates should be accompanied by error margins ................................................................. 8
  2.3 A harmonized Nordic definition of average daily road traffic ............................................................ 9
  2.4 Some notes on Time Mean Speed and Space Mean Speed .............................................................. 11
  2.5 Weighting data for average speed ..................................................................................................... 17
  2.6 Recommendations for Quality Declarations of Road Traffic Surveys .......................................... 20
  2.7 Nordic indexes ................................................................................................................................... 22
    2.7.1 Background ................................................................................................................................. 22
    2.7.2 A survey to the Nordic countries regarding harmonization .................................................... 23
    2.7.3 Delivery instructions for Nordic Indexes webpage ..................................................................... 24
  2.8 Day/date-model ................................................................................................................................. 26
3 Evaluation of the accuracy of traffic counting devices .......................................................................... 28
  3.1 Vehicle count (one vehicle class) ....................................................................................................... 28
  3.2 Vehicle Classification (two or more classes) .................................................................................... 29
    3.2.1 Description of TLS (BAST) evaluation .................................................................................... 29
    3.2.2 True Vehicle Accuracy (TVA) and Classified Vehicle Accuracy (CVA) .................................... 30
    3.2.3 The Motivation for Classified Vehicle Accuracy ....................................................................... 31
  3.3 The need for a standardized population .......................................................................................... 31
  3.4 Adjusting for different errors ........................................................................................................... 32
  3.5 Web application ............................................................................................................................... 32
4 Dissemination ........................................................................................................................................ 35
  4.1 Workshop: Technology and data sources, Arlanda 7th June 2017 ................................................. 35
  4.2 Natmec, Irvine, California June 2018 ................................................................................................. 36
  4.3 Workshop Data Acquisition, Arlanda 16th October 2018 .............................................................. 36
  4.4 Workshop: Speed, Arlanda 4th June 2019 ....................................................................................... 37
5 Implementation plan ............................................................................................................................ 38
  5.1 Summary of suggestions .................................................................................................................. 38
  5.2 Organizational challenges ................................................................................................................ 41
  5.3 Technology / devices / method ........................................................................................................ 41
  5.4 Recommendations to continuation of the Nordic co-operation within the traffic data area 43

References .................................................................................................................................................. 45
1 Introduction

1.1 Background

NorSIKT I and NorSIKT II have brought the traffic data professionals in the Nordic countries together and clearly shown the benefit from joint Nordic projects within the NordFoU cooperation.

The NorSIKT projects, both finalized in 2015, have produced important results within the traffic data area concerning:

- Vehicle classification systems
- Performance of different type of technologies for traffic data collection
- Procedures for testing traffic data collection equipment and vehicle detection systems
- Quality assurance of data collection equipment
- Specifications for purchase of equipment
- Harmonization of traffic parameters
- Nordic indexes for vehicle mileage and speed development

The ambitions with NorSIKT I and NorSIKT II have been to come up with findings that can lead to implementation and change in practice by harmonizing the methodology in the traffic data area in the Nordic countries. The work in NorSIKT I and NorSIKT II is well documented through several reports and a final report for both projects. They are the final reports that form the basis for the NorSIKT IP project.

To ensure that implementation take place, the project team has been agreed that the best way is to continue the Nordic collaboration with road traffic data through follow up projects. To ensure that the results are used and that the collaboration continues, the Nordic road authorities have started a follow-up project called NorSIKT IP.

The main purpose of NorSIKT IP is to ensure implementation of the main results in the NorSIKT I and NorSIKT II projects. The project group has been working in close co-operation with the bodies responsible for the different topics mentioned above and has followed the work carried out in those areas to ensure implementation of the NorSIKT “ideas” where it is most appropriate.

Traffic data technology has been steadily advancing, and it has been a goal for NorSIKT IP to stay updated on new solutions that can complement existing systems or replace traditional technology.

The Nordic countries will have different strategies and approaches when it comes to changes in the routines for collecting and presentation of traffic data. This has been taken into account in the implementation process. The recommendation regarding motor vehicle classification is an example where it is necessary to make national adjustments within an agreed framework.

Traffic data technology for capturing and collecting road traffic data is constantly evolving and a goal within NorSIKT IP is to keep the authorities updated on new solutions that can complement existing systems or replace traditional technologies.
One of the goals of NorSIKT IP is to establish permanent routines for calculating the Nordic speed barometer and Nordic barometer for change / development of the total traffic work. It is also a goal to harmonize definitions, statistical methods and quality declarations for other traffic parameters.

1.2 Working process

The project group determined it was necessary to hire a statistics company for academic support for the implementation of the project. The Swedish company Statisticon was selected for this assignment.

The assignment consists of the following tasks:

Traffic parameters
1. Develop a plan to harmonize the proposals in NorSIKT IP.
2. Develop a standard for quality declarations for traffic parameters.
3. Establish fixed routines for calculating Nordic parameters for Traffic Work's change / development and Speed change / development.
4. Develop a method and calculate the 2017 monthly Traffic Work Change on State Roads in Sweden according to the "date model" and produce a report describing the difference with the Swedish Transport Administration's existing "day model".

Traffic measurement systems and capture methods
5. Updating available techniques and fishing methods and note their possibilities and limitations.
6. Prepare proposals for quality standards
7. Proposal on how classification principles should be implemented.

Other
8. Support for conducting seminars and workshops
9. Provide support for final reporting of the project.

The reports delivered by Statisticon describe findings and form the basis for the recommendations and implementation plan.
2 Summary of findings and recommendations

2.1 Summary

Table 2.1.1 summarizes the status for the suggestions in the different areas covered by NorSIKT IP. More details can be found in the following chapters. Each section in chapter 2 and the whole chapter 3 are a summary of more detailed reports, referenced to in each section/chapter. The color coding and abbreviations in the cells should be read as follows:

- **No**: Country does not fulfill suggestion. No harmonization.
- **PL**: Country is planning to fulfill suggestion. No harmonization yet.
- **OK**: Country is partly fulfilling suggestion. Partial harmonization.
- **OK**: Country is fulfilling suggestion. Harmonization.

Table 2.1.1 is also presented in section 5.1 along with some country specific comments.
Table 2.1.1. Suggestions for harmonization from NorSIKT II and the status for each country at the end of NorSIKT IP (February 2020)

<table>
<thead>
<tr>
<th>Area</th>
<th>Suggestion</th>
<th>Explanation</th>
<th>DK</th>
<th>FI</th>
<th>FO</th>
<th>IS</th>
<th>NO</th>
<th>SE</th>
<th>See section</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>All estimates should be accompanied by error margins.</td>
<td></td>
<td>PL</td>
<td>PL</td>
<td>No</td>
<td>No</td>
<td>OK</td>
<td>OK</td>
<td></td>
<td>2.2</td>
</tr>
<tr>
<td></td>
<td>The sampling method chosen should be validated and well described and justified in the technical documentation (quality declaration).</td>
<td></td>
<td>OK</td>
<td>OK</td>
<td>PL</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td></td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Agree on a standard for quality declarations of all statistics produced.</td>
<td></td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td></td>
<td>2.6</td>
</tr>
<tr>
<td>ADT</td>
<td>Agree on conceptual definitions of ADT (including weekday, weekend and ADT for heavy vehicles).</td>
<td></td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td></td>
<td>2.3</td>
</tr>
<tr>
<td></td>
<td>If comparisons of weekday AADT are needed: use Tuesday 00.00 – Thursday 24.00 for weekday AADT for either for Aug-May or for the whole year Jan-Dec.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No harmonization</td>
<td>2.3</td>
</tr>
<tr>
<td></td>
<td>Harmonize the documentation of the methods for measuring AADT. In the documentation there should be a part that verifies the validity of the method used.</td>
<td></td>
<td>PL</td>
<td>PL</td>
<td>PL</td>
<td>No</td>
<td>OK</td>
<td>PL</td>
<td></td>
<td>High</td>
</tr>
<tr>
<td>Change in total vehicle mileage</td>
<td>All countries present monthly statistics per calendar month.</td>
<td></td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td></td>
<td>2.7</td>
</tr>
<tr>
<td></td>
<td>Sweden starts using the date model (in parallel with the day-model to investigate the differences).</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Not applicable</td>
<td>2.8</td>
</tr>
<tr>
<td></td>
<td>Find a part of the road network that is comparable between all Nordic countries and do the estimates for this network.</td>
<td></td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td></td>
<td>2.7</td>
</tr>
<tr>
<td></td>
<td>Each country should use the correct estimation method (perhaps by imputing missing data) or at least validate that the method used is a good estimate of the correct parameter.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Not dealt with within the project</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Every country should present actual estimates of the average speeds and not only indexes.</td>
<td></td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>No</td>
<td></td>
<td>2.7</td>
</tr>
<tr>
<td>Speed index</td>
<td>All countries agree that it is the free flow speed that should be estimated. Hence, an agreement on the conceptual level.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Not dealt with within the project</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Agree on how to accomplish this. E.g. delete data from congestion etc. like the Danish model or use the 85th percentile.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Not dealt with within the project</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Average speed should be defined as time mean speed and not space mean speed.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Both methods can be used</td>
<td>2.4</td>
</tr>
<tr>
<td></td>
<td>Calculate average speed per car and not per road section.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Method depends on selection process</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>Find a part of the road network that is comparable between all Nordic countries and do the estimates for this network.</td>
<td></td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td></td>
<td>2.7</td>
</tr>
</tbody>
</table>
2.2 All estimates should be accompanied by error margins

In the final report in NorSIKT II [9] from 2014, 16 suggestions for different aspects of harmonization among the Nordic countries were proposed. In the NorSIKT IP report with the title All estimates should be accompanied by error margins [11], suggestion 1 is examined. The report is summarized below. Suggestion 1 in the final report from NorSIKT II is shown below.

Suggestion 1: All estimates should be accompanied by error margins.

Table S1. Action needed to achieve suggestion 1.

