CEDR

Conférence Européenne
des Directeurs des Routes

Conference of European
Directors of Roads

Road Data and Performance Indicators

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This report is: **FOR INFORMATION**

1 Executive summary

This report summarises the activities engaged in as part of Tasks M3 (Road Data) and M8 (Performance Indicators) during CEDR's first Strategic Plan (2005-2009) and as such represents the final report on Tasks M3 and M8.

The purpose of Tasks M3 and M8 was to address the increasing requests made to CEDR member states to provide information, to the European Commission (EC) and others, about the performance of their road networks and to address inconsistencies in the data and referencing information that underpins this information.

An improved performance reporting framework was developed. This framework is based on a common location referencing model for the TERN network and a consistent set of performance indicators based on common data definitions and commonly available base data.

A pilot study was undertaken, which concluded