<table>
<thead>
<tr>
<th>Action</th>
<th>Sweden</th>
<th>Norway</th>
<th>Denmark</th>
<th>Finland</th>
<th>Iceland</th>
</tr>
</thead>
<tbody>
<tr>
<td>AADT</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>Calculate</td>
<td>Calculate</td>
</tr>
<tr>
<td>Change in total vehicle mileage</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>Calculate</td>
<td>Calculate</td>
</tr>
<tr>
<td>Speed index</td>
<td>OK</td>
<td>OK</td>
<td>Calculate</td>
<td>Calculate</td>
<td>Calculate</td>
</tr>
</tbody>
</table>

As seen from the table, Sweden, Norway and Denmark fulfill the requirement regarding suggestion 1. It was decided during the project meeting in Trondheim October 10-11, 2017 that a short survey should be performed in Finland and Iceland. Since the Faroe Island also is a part of the NorSIKT IP project, they were also included in the survey. The purpose of the survey was to investigate plans regarding the possible implementation of calculation of error margins in different traffic parameters. The report presents results from the survey.

Below, we show three tables with a short version of the answers in the survey. The full answers to the survey is also presented in [12].

In appendix 3 in the report [9] links to webpages with methodology regarding calculation of error margins for traffic parameters are provided.

Table 2.2.1. Question 1a-c and short reply from each country

<table>
<thead>
<tr>
<th>Questions</th>
<th>Finland</th>
<th>Faroe Islands</th>
<th>Iceland</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question 1a. Do you intend to calculate error margins for AADT in the future?</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Question 1b. If Yes on question 1a, does your intention include all estimates of AADT? If not, please describe which delimitations you intend to use.</td>
<td>Only for total ADT.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question 1c. Do you have a time plan for when the calculations will be operational and error margins can be published? If Yes, please state the year when you think error margins will be published.</td>
<td>The error margin described above is published in the road data bank for each road section.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Questions</td>
<td>Finland</td>
<td>Faroe Islands</td>
<td>Iceland</td>
</tr>
<tr>
<td>-----------</td>
<td>---------</td>
<td>---------------</td>
<td>---------</td>
</tr>
<tr>
<td><strong>Question 2a.</strong> Do you intend to calculate error margins for the estimate of change in vehicle mileage in the future?</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td><strong>Question 2b.</strong> If Yes on question 2a, does your intention include all estimates of change in vehicle mileage? If not, please describe which delimitations you intend to use.</td>
<td>See reply in appendix 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Question 2c.</strong> Do you have a time plan for when the calculations will be operational and error margins can be published? If Yes, please state the year when you think error margins will be published.</td>
<td></td>
<td>2018</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Questions</th>
<th>Finland</th>
<th>Faroe Islands</th>
<th>Iceland</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Question 3a.</strong> Do you intend to calculate error margins for the estimate of speed index in the future?</td>
<td>No.</td>
<td>No</td>
<td>It is interesting but no plan exist</td>
</tr>
<tr>
<td><strong>Question 3b.</strong> If Yes on question 3a, does your intention include all estimates of speed indexes? If not, please describe which delimitations you intend to use.</td>
<td>No.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Question 3c.</strong> Do you have a time plan for when the calculations will be operational and error margins can be published? If Yes, please state the year when you think error margins will be published.</td>
<td>No</td>
<td>No, it has not been decided yet.</td>
<td></td>
</tr>
</tbody>
</table>

### 2.3 A harmonized Nordic definition of average daily road traffic

The report [5] is based on an investigation in a previous project (NorSIKT2, see [10]) where definitions of average daily traffic (ADT) in the Nordic countries were mapped and harmonized definitions were proposed. The report starts with a summary of these proposals. Thereafter, some adjustments are made to the proposed definitions, initiated at project (NorSIKT IP) meetings in Trondheim and Uppsala in 2017/2018.

The report proposes conceptual definitions of ADT, i.e., definitions that formulate what you want to measure, regardless of the current data collection method. Each country may then need to formulate - for each measure of average traffic - an operational definition where the parameter ADT is described in terms of what can be measured, given the data collection method used. For estimation of the parameters there exists a variety of methods not reported here. Thus, in this report, only conceptual definitions are proposed.

The following aspects on the ADT concept are discussed in the report.

- Which units should "ÅDT" be counted in?
• Should ADT be defined for total traffic or are specific definitions for individual vehicle classes (especially light and heavy traffic) required?
• Should ADT be defined for weekdays and weekends?
• Should ADT be counted in one or two directions?
• What time period should ADT be related to?

The report concludes with the following suggested harmonized definitions of average daily traffic (ADT).

**Definition of ADT**

A general definition of road traffic ADT is the following

*Suggested definition for road traffic ADT:*

ADT is the total traffic volume, counted as the number of objects, passing a "point" (or a road segment with constant traffic volume) over a period of time, divided by the number of days during the time period. The traffic across the road (in both directions) is counted. Objects may be one, or more, of vehicles, motor vehicles, bikes or persons.

**Comments**

By *vehicle* is meant a device on wheels, continuous belts, runners or the like which is arranged mainly for travel on the ground and does not run on rails.

By *motor vehicle* is meant a vehicle for which propulsion is provided with a motor, but not such an electric vehicle which is considered to be a bicycle.

**Definition of AADT**

The concept Annual Average Daily Traffic (AADT) is now defined as

*Suggested definition of road traffic AADT:*

AADT is the total traffic volume, counted as the number of objects passing a "point" (or a road segment with constant traffic volume) over a calendar year, divided by the number of days during the year. The traffic across the road (in both directions) is counted. Objects may be one, or more, of vehicles, motor vehicles, bikes or persons.

**Definition of ADT for heavy traffic**

Heavy road traffic ADT is defined as

*Suggested definition of heavy road traffic ADT:*

The heavy traffic ADT is the total traffic volume, counted as the number of motor vehicles with a maximum permissible weight greater than 3.5 tons (including total weight of a trailer, if any) passing a "point" (or a road segment with constant traffic volume) over a period of time divided by the number of days during the time period. The traffic across the road (in both directions) is counted.
Comment
Heavy traffic includes all types of motor driven vehicles with maximum permissible weight\(^1\) > 3.5 tons. This will mainly be lorries and busses. For road trains\(^2\) the maximum permissible weight for the trailer or semi-trailer is also included. The maximum permissible weight is the sum of the unladen vehicle weight and the load capacity.

Definition of ADT for weekdays and weekends
As definitions of weekday ADT and weekend ADT is suggested:

**Suggested definition of weekday ADT:**
The weekday ADT is the total traffic volume, counted as the number of objects passing a “point” (or a road segment with constant traffic volume) on weekdays over a period of time, divided by the number of weekdays during the time period. The traffic across the road (in both directions) is counted. Objects may be one, or more, of vehicles, motor vehicles, bikes or persons.

**Suggested definition of ADT for weekend traffic:**
ADT for weekend traffic is the total traffic volume, counted as the number of objects passing a “point” (or road segment with constant traffic volume) on weekends over a period of time divided by the number of weekend days during the time period. The traffic across the road (in both directions) is counted. Objects may be one, or more, of vehicles, motor vehicles, bikes or persons.

Comment
The definitions of “weekend” and “weekday” varies among the Nordic countries. These concepts are not harmonized since all countries have their own time series and, in addition, all countries have national holidays and therefore unique calendars.

2.4 Some notes on Time Mean Speed and Space Mean Speed

The memorandum “Some notes on Time Mean Speed and Space Mean Speed”, i.e. NorSIKT IP report [7], explains various terms relating to road traffic speed and travel time, as a foundation for the development of a shared comparable speed index for the Nordic countries.

The original report is organized in the following way. The basic speed terminology, Space mean speed and Time mean speed, is introduced in chapter 2, illustrated by examples from real-world data (chapter 3) and exercises (chapter 4) on artificial data. In chapter 5 a more theoretical approach is introduced and speed parameters are defined. In chapter 6 the advantages and disadvantages of Space Mean Speed and Time Mean Speed are summarized. Some further aspects on the estimation of

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\(^1\) Maximum permissible weight and maximum permissible laden weight are synonyms

\(^2\) Lorry with trailer or articulated vehicle (road tractor with semi-trailer)
Space Mean Speed are discussed in chapter 7 and additional terminology is introduced in chapter 8. In the present short summary of the original report, we focus on chapter 2, 5 and 6.

**Basic terminology**
When measuring the average speed of multiple vehicles, a distinction is made between Time mean speed (TMS) and Space mean speed (SMS). Time mean speed is based on momentary snapshots, whereas space mean speed is calculated from travel time duration over a road section.

**Point speed and Time Mean Speed**
Point speed is the speed that can be measured at a given point on a road section. It is also called point speed if the speed is based on time duration over a short road section (a few metres).

The average speed of multiple vehicles passing a point is called time mean speed.

The Time mean speed is the arithmetic mean of the vehicles point speeds:

\[
\bar{u}_p = \frac{u_{p1} + u_{p2} + \ldots + u_{pn}}{n} = \frac{\sum_{i=1}^{n} u_{pi}}{n}
\]

Where:
- \(\bar{u}_p\) = average point speed = time mean speed
- \(u_{pi}\) = point speed of vehicle \(i\)
- \(n\) = number of vehicles

**Travel speed and Space mean speed**
Travel speed is based on the time taken to travel a section of road and is defined as the length of a section divided by time duration across the section.

Travel speed of an individual vehicle is found by:

\[
u_{si} = \frac{d}{t_i}
\]

Where:
- \(u_{si}\) = Travel speed of vehicle no. \(i\)
- \(d\) = Length of road section (distance)
- \(t_i\) = Travel time for vehicle no \(i\)

The average travel speed for a stream of traffic is called Space mean speed\(^3\). When calculating the space mean speed for a stream of traffic, the time duration is the central parameter. The easiest way to explain this is to first calculate the average time duration, then calculate the average travel speed by dividing the length of the road section by average time duration.

---

\(^3\) The most common term is “space mean speed”, but “section speed” is also used.
Using the formula above, we can derive an expression for calculating the space mean speed using measurements of speed of individual vehicles. In many cases, this formula can be easier to use, but is not as easy to understand as the formula-based time duration. The result will however be the same.

\[
\bar{t} = \frac{t_1 + t_2 + \cdots + t_n}{n} = \frac{1}{n} \sum_{i=1}^{n} t_i
\]

\[
\bar{u}_s = \frac{d}{\bar{t}} = \frac{d}{\frac{1}{n} \sum_{i=1}^{n} t_i}
\]

Where:
- \( \bar{t} \) = Average travel time on road section
- \( \bar{u}_s \) = Space mean speed
- \( d \) = Length of road section
- \( t_i \) = Travel time for vehicle \( i \)
- \( n \) = Number of vehicles

Using the formula above, we can derive an expression for calculating the space mean speed using measurements of speed of individual vehicles. In many cases, this formula can be easier to use, but is not as easy to understand as the formula-based time duration. The result will however be the same.

\[
\bar{u}_s = \frac{d}{\bar{t}} = \frac{\frac{1}{n} \sum_{i=1}^{n} t_i}{\frac{1}{n} \sum_{i=1}^{n} u_{si}} = \frac{1}{n} \sum_{i=1}^{n} \frac{d}{u_{si}}
\]

Where:
- \( \bar{u}_s \) = Space mean speed
- \( d \) = Length of road section
- \( u_{si} \) = Travel speed of vehicle \( i \)
- \( t_i \) = Travel time for vehicle \( i \)
- \( n \) = Number of vehicles

Note that \( \bar{u}_s \) is the harmonic mean of speeds for individual vehicles \( u_{si} \)

**Relationship between Time Mean Speed and Space Mean Speed.**

The time mean speed for a stream of traffic will always be greater than or equal to the space mean speed, assuming the speed remains constant across the road section. Thus, if a road section has a constant speed level, the time mean speed will be greater than the space mean speed. This is because when calculating space mean speed, slow-moving vehicles are given more weight than in the calculation for time mean speed. In the calculation of space mean speed, the time duration is weighted rather than the speed. How great the difference between the two speeds will be depends on the spread of the individual vehicles, among other things.

The formula for the relationship was developed by Wardrop [17]:

\[
\frac{\bar{u}_s}{\bar{u}_s} = \frac{d}{\bar{t}} = \frac{1}{n} \sum_{i=1}^{n} \frac{d}{u_{si}}
\]
The difference between time mean speed and space mean speed across a road section with constant speeds will also depend on the spread of the speeds. The time mean speed and space mean speed will only be equal if the variance is zero, i.e. if all vehicles are travelling at a constant and equal speed.

**A theoretical perspective**

A certain amount of total vehicle mileage is done at speed \( u \), along with a corresponding amount of travel time. These amounts can be described as statistical distributions, where the average speed can be interpreted as the expected value for each distribution. Time mean speed (TMS) can therefore be regarded as the mean value of the total vehicle mileage distribution of the speeds, while space mean speed (SMS) is the mean value of the travel time distribution of the speeds. The theory behind these results is presented in the original report following the presentation in Danielsson (1999).

First, a number of terms and definitions are introduced. Traffic is normally described as a phenomenon in both time and space. Therefore, we assume that each point on the road network we are studying directly corresponds to a point \( x \) in the interval \([0, X]\), where \( X \) is the road network’s total length. The road network is examined during a time interval \([0, T]\), and \( t \) represents a point in time in this interval. The total area \([0, X] \times [0, T]\) is called \( A \). Figure 2.4.1 shows \( A \).

Figure 2.4.1. Illustration of traffic distribution in time and space, \( A = [0, X] \times [0, T] \)

\[
\bar{u}_p = \bar{u}_x + \frac{\sigma_{\bar{u}_x}}{\bar{u}_x}
\]

Where:
- \( \bar{u}_p = \) Time mean speed
- \( \bar{u}_x = \) Space mean speed
- \( \sigma_{\bar{u}_x}^2 = \) Variance (spread) of travel speeds for vehicle \( i \)

---

*Vehicle mileage is measured as kilometres driven*
**Flow** is defined as the number of vehicles that pass a certain point \( x \) on the road during period \([0; T]\).

Flow is represented by \( q(x; T) \).

*Concentration* (or density), is defined as the number of vehicles on the road \([0, X] \) at any instant \( t \).

Concentration is represented by \( r(t; X) \).

Total vehicle mileage in area \( A \) is defined as

\[
Q(A) = \int_{0}^{X} q(x; T) \, dx
\]

Total vehicle mileage is illustrated in Figure 2.4.2. The points on the horizontal axis represent crossroads or junctions where the flow increases and decreases. Total vehicle mileage is thus the integral of flow function \( q(x; T) \) over interval \([0; X]\) or, alternatively, the green area in Figure 2.4.2.

**Figure 2.4.2.** Total vehicle mileage over period \( T \) on a hypothetical road network of length \( X \)

![Flow diagram](image1)

**Travel time** in \( A \) is defined as

\[
R(A) = \int_{0}^{T} r(t; X) \, dt
\]

This function is illustrated in Figure 2.4.3. The concentration function \( r(t; X) \) changes over time when vehicles join or leave the road. The travel time taken to produce the total vehicle mileage \( Q(A) \) is the integral of the concentration function over interval \([0; T]\) or, alternatively, the red area in Figure 2.4.3.

**Figure 2.4.3.** Travel time on a hypothetical road network of length \( X \) over period \( T \)

![Concentration diagram](image2)

The mean speed \( \mu(A) \) can now be defined as
\[ \mu(A) = \frac{Q(A)}{R(A)} \]

Note that \( Q(A) \) is the total distance covered by all traffic over the time period, and \( R(A) \) is the travel time used for this. The mean speed is therefore defined in terms of “distance divided by time”. This conforms with the usual physical definition of speed, the difference here being that distance and travel time are aggregated for many vehicles.

Using the above terminology, it is shown in the original report that space mean speed can be defined as the expected value of the travel time distribution of the speeds. Similarly, it is shown that the expected value of the total vehicle mileage distribution of the speeds is the time mean speed. The interpretation of the two speed measures is discussed and it is concluded that SMS has a clear interpretation as the average speed of the road traffic, as given by \( \mu(A) \). What TMS estimates is more difficult to interpret.

It is also shown in the original report how the theoretical results can be applied in a real-world example.

**Advantages and disadvantages of TMS and SMS**

When choosing between TMS and SMS, there are a number of arguments for using SMS for speed studies.

- SMS estimates a parameter, \( \mu(A) \), which has a clear interpretation as the average speed of the road traffic. What TMS estimates is more difficult to interpret.
- SMS uses the physical definition of speed: “distance divided by time” or “total vehicle mileage divided by total travel time”.
- The so-called fundamental identity, i.e. the flow is equal to the speed multiplied by the travel time, is valid only if the speed is measured with SMS.
- The time vehicles spend on successive road sections can be added together, whereas speeds cannot. SMS is based on travel times and therefore has an advantage when it comes to making accurate estimations. TMS, which is based on adding speeds together, therefore has a built-in problem structure.

On the other hand:

- The difference between TMS and SMS is often small if we are not concerned about congestion problems.
- Estimations of changes in speed, for example speed index, based on TMS and SMS are likely to be very similar.
- We may also be forced to choose one method over the other if the measurement equipment or previously collected data does not allow for calculation of both. The Swedish speed index, for example, uses data saved as arithmetical mean values of vehicle speeds per hour. SMS can thus not be calculated, but TMS should give a very similar result.
- Wardrop [17] points out that measurements of travel time often have a greater variability than measurements of speed. This means that the precision of TMS is often greater than that of SMS.

There are clearly advantages and disadvantages of both SMS and TMS. Perhaps the most important thing is to stick to the same method when making repeated measurements.
2.5 Weighting data for average speed

In the final report in NorSIKT II [6] from 2014, 16 suggestions for different aspect of harmonization among the Nordic countries were proposed. Suggestion 15 was: “Calculate average speed per car and not per road.” The suggestion indicates that the number of cars should be used as weights in calculations when e.g. aggregating data and calculating average speed from several measurement points. If this suggestion would be implemented, then there would be a harmonization among the Nordic countries regarding weighting method. However, when this suggestion was more deeply discussed in the implementation phase (NorSIKT IP) no general agreement could be reached. Instead, some counterexamples were discussed when other weighting systems could be motivated.

In the NorSIKT IP report [14], written in Swedish, one specific counterexample is given: the Swedish system for calculation of a national (and regional) speed index on a monthly basis (in Swedish “Hastighetsindex”). In the Swedish speed index weighting is done according to road, not per car. The report gives a background to the speed index, since the motivation of the weighting system can be found in the origin of the index. Below, a summary of the background with the origin of the speed index is given as well as the motivation to the weighting system. But first, we summarize some conclusions from the discussion in the report.

Conclusions of the NorSIKT IP report

It is concluded that how weighting is done depends on several factors. If the road sections (or measurement points) are selected by a probability sample, the most natural weighting is according to the sampling design, i.e. the inverse of the inclusion probability. If the road sections are selected by other means, i.e. not probability sampling, one has to motivate, and argue for, the used weighting system when aggregating data. If one, for example, have a certain number of measurement points (not selected by probability sampling) located at the same distance from each other (e.g. X km between each measurement point), it can be motivated to calculate average speed by weighting with number of cars (i.e. each car has the same weight). In other situations, this principle might not be recommendable. Hence, it is difficult to recommend a general principle to always calculate average speed by car and not by road. The weighing method ought to be linked to how the measurement points, or road sections, are selected and the purpose of the speed measure.

In the report [14], it is stated that weighting can be done according to several factors:

(i) Road section
(ii) Number of cars
(iii) Vehicle mileage
(iv) Travel time
(v) Sampling design (inverse of inclusion probability)

---

5 If this weighting is used, it is also normal to account for the number of cars passing the measurement point. This means that the calculations in fact take the number of cars passing into account, but the weighting system is not explicitly formed by numbers of cars. The weighting system is explicitly formed by the the sampling design. In one sense one might say that the weighting with cars enters implicitly into the calculations.

6 If twice as many cars passes measurement point A than point B, then the speeds at point A will weight twice compared to the speeds at point B.
Summary of the speed index in Sweden, the counterexample in [14]

As mentioned above, the weighting in the Swedish speed index is done according to road, not car. In the report [14] this is used as a counterexample against the suggestion to always “weight by car”. The motivation for the weighting system can be found in the origin of the index.

During 1996-2004 large speed surveys on the whole national road network\(^7\) was performed by the Swedish Transport Administration (in Swedish Trafikverket). The survey was based on a probability sample of measurement points\(^8\) and produced estimates of speed level on a national level, as well as for various domains: for example, regional divisions and speed limits. The survey was stopped 2004 due to cost reasons. However, there was still a need for monitoring the speed on the national road. After investigations, the solution became a speed index for the state road networked that was based on data collected within the already existing system for estimating change in vehicle mileage (in Swedish TF-systemet).

In the TF-system, data is collected continuously during the whole year at 83 measurement points. The traffic flow, to calculate change in vehicle mileage, is the most important variable and speed data comes as a by-product. This data cannot be used to estimate speed levels on a national level but has showed useful for estimating change in speed levels; i.e. a speed index. The speed index has been published on the Swedish Transport Administration web site since 2008 and times series are available monthly from 1996 and forward.

Since the speed index is based on another road traffic system, change in vehicle mileage (TF-system), the survey is not optimaly design for measuring speed. In the TF-system road sections are drawn by a probability sample\(^9\) where the inclusion probability is proportional to the vehicle mileage performed on the road section\(^10\). This means that on roads with high vehicle mileage there are more measurement points.

Since the measurement points are drawn by a probability sample, a natural weighting factor would be according to the sampling design (the inverse of the inclusion probability), according to what is stated above. But since the TF-system is designed for another parameter, change in vehicle mileage, it was concluded in the investigations in early 2000 before the speed index was launched that this weighting was not appropriate.

Instead, weighting was done according to road. This can be motivated by the following argument:

- The selected measurement points are overrepresented on road sections with high vehicle mileage. This is the purpose of the sampling design for the TF system. If each car (which passes the measurement point) were to be weighted equally, the speed performed on roads with high vehicle mileage would become dominant in the speed index estimation. The speed of road sections with high vehicle mileage would then weigh relatively heavier than the vehicle mileage performed on the entire road network. It is not obvious that the speed of this type of roads would better represent the entire road network. Therefore, weighing each car equally would probably lead to a poorer estimate of a speed index parameter for the whole road net-

---

\(^7\) That is both the state road network as well as the municipal road network.

\(^8\) Approximately 1600 on the state road network and 800 on the municipality road network.

\(^9\) By a two stage probability sample procedure.

\(^10\) This information is available for all road sections in the Swedish road network, some estimated are however quite old.
work. Instead, weighting each road section equally has shown to better estimate how speed develop over time.

In the report [14], the estimation procedure is described in technical terms. The estimation procedure involves a post-stratification procedure not described in this summary.
2.6 Recommendations for Quality Declarations of Road Traffic Surveys

This report [6] contains common guidelines for documenting the quality of statistical surveys in the field of road traffic. The quality concept suggested here is based on the regulations drawn up by Statistics Sweden (the Swedish central bureau of statistics, see [15]) and applicable to the Swedish official statistics. The quality concept covers the main areas relevance, accuracy, timeliness, availability and clarity and comparability and coherence.

Some recasting of Statistics Sweden’s regulations has been made to suit traffic statistics applications. The ambition is that the recommendations should lead to documents describing different aspects of quality, which can be understood by external users and non-statisticians.

The memorandum begins with two sections explaining some trade terms used in the survey methodology, such as population, variable, parameter, frame, sampling, coverage and missing items. Then follow the recommendations presented under a set of headings. Under each heading it is suggested what should be written, sometimes accompanied by a motivation. The headings are

<table>
<thead>
<tr>
<th>1</th>
<th>Relevance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Purpose and information needs</td>
</tr>
<tr>
<td>1.1.1</td>
<td>Purpose of the statistics</td>
</tr>
<tr>
<td>1.1.2</td>
<td>User information needs</td>
</tr>
<tr>
<td>1.2</td>
<td>Content of the statistics</td>
</tr>
<tr>
<td>1.2.1</td>
<td>Object, population and sampling frame</td>
</tr>
<tr>
<td>1.2.2</td>
<td>Variables</td>
</tr>
<tr>
<td>1.2.3</td>
<td>Parameters</td>
</tr>
<tr>
<td>1.2.4</td>
<td>Domains of study</td>
</tr>
<tr>
<td>1.2.5</td>
<td>Reference period</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Sources of inaccuracy</td>
</tr>
<tr>
<td>2.1.1</td>
<td>Sampling</td>
</tr>
<tr>
<td>2.1.2</td>
<td>Coverage</td>
</tr>
<tr>
<td>2.1.3</td>
<td>Measurement</td>
</tr>
<tr>
<td>2.1.4</td>
<td>Missing items (“Nonresponse”)</td>
</tr>
<tr>
<td>2.1.5</td>
<td>Processing</td>
</tr>
<tr>
<td>2.1.6</td>
<td>Estimation</td>
</tr>
<tr>
<td>2.1.7</td>
<td>Model assumptions and model validation</td>
</tr>
<tr>
<td>2.2</td>
<td>Preliminary statistics compared to final statistics</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3</th>
<th>Timeliness</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>Production time</td>
</tr>
<tr>
<td>3.2</td>
<td>Frequency</td>
</tr>
<tr>
<td>3.3</td>
<td>Punctuality</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4</th>
<th>Availability and Clarity</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1</td>
<td>Forms of dissemination</td>
</tr>
<tr>
<td>4.2</td>
<td>Access to microdata</td>
</tr>
<tr>
<td>4.3</td>
<td>Presentation</td>
</tr>
<tr>
<td>4.4</td>
<td>Documentation</td>
</tr>
</tbody>
</table>

<p>| 5 | Comparability and Coherence |</p>
<table>
<thead>
<tr>
<th>5.1</th>
<th>Comparability over time</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.2</td>
<td>Comparability between domains</td>
</tr>
<tr>
<td>5.3</td>
<td>Coherence with other statistics</td>
</tr>
<tr>
<td>5.4</td>
<td>Numeric match</td>
</tr>
<tr>
<td>5.5</td>
<td>Comparability and coherence with surveys of the other Nordic countries</td>
</tr>
</tbody>
</table>
2.7 Nordic indexes

2.7.1 Background

The Nordic countries have, within the different phases of the NorSIKT, project tried to establish a way to publicly present (estimates of) traffic parameters. In this context often called Nordic indexes. This work involves two major tasks:

1. The collection of statistical data regarding traffic parameters from each country and shapefiles regarding the road network
2. A platform, or more precisely a web platform, for publication of the indexes

The first steps towards publication of Nordic indexes was taken 2014. These efforts resulted in that some, but not all, of the Nordic countries delivered data on traffic parameters. A web platform was also created where the road networks were displayed on a map together with some graphs with time series of some traffic parameters.

Within NorSIKT IP, the ambition was to

- “Establish fixed routines for calculating Nordic parameters for the change and development of vehicle mileage and change and level of speed”.

To summarize the work in NorSIKT IP, we conclude that today there exists a fixed routine for delivery of statistical data regarding traffic parameters and also regarding shapefiles, see [13]. That concerns point 1 in the list above. Regarding point 2, a web platform, the only existing platform today (as of August 2019) is the same web platform as the one that was constructed within earlier NorSIKT phases. Moreover, this web page has not been updated with the more recent data regarding traffic parameters. The plan for the future is to build a new web platform for presentation and visualization of traffic parameters and road networks. The ideas and plans for this future step are described more in chapter 5.

Below we give a brief summary of the work that was performed within NorSIKT IP to establish fixed routines for Nordic parameters. In NorSIKT II [9] from 2014, 16 suggestions for different aspect of harmonization among the Nordic countries were proposed. During a project meeting in Trondheim in October of 2017 it was decided that six of the 16 suggestions should be grouped together and handled within the Nordic Indexes[14]. As a first step in this process, a survey to all Nordic countries was performed to investigate the willingness and possibilities each country had regarding a harmonization. The result from the survey is documented in [12] and summarized below.

Based on the result from the survey, and following discussions during project meetings, an instruction for regularly delivery of statistical data and shapefiles was completed, see [13]. This report is also summarized below.

11 Shapefiles is used to construct interactive maps e.g. on a web platform (for example like Google maps)
12 See https://arcg.is/18W8ya
13 Freely translated. The orginal swedish wording was “Etablering av fasta rutiner för beräkning av nordiska parametrar för Trafikarbetets förändring/utveckling och Hastighetsförändring/utveckling”
14 This part of NorSIKT IP was called task 3.
2.7.2 A survey to the Nordic countries regarding harmonization

There were six suggestions for harmonization from NorSIKT II [9] that was investigated in the survey. The suggestions were

- Regarding change in total vehicle mileage
  - Suggestion 7: All countries present monthly statistics per calendar month.
  - Suggestion 9: Find a part of the road network that is comparable between all Nordic countries and do the estimates for this network.

- Regarding speed index
  - Suggestion 11: Every country should present actual estimates of the average speeds and not only indexes.
  - Suggestion 12: All countries agree that it is the free flow speed that should be estimated. Hence, an agreement on the conceptual level.
  - Suggestion 13: Agree on how to accomplish this. E.g. delete data from congestion etc. like the Danish model or use the 85th percentile.
  - Suggestion 16: Find a part of the road network that is comparable between all Nordic countries and do the estimates for this network.

In the report [12] the results from the survey is presented. After the report was finalized different aspects were discussed and revisions were made, notably the definition of a harmonized road network. This means that some of the conclusions in the report are no longer valid. The delivery instructions [13] contains what all countries agreed upon. Below, we provide comments regarding the suggestions and whether there is a harmonization.

**Suggestion 7: All countries present monthly statistics per calendar month (change in VM).**
In the most recent delivery of statistical data\(^\text{15}\) for Nordic Indexes, the following countries did not present monthly statistics regarding change in VM: Faroe Islands, Finland and Iceland. The following countries did present monthly statistics regarding change Denmark, Norway and Sweden. Hence, there is no harmonization regarding this suggestion.

**Suggestion 9: Find a part of the road network that is comparable between all Nordic countries and do the estimates for this network (change in VM).**
In the early work in NorSIKT II in 2014 regarding Nordic Indexes, the E-roads\(^\text{16}\) were selected to be the most comparable road network. After scrutiny and discussions in NorSIKT IP, it was realized that the E-roads are not fully comparable\(^\text{17}\). The only way to find a fully comparable road network is a highly delimited, and thus limited, road network\(^\text{18}\). Such a delimited road network is not fruitful for comparisons. Hence, it was decided that each country should decide by themselves what constitutes the appointed road network regarding Nordic indexes. This road network would then not be comparable, but

---

\(^{15}\) This data is regarding 2018 and earlier years.

\(^{16}\) Or comparable roads if a country does not have E-roads

\(^{17}\) For example, in Denmark the E-roads are almost 100 percent motorways, this is not the case in e.g. Norway.

\(^{18}\) For example, roads with speed limit 70 km/h outside urban areas (which has to be defined).
each country should document the road network which will be helpful when interpreting possible differences in the indexes. This is what is stated in report [12]. However, a revision back to using E-roads as road network for vehicle mileage was decided in NorSIKT IP. This is stated in the delivery instruction [13]. Regarding suggestion 9, we can state that there is a harmonization since E-roads are used as road network. But the E-roads are not fully comparable between countries.

Suggestion 11: Every country should present actual estimates of the average speeds and not only indexes.
In the most recent delivery of statistical data\textsuperscript{19} for Nordic Indexes, the following countries did not present estimates of the average speed: Finland, Iceland and Sweden. The following countries did present estimates of the average speed: Denmark, Faroe Islands and Norway. Hence, there is no harmonization regarding this suggestion.

Suggestion 12: All countries agree that it is the free flow speed that should be estimated. Hence, an agreement on the conceptual level. Suggestion 13: Agree on how to accomplish this. E.g. delete data from congestion etc. like the Danish model or use the 85th percentile.
It was decided that each country will individually decide if they should use free flow speed or not. The only countries that use free flow speed are Denmark and the Faroe Islands. Hence, there is no harmonization regarding this suggestion.

Suggestion 16: Find a part of the road network that is comparable between all Nordic countries and do the estimates for this network.
This is the same suggestion as suggestion 9, but regarding speed parameters instead of vehicle mileage. Regarding speed parameters, it was decided (contrary to vehicle mileage) that each country should individually decide which road network that should be appointed. The appointed road network chosen among the Nordic countries is primarily the state-owned road network. In that sense, there is some sort of harmonization, but the state owned road network differs between countries. For example, in some countries the motorways constitute a large share of all state roads but in other countries they constitute only a small part.

Based on the report [12] and project-meeting decisions regarding the suggestions described above, a document with delivery instructions [13] was formed. Below we give a summary of key aspects in the delivery instructions.

2.7.3 Delivery instructions for Nordic Indexes webpage
The current version of the document with delivery instructions [13] is version 1.2. This version was preceded by a first final version 1.0. Due to revisions the new version 1.2 was formed. We do not go into detail here about the difference between the versions\textsuperscript{20}. The delivery instructions in version 1.2, i.e. document [13], is organized by the following chapters:

1. Introduction
2. Description of road network
3. Shapefiles

\textsuperscript{19} This data is regarding 2018 and earlier years.

\textsuperscript{20} It can be mentioned that the road network for VM was change between version 1.0 and 1.2.
4. Statistical data

Chapter 1 is an introduction which gives an overview of what should be delivered. Here is also explained the difference between version 1.0 and version 1.2. In chapter 2 the road network is described in detail. It is also stated that each country should provide information about the length in km of the road network (both the E-road for VM and the appointed road network for speed). The length should be divided into speed limits and road types, e.g. number of km of motorways with speed limit 110 km/h. The format for delivery as well as file name convention is stated in this chapter.

Chapter 3 specifies the layers and associated tables for the shapefiles that describes the road network. The coordinate system for shapefiles, file naming convention, time plan for delivery as well as how to delivers is also stated.

Chapter 4 specifies which statistical data, i.e. the estimates of traffic parameters, that should be delivered. These data constitute the Nordic indexes. In summary the following should be delivered:

- **Speed:**
  - monthly figures for speed levels and speed index for roads on the appointed road network divided into speed limits 50, 60, 70, 80, 90, 100, 110 and 120 km/h. For speed index a total index for the whole network should also be delivered.
  - Starting period for speed level is January 2011. Starting period for speed index is January 2012.
- **Change in vehicle mileage (monthly figures):**
  - Monthly figures for two different parameters: (i) The monthly change in vehicle mileage when one month current year is compared to the same month previous year, and (ii) the monthly change in vehicle mileage when a 12-month period current year is compared to the same 12-month period previous year.
  - Starting period is January 2012.
- **Vehicle mileage (yearly figures):**
  - The total vehicle mileage per year for the E-roads
  - Change in total vehicle mileage per year for the E-roads
  - Total road length for the E-roads per year
  - Total vehicle mileage per km per year

Regarding the traffic parameters above, point estimates should be provided and not interval estimates (confidence intervals) To organize the delivery of the data a file template in Excel is provided. The file naming convention, variable naming convention and time plan and periodicity for delivery is stated in chapter 4.

All countries deliver what they can. Hence, it is acceptable if a country cannot deliver e.g. speed index. In that sense all traffic parameters are non-mandatory.

Both shape files and statistical data should be delivered once a year, in March. For example, in March 2019 data regarding 2018 should be delivered. The shape file should preferably be extracted close to January 1 each year.

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21 Since speed index for e.g. January 2012 is the ratio between January 2012 and 2011, which is the starting period for speed levels, it is not required to deliver speed index for 2011.
2.8 Day/date-model

Introduction
In this project Statisticon was assigned to compare the Swedish \textit{day-method} for measuring change in vehicle mileage with the \textit{date-method} used in the other Nordic countries. The two methods differ in the way dates are matched from the current year to the comparison year. The whole report can be found in [4].

Data
The data used to evaluate the two methods are number of cars from 83 measure points in Sweden. For each day, hourly measures are reported giving 24 estimates of number of cars each day at respective measure point. The available data ranges from January 2012 to September 2017. Since the change in vehicle mileage is compared with the previous year, the earliest comparing possible is for January 2013.

The Date-method
In the date-method each day in a specific month is matched to the same date the same month a year before. So the 3\textsuperscript{rd} of April is matched with the 3\textsuperscript{rd} of April the previous year. This means that the matching of individual days can be rather non-comparable. For one year the 3\textsuperscript{rd} of April could be a weekday but the previous year it could be a weekend. Or the 3\textsuperscript{rd} of April could be a holiday during Easter one year that is matched with a regular weekday the previous year. However, since there are approximately 30 days that are matched each month in most cases the difference observed in the matching at the day-level will even out over a whole month. The main difference can occur when Easter is in one month one year but in another month the previous year. An observed difference in vehicle mileage with this method could then be due to a shift when Easter takes place rather than a change in ‘true’ vehicle mileage.

The Day-method
In the day-method the ambition is to reduce the effect of holidays and number of weekends per month. Hence, if the 3\textsuperscript{rd} of April is the first Saturday of the month the present year it's matched with the first Saturday the previous year. And big holidays, e.g. Maundy Thursday, are matched with Maundy Thursday the previous year.

So the Day-method strives to reduce the effect of holidays and that the same month can have different number of weekdays different years. For the big holidays there are clear rules how to do the matching. However, for regular weekends and weekdays there will be a subjective component in the decision how to do this matching.

Results
For the comparison two different parameters were used:
   a) \textit{the monthly change}, a comparison of the vehicle mileage for one month compared to the corresponding time period the year before and
   b) \textit{the twelve-month comparison}, is a similar comparison but for a twelve-month period compared to the corresponding twelve months the year before.
In figure 2.8.1 comparison for the monthly change is presented.

Figure 2.8.1. Monthly change in vehicle mileage day- and date-method (R= percentage change)

Each point represents an estimate of the change in vehicle mileage compared to the same month 12 months ago. In the main report [4], similar results are presented for the twelve-month comparison. The results show that the two methods generally give similar results. However, in the monthly comparison, some months showed rather large differences between the methods (e.g. January 2017). These differences are mainly due to the day-method using days outside of the month of the comparison year which are not included in the date-method. The 12-month comparisons show small differences between the two methods. This could be expected as the difference in which days that are included in each method will decrease.

Conclusion
This report is not able to show which method best measures the true value of vehicle mileage. However, it is shown that the difference between the models is generally small. The day-method have some rules for the matching of days but also room for subjective judgements in the matching process. This means that the model requires a subjective assessment from the person making the matching list. This makes the method dependent on the person making the list and could lead to systematic differences when a new person is assigned to making the matching list.

The date-method on the other hand has no subjective assessments and the comparisons over years are for the same calendar-periods. This report recommends the date-method over the day-method. This recommendation is due to this report showing that the differences between the two methods over time are small and the date-method is the more objective of the two methods since no subjective judgement is needed in the matching of days.
3 Evaluation of the accuracy of traffic counting devices

This part of the project was initially divided into three different tasks.

1. Update available techniques and their possibilities and limitations.
2. Develop a suggestion of a standard for evaluating the accuracy of a counting device.
3. Suggestion to how classification principles shall be done.

After some initial work on all three parts that were presented at a meeting in Uppsala (January 2018), the NorSIKT group decided to focus mainly on the second task. Some results regarding the other two tasks can be found in [3].

3.1 Vehicle count (one vehicle class)

Vehicle count and classification are closely related. Vehicle count could be seen as a special case of classification with only one vehicle class, i.e. classify as vehicle or not vehicle. The case of just counting the total number of vehicles passing a measurement point is considerably less complicated compared to the multiple vehicle class case and is therefore treated separately here. The simplest measure is the accuracy of the device.

\[
\text{Accuracy} = \frac{\text{Number of counted vehicles}}{\text{Number of true vehicles}} \times 100
\]  

A challenge is how to handle ghost vehicles i.e. a registration without any vehicle passing the device (could be due to e.g. animals passing or weather events). Assume the device misses five vehicles but also register five ghost vehicles then the number of registered vehicles will be identical to the number of passing vehicles even though the device missed five vehicles. The measure of accuracy will be 100%, regarding the total count, but the device is not perfectly accurate. So even with the simplest measure of accuracy there could be methodological challenges that needs to be handled.

Two other commonly used measures are the Mean Absolute Error (MAE) and the Mean Absolute Percent Error (MAPE).

\[
\text{MAE} = \frac{1}{n} \sum_{i=1}^{n} |T_i - M_i| \times 100 \quad (3.2)
\]

\[
\text{MAPE} = \frac{1}{n} \sum_{i=1}^{n} \left| \frac{T_i - M_i}{T_i} \right| \times 100 \quad (3.3)
\]

\[T_i = \text{True number of vehicles for measurement interval } i\]

\[M_i = \text{Measured number of vehicles for measurement interval } i\]

\[n = \text{Number of measurement intervals}\]
An important aspect to consider when using these measures is that they are dependent on the choice of time-span (number of measurement intervals). The error rate will in general be different if, for example, the evaluation is done per hour, day, week, month or year. This characteristic is illustrated with several examples in [3].

### 3.2 Vehicle Classification (two or more classes)

#### 3.2.1 Description of TLS (BAST) evaluation

A popular method for evaluation originates from the Federal Highway Research Institute in Germany, see [2], and will be denoted the TLS evaluation. To explain the measures used, table 3.2.1 will be used as an example of a classification. Each row contains the number of true vehicles per class. The columns are how these vehicles were classified according to the device. For example, \( M_{1,1} \) represents the number of true motorcycles which were also classified as motorcycles. The value \( M_{1,2} \) represents the number of true motorcycles which were classified as cars.

<table>
<thead>
<tr>
<th>Vehicle class</th>
<th>Total</th>
<th>Motorcycle</th>
<th>Car</th>
<th>Bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motorcycle</td>
<td>( S_1 )</td>
<td>( M_{1,1} )</td>
<td>( M_{1,2} )</td>
<td>( M_{1,3} )</td>
</tr>
<tr>
<td>Car</td>
<td>( S_2 )</td>
<td>( M_{2,1} )</td>
<td>( M_{2,2} )</td>
<td>( M_{2,3} )</td>
</tr>
<tr>
<td>Bus</td>
<td>( S_3 )</td>
<td>( M_{3,1} )</td>
<td>( M_{3,2} )</td>
<td>( M_{3,3} )</td>
</tr>
<tr>
<td>Ghost</td>
<td>( S_4 )</td>
<td>( M_{4,1} )</td>
<td>( M_{4,2} )</td>
<td>( M_{4,3} )</td>
</tr>
<tr>
<td>Total</td>
<td>( T )</td>
<td>( Z_1 )</td>
<td>( Z_2 )</td>
<td>( Z_3 )</td>
</tr>
</tbody>
</table>

The evaluation is based on two measures denoted \( E_1 \) and \( E_2 \), explained below.

\[ E_{1\text{motorcycle}} = \frac{M_{1,1}}{S_1} \quad (3.4) \]

\( E_1 \) is the proportion of motorcycles that is correctly classified. Furthermore, in TLS classification, a 95% confidence interval is calculated based on the binomial distribution for \( E_1 \). The lower limit of this confidence interval is denoted the “statistically relevant detection rate”. This lower limit is used to evaluate whether the measuring device is approved or not for a specific class.

\( E_2 \) is also evaluated for each vehicle class. \( E_2 \) for motorcycle is example is calculated as

\[ E_{2\text{motorcycle}} = \frac{S_1 - M_{2,1} - M_{3,1} - M_{4,1}}{S_1} \quad (3.5) \]

It is the number of true motorcycles minus the sum of the number of vehicles incorrectly classified as motorcycles divided by the true number of motorcycles. We can rewrite the equation as

\[ E_{2\text{motorcycle}} = 1 - \frac{M_{2,1} + M_{3,1} + M_{4,1}}{S_1} \quad (3.6) \]
Even though there is a clear definition of $E_2$, it could be a bit difficult to understand this measure. ($E_2$ can e.g. be negative.) Similarly, to $E_1$ a 95% confidence interval is calculated for $E_2^{22}$.

Another aspect of $E_2$ is that it’s dependent of the mix of vehicles passing the measuring device. To control for this the calculations are, in general, based on a standardized to a normal population (see below).

In our analysis of different measures, we derived what we considered to be the best measures to use, TVA and CVA.

### 3.2.2 True Vehicle Accuracy (TVA) and Classified Vehicle Accuracy (CVA)

Since $E_2$ is difficult to interpret we suggest two ‘new’ concepts for the evaluation of a traffic counting device. The True Vehicle Accuracy and the Classified Vehicle Accuracy.

**True Vehicle Accuracy (TVA)**

The True Vehicle Accuracy is identical to the $E_1$ measure for the TLS classification. The formula is:

$$TVA_{\text{motorcycle}} = \frac{M_{1,1}}{S_1} \quad (3.7)$$

The measure is interpreted as the percentage correctly classified vehicles for a specific true vehicle class.

**Classified Vehicle Accuracy (CVA)**

The second measure is the Classified Vehicle Accuracy (CVA). It is interpreted as the percentage correctly classified vehicles among those classified to a specific vehicle class. Hence, TVA is conditioned on the true status of the vehicle while CVA is based on the classified class of the vehicle. The formula is

$$CVA_{\text{motorcycle}} = \frac{M_{1,1}}{Z_1} \quad (3.8)$$

That is the number of correctly classified vehicles in a vehicle class divided by the total number of vehicles classified to that specific class. If for example, CVA is 90% for motorcycles one can interpret that number as 90% of the total number of vehicles classified as motorcycles are true motorcycles. Both TVA and CVA are defined as conditional probabilities which is an advantage from a statistical perspective.

---

22 The confidence interval for $E_2$ is not straight forward since $E_2$ cannot be considered a proportion since it can take negative values.
3.2.3 The Motivation for Classified Vehicle Accuracy

In comparison with the BAST method TLS, TVA and E1 are identical. The difference is between E2 and CVA. There are some aspects where we think CVA has advantages over E2.

a) Ease of Computation

The CVA is a simple division between two quantities while E2 is a more complex computation. The CVA also has a similarity with the TVA where the numerator is the same for both equations.

b) Intuitive interpretation

The CVA is the percentage of correctly classified vehicles among those classified to a specific class. If we have a CVA for cars of 90% that means that if we pick any vehicle from the vehicles classified as car there is a 90 percent probability that the vehicle is a car. If E2 is 90% it means that the number of wrongly classified cars for a vehicle class in relation to the total number of true vehicles for that class is 10% (not so easy to understand).

c) Parallels to other sectors

The TVA and CVA have similar measures under different names which are used in other sectors in society. In statistics and commonly in medical science sensitivity (also called true positive rate) is computed in the same manner as TVA. In the same fields CVA is calculated similar to the positive predictive value (PPV). In pattern recognition and information retrieval, the measure with same definition as TVA is called precision and for CVA the measure is called recall.

3.3 The need for a standardized population

The E2 and the CVA measures are both dependent on the proportions of different vehicle-types that are counted in a specific evaluation (population-mix). This leads to complications when comparing devices since which device that is best can depend on the choice of test-population. For a detailed example see [3]. In TLS they use the German standard population which is given in [2] as shown in table 3.3.1 is used for evaluations.

Table 3.3.1. German standard population percentages

<table>
<thead>
<tr>
<th>Fahrzeugklasse</th>
<th>Anteil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motorrad</td>
<td>0,7%</td>
</tr>
<tr>
<td>Pkw</td>
<td>75%</td>
</tr>
<tr>
<td>Lieferwagen</td>
<td>6%</td>
</tr>
<tr>
<td>Pkw mit Anhänger</td>
<td>1%</td>
</tr>
<tr>
<td>Lkw</td>
<td>5%</td>
</tr>
<tr>
<td>Lkw mit Anhänger</td>
<td>5%</td>
</tr>
<tr>
<td>Sattelkraftfahrzeuge</td>
<td>7%</td>
</tr>
<tr>
<td>Bus</td>
<td>0,3%</td>
</tr>
</tbody>
</table>

Verkehrszusammensetzung (konstant)

To make a comparison between devices fair and also have the possibility to compare evaluations over time a standardization to a standardized population should be done in the evaluation.
3.4 Adjusting for different errors

The methods presented so far treat any misclassification equally. It does not matter if a car is classified as a truck, bus or a motorcycle, all errors will have an equal weight. However, there are instances where different errors are not equally important. For example, if we classify vehicles to evaluate wearing on roads, classifying a motorcycle as a car is not as a serious error as classifying it as a truck.

In an effort to quantify this error, a penalty matrix can be used. The penalty matrix assigns a value between 0 and 2, 0 being no error and 2 being a serious error. Table 3.4.1 gives an example of a penalty matrix. Each penalty score is then multiplied by the corresponding percentage of vehicles in that classification and summed together. This gives a penalty score per vehicle.

<table>
<thead>
<tr>
<th>Vehicle class</th>
<th>Classified as</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Motorcycle</td>
</tr>
<tr>
<td>Motorcycle</td>
<td>0</td>
</tr>
<tr>
<td>Car</td>
<td>1</td>
</tr>
<tr>
<td>Bus</td>
<td>2</td>
</tr>
<tr>
<td>Missing/ Not identified</td>
<td>0</td>
</tr>
<tr>
<td>Ghost</td>
<td>2</td>
</tr>
</tbody>
</table>

Some points on the scale have intuitive penalty points. As mentioned earlier a correct classification should give zero penalty points. Also classifications where the reference measurement device could not identify the class of the vehicle should not be penalized. In other cases, the penalty points should be assigned based on the aims of the classification performed.

By using a standardized population and a penalty matrix, an error score per vehicle can be calculated. This metric can then be used as a useful tool to evaluate and compare different equipment. It could then also be a good criterion for the selection process in a procurement-evaluation.

The suggested approach by using TVA and CVA together with a standardized population and a penalty matrix is implemented in a web-application. This application is described in the next section.

3.5 Web application

To implement the ideas presented in 3.2-3.4, a web-application\(^23\) (EVMD - Evaluation of Vehicle Measurement Devices) has been developed. After selecting which vehicle classes to be used the user enters data and parameters in four sections, see figure 3.5.1.

1) **Result from the test:** The actual data from the test, i.e. number of vehicles classified in each category.

2) **Standard population:** The proportion of vehicles in each category according to a standard population. If the actual mix of vehicles that was observed in the test will be used the user can just click on “Use empirical population”

3) **Evaluation requirements:** Here the user can specify any minimum criteria that the device should pass.

\(^{23}\) [https://svara.statisticon.se/norsikt](https://svara.statisticon.se/norsikt)
4) **Matrix of importance/penalty**: The default is that each error is considered equal. However, if the user wishes to differentiate between more or less severe errors this evaluation can be specified in this table.

Table 3.5.1. Screen for entering data and specifications in the web-application, EVMD - Evaluation of Vehicle Measurement Devices

After entering the data and other parameters, the software derives the relevant measures as described in 3.2-3.4, see figure 3.5.2. The main result is the TVA and CVA for each vehicle type. Also the measures E1, E2 and the F1 measures are provided. Results passing the evaluation requirements are seen in green and results failing the requirement are show up as red. TVA and CVA are also illustrated in a graph so that it is easy to compare the device’s ability to classify different types of vehicles.
Table 3.5.2. Screen illustrating some of the results in the web-application, EVMD - Evaluation of Vehicle Measurement Devices

<table>
<thead>
<tr>
<th>Evaluation</th>
<th>Motorcycle</th>
<th>Car</th>
<th>HGV/HCV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall evaluation</td>
<td>60%</td>
<td>75%</td>
<td>85%</td>
</tr>
<tr>
<td>Car standardization</td>
<td>70%</td>
<td>55%</td>
<td>75%</td>
</tr>
<tr>
<td>Fill distance</td>
<td>65%</td>
<td>65%</td>
<td>75%</td>
</tr>
<tr>
<td>TLS classification (EAST)</td>
<td>60%</td>
<td>80%</td>
<td>80%</td>
</tr>
<tr>
<td>E</td>
<td>80%</td>
<td>75%</td>
<td>70%</td>
</tr>
<tr>
<td>E standardization</td>
<td>70%</td>
<td>60%</td>
<td>75%</td>
</tr>
<tr>
<td>Penalty score (points per 100% vehicle)</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
</tr>
</tbody>
</table>

Graph

- ATP
- Motorcycle
- HGV/HCV
- 100%
- 50%
4 Dissemination

The following workshops have been conducted as part of knowledge dissemination:

- Technology and data sources, Arlanda 7th June 2017
- Data Acquisition, Arlanda 16th October 2018
- Speed, Arlanda 4th June 2019

In addition to the workshops, NorSIKT IP was also represented at the following international conference as part of the dissemination activities:

- NaTMEC, Los Angeles June 2018

In the following is given a short description of the theme for each of the dissemination activities with reference to where the presented material can be found

4.1 Workshop: Technology and data sources, Arlanda 7th June 2017

Introduction to the workshop:

Technology and data sources
Today’s traffic data is mainly collected from fixed points based on inductive loops, radar, hoses, piezo cables, etc. Now we see a development with great potential for different data from mobile phones (telecommunications companies, Google, Apps), and vehicles (car manufacturers, navigation systems, fleet management systems, etc.). Concepts such as “Crowd sourcing”, “Emerging technologies”, “Big data”, “ITS drives” and “Cloud solutions” are launched as exciting opportunities. There are many possibilities and solutions. What solutions do we see to be central to the registration of traffic data 5-10 years ahead?

Data Needs
Traffic data is used today for statistical purposes, traffic management, traffic information, route planning, incident detection, control activities, model development, traffic safety analyzes, road design, road design and a number of other purposes. We are now experiencing a great demand for pedestrian and cyclist data. At the same time, autonomous vehicles will be a key part of the transport systems of the future. How does this change the need for data going forward?

Data quality
In NorSIKT, there has been a strong focus on data quality. High accuracy recording devices are in many cases relatively expensive - in purchasing, installation and operation. New players today offer cheap sensors, but with poorer accuracy. Will future solutions consist of many cheap sensors rather than costly ones? And is it better to have a few records with high accuracy than a lot of data with less accuracy?

The program and presentations for the workshop on technology and data sources can be found on the NordFOU.org web site.
4.2  NaTMEC, Irvine, California June 2018

The following papers were presented by NorSIKT IP representatives at the NaTMEC 2018 conference:

- Bicycle Travel Speed, Torbjørn Haugen
- The Norwegian Traffic Data System, Torbjørn Haugen
- Configuration of Wheel Mounting – Singel or Dual, Bjarne Bach Nielsen
- Wi-Fi and Bluetooth Based Sensors for Pedestrian Detection in Urban Areas, Maxmillian Franz Böhm

The NorSIKT IP presentations can be found here: https://www.natmec.org/presentations-2018

4.3  Workshop Data Acquisition, Arlanda 16th October 2018

Title: “Towards better data quality, cost-efficiency and network coverage via vehicle-based data acquisition”

Hosts: The workshop was hosted by the NorSIKT project and the NEXT-ITS working groups on traffic management and Information and Communication Technologies.

Collecting traffic data is one of the components of traffic management because traffic data are used as an input to support traffic control. The current roadway-based infrastructure for traffic data collection, such as loops, microwave sensors, or laser detectors will be replaced by vehicle-based data. That will result in cost savings as well as the new generation of traffic data that is more powerful than the existing one. Thus, the workshop focuses on possibilities, examples and best practices of vehicle-based data acquisition. The main topics are:

- State-of-the-Art concerning fixed data sources
- Mobile data sources: best practices, experience and projects
- Data quality of mobile data sources and the relation between fixed sources and mobile sources.

The workshop aimed at giving an overview on the NorSIKT project, the status of mobile data acquisition from NorSIKT’s and NEXT-ITS’ point of view including best practices, experiences and the relation between fixed and mobile data sources. Furthermore, the workshop aimed at information exchange between the involved projects and the participants in general.

The program and presentations for the workshop on data acquisition can be found on the NordFOU.org website.
4.4 Workshop: Speed, Arlanda 4th June 2019

Theme for the workshop

For the work on road safety, it is important to know the speed level on our roads. There are many measurements of traffic speeds, but what should be measured and how should data be compiled? The purpose with the workshop was to gather producers and users of speed data from the Nordic countries and discuss opportunities and challenges. The Nordic countries do speed measurement and calculate speed parameters different ways and handle challenges differently. What can we learn from each other?

The program and presentations for the workshop on speed can be found on the Nord-FOU.org website.1
5 Implementation plan

The main objective with the NorSIKT IP project has been to prepare for implementation of the main results from NorSIKT I and NorSIKT II projects into the Nordic road administrations. There has been emphasis on conclusions and recommendations in the NorSIKT II project since the classification scheme developed in NorSIKT I already is adopted in the traffic data collection routines in several Nordic countries.

Another important objective has been to continue the Nordic co-operation within the traffic data area, and this stands out as one successful achievement from the NorSIKT IP project. It has also been revealed challenges when it comes to implementation and harmonization and it has become clear that only a few of the suggestions from the NorSIKT II project are feasible to implement on a short term. This is further commented in the two following paragraphs.

5.1 Summary of suggestions

Table 5.1.1 summarizes the status for the suggestions in the different areas covered by NorSIKT IP. For each of the suggestions, the status regarding implementation is indicated for each country.

The color coding and abbreviations in the cells should be read according to:

- **No**: Country does not fulfill suggestion. No harmonization.
- **PL**: Country is planning till fulfill suggestion. No harmonization yet.
- **OK**: Country is partly fulfilling suggestion. Partial harmonization.
- **OK**: Country is fulfilling suggestion. Harmonization.
<table>
<thead>
<tr>
<th>Area</th>
<th>Suggestion</th>
<th>Explanation</th>
<th>Country</th>
<th>See section</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>All estimates should be accompanied by error margins.</td>
<td></td>
<td>DK</td>
<td>PL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The sampling method chosen should be validated and well described and justified in the technical documentation (quality declaration).</td>
<td></td>
<td>FI</td>
<td>PL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Agree on a standard for quality declarations of all statistics produced.</td>
<td></td>
<td>FO</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>ADT</td>
<td>Agree on conceptual definitions of ADT (including weekday, weekend and ADT for heavy vehicles).</td>
<td></td>
<td>IS</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td></td>
<td>If comparisons of weekday AADT are needed: use Tuesday 00.00 – Thursday 24.00 for weekday ADT for either for Aug-May or for the whole year Jan-Dec.</td>
<td></td>
<td>NO</td>
<td>OK</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Harmonize the documentation of the methods for measuring AADT. In the documentation there should be a part that verifies the validity of the method used.</td>
<td></td>
<td>SE</td>
<td>OK</td>
<td></td>
</tr>
<tr>
<td>Change in total vehicle mileage</td>
<td>All countries present monthly statistics per calendar month.</td>
<td></td>
<td></td>
<td>OK</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sweden starts using the date model (in parallel with the day-model to investigate the differences).</td>
<td></td>
<td></td>
<td>Not applicable</td>
<td>PL</td>
</tr>
<tr>
<td></td>
<td>Find a part of the road network that is comparable between all Nordic countries and do the estimates for this network.</td>
<td></td>
<td></td>
<td>OK</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Each country should use the correct estimation method (perhaps by imputing missing data) or at least validate that the method used is a good estimate of the correct parameter.</td>
<td></td>
<td></td>
<td>OK</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Every country should present actual estimates of the average speeds and not only indexes.</td>
<td></td>
<td></td>
<td>OK</td>
<td></td>
</tr>
<tr>
<td>Speed index</td>
<td>All countries agree that it is the free flow speed that should be estimated. Hence, an agreement on the conceptual level.</td>
<td></td>
<td></td>
<td>Not dealt with within the project</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Agree on how to accomplish this. E.g. delete data from congestion etc. like the Danish model or use the 85th percentile.</td>
<td></td>
<td></td>
<td>Not dealt with within the project</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Average speed should be defined as time mean speed and not space mean speed.</td>
<td></td>
<td></td>
<td>Both methods can be used</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Calculate average speed per car and not per road section.</td>
<td></td>
<td></td>
<td>Method depends on selection process</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Find a part of the road network that is comparable between all Nordic countries and do the estimates for this network.</td>
<td></td>
<td></td>
<td>OK</td>
<td></td>
</tr>
</tbody>
</table>
As can be seen, suggestions 3, 4, 9 and 16 come out with the clearest commitment for implementation:

Suggestion 3: Agree on a standard for quality declarations of all statistics produced.
Suggestion 4: Agree on conceptual definitions of ADT (including weekday, weekend and ADT for heavy vehicles).

For the two Nordic indexes (suggestion 9 and 16): find a part of the road network that is comparable between all Nordic countries and do the estimates for this network. Note that the networks are different for the mileage and speed indexes.

It has been a goal to achieve the highest possible level of harmonization with regards to definitions, statistical methods and quality declarations for other traffic parameters. Why so many of the suggestions has not become green and thereby ready for implementation, is especially the fact that traffic data is a complex area and it has been out of the scope for the NorSIKT IP project to conduct a process to anchor commitment on a sufficient high level in the road administrations. The work that has been done, however, is a sound basis to continue the work on harmonizing.

In the following is a description from each country as additional comments to table 5.1.1.

Denmark
The Danish Road Directorate (DRD) has found the NorSIKT project to be a very beneficial professional collaboration which has increased the professional level across the Nordic countries.

In 2003/2004 DRD started out using pattern recognition with new counting equipment and has since by way of the NorSIKT project, continued to implement this where possible. As of today, the NorSIKT vehicle classes are implemented in more than half of the counting equipment used by DRD. This means, that the traffic on most of the Danish network of motorways is registered by counting equipment using pattern recognition. DRD has chosen to work with 14 vehicle classes, since vans (light goods vehicles) are divided into two classes; large and small.

DRD wishes to continue working to improve on uncertainty intervals in traffic counts.

DRD has no intention to create a concrete speed-index, since a greater value and information is seen in the speed-barometer method used today to highlight changes in speed development in road traffic, where free-flow defines the real possible speed.

Finland
Finnish Transport Infrastructure Agency (FTIA) and its’ predecessor agencies has outsourced the sample traffic counts and production of ADT since 2006. The present contract for delivery of the sample counts and the ADT on state roads is valid until January 2021. At the moment, FTIA with Traffic Management Group Finland Ltd. (which is now responsible on the traffic data on state roads) are doing preparatory work for a new procurement. This is a good opportunity to include possible new requirements for harmonizing documentation (quality declarations, method etc.) or counting new parameters (error margins by estimate) into the new contract for delivery. FTIA is therefore ready to implement most of the recommendation of the NorSIKT-project dealing with the traffic counts in the following few years. At this time, FTIA has no plans to present the speed indexes.
Faroe Islands
From March 1 2020, it is scheduled to report monthly Speed index and Change in total vehicle mileage (suggestion 7).

Iceland
Regarding suggestion 2: The sampling method chosen is well described in Icelandic.

Regarding suggestion 7: Iceland is already presenting monthly statistic of change of traffic volumes on the ring road (not vehicle mileage). Information on vehicle mileage are published yearly.

Regarding suggestion 11: Iceland is already presenting the estimates of the average speed in summer time on the ring road (and some more). Speed indexes are not presented.

Norway
We are satisfied to have harmonized the most important parameters.

Sweden
Documentation is important and Sweden is planning to update the documentation according to the new common guidelines described in 2.6 during next year (2020).

Sweden is also planning to change the method of comparing years for change in mileage from the day method to the date method described in chapter 2.8. Changes in the supporting IT system was made and estimates from beginning of 2020 will be according to the date method.

Sweden does not present speed levels because the measurements of speed are not good enough. There are only a few places where speed is measured and the measurements of speed are not very accurate. We consider the measurement to be good enough to present changes but not levels.

5.2 Organizational challenges
The NorSIKT IP project has revealed an important barrier for implementation of several of the suggestions for harmonization and that is the fact that the road authorities have been developing in different directions when it comes to buying traffic data as a service contra managing traffic data collection and traffic data statistics in house. This has been clearer during the NorSIKT IP project and has to be an important part of any follow up action.

5.3 Technology / devices / method
Traffic measurement are facing many new challenges and opportunities as new technologies comes to the market. For example, drones, mobile phones, satellite images, ETC transponders and self-driving cars gives rise to many new ways to count and track vehicles and their trips. The use of floating car data (FCD) has been evaluated for many years. Many good results have been reported but there are still issues with representativeness. In the future, this problem might be reduced when the propor-
tion of vehicles having a specific device increases but still this is a real concern when trying to estimate statistical parameters. "If currently the representativeness of FCD can be considered an issue, currently growing trend in FCD penetration should naturally overcome this issue."[1]

Depending on the purpose, the use of new techniques can be more or less suitable. There are many studies reporting good results for monitoring traffic jams and estimation of travel times. However, when the purpose is to estimate a statistical parameter e.g. AADT, average speed or change in vehicle mileage, the question of representativeness is of crucial importance.

In Sweden e.g. the estimation of AADT for a specific road segment is based on a random sample of days. Four periods per year (each lasting 2-4 days) are selected at random for the measurement to be performed. By this procedure we know that there is no systematic error in the selection of days.

If we get FCD (e.g. from a GPS-provider or a carmaker) we might get data for every day of the year. This is an obvious improvement compared to the selection of only four short periods per year. However, now we have a case where we only register a fraction of the cars passing the measurement point. (With pneumatic tubes every car is registered.) If we can only count the number of cars who uses a specific probe/device, we need to know what proportion of the cars they represent if we want to make inference to the population of cars. In Ajmar et al. [1] they found that the proportion of all cars that they could track with their device varied between 0.7% and 1.4% depending on what hour of the day they were measuring. Trying to estimate the total number of cars based on the number of tracked cars would in this case be very unreliable since the proportion tracked cars varies with a factor of two (1.4/0.7≈2).

In table 5.3.1 we represent different scenarios where the Swedish measurement of AADT is an example of scenario 3. Many of the new FCD will be in scenario 1 or 2 which gives rise to new statistical challenges.

Table 5.3.1. Example of different scenarios regarding samples of days and vehicles regarding AADT.

<table>
<thead>
<tr>
<th>REGISTER A SAMPLE OF THE DAYS</th>
<th>REGISTER ALL DAYS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Register a sample of the cars</td>
<td>Scenario 1</td>
</tr>
<tr>
<td>Register all cars</td>
<td>Scenario 2</td>
</tr>
<tr>
<td>Register all cars</td>
<td>Scenario 3</td>
</tr>
<tr>
<td>Register all cars</td>
<td>Scenario 4</td>
</tr>
</tbody>
</table>

As more and more new data becomes available there are new opportunities to combine data from FCD with data from stationary devices. A study in the Netherlands showed that they could replace some of their sensors with FCD. "Replacing part of all road sensors with Google data has limited and acceptable impact on quality. For example on the A12 we found that replacing 20% of the sensors with Google data diminishes data quality by a mere 3% on accuracy."[16] In Florida they made a study [8] using FCD together with permanent count stations to train a neural network to estimate AADT and according to their evaluation the results were very promising, see figure 5.3.2. In the right part of the figure they show estimates of AADT compared to the true volumes and we can see a rather good agreement.

24 The Google data, also called floating car data (FCD), originates from Google-enabled devices carried by persons travelling in vehicles on the road.
The Swedish Transport Administration is running a test project using ‘Big Data’ to estimate traffic flows. In this project several different techniques are tested and compared. However, at this time-point no results from the project are released.

From a statistical perspective, the new sources of data give rise to many new challenges concerning how to combine different data sources and how to obtain reliable estimates of important statistical parameters.

5.4 Recommendations to continuation of the Nordic co-operation within the traffic data area

The digitalization process affects traffic data capture. It is constantly developing and there are big and new challenges. It is important to preserve the professional network of people that exists today (easy to tear down but difficult to build new networks). Corresponding NorSIKT projects will be needed to maintain and strengthen Nordic co-operation within the traffic data area.

When it comes to collecting traffic data, it is important to prepare for the changes and it is foreseen that there is a need for development and testing in collaboration with the industry. Big data and statistical tools and methods are other important keywords.

The NorSIKT IP project group recommend that the continuation of the co-operation within the traffic data area starts with a process building on the results from the NorSIKT IP project. It is suggested a new project that can have the working title “Presentation of traffic data” where the Nordic Indexes will have a natural place.

The web application for evaluation of traffic counting devices is suggested to be offered as a service. The cost for the necessary improvement to finalize the application is estimated to be quite low and
could potentially be split between the Nordic partners. It is suggested that the developer of the application make a description of the needed improvements to be discussed between the Nordic road authorities.
All reports written within the NorSIKT IP project can be found on:
http://www.nordfou.org/knowledge/Sider/default.aspx

[10] Forsman and Bring (2013). Gemensam Nordisk definition av ÅDT. Deluppdrag 1, NorSIKT 2. (In Swedish.)
[16] van den Haak W.P. and M.F. Emde, Validation of Google floating car data for applications in traffic management.

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The reports can be found on the web address given at February 2020.
NordFoU
CVR nr.: 35272704
Nordfou.org
Carsten Niebuhrs
Gade 43, 5. sal
1577 København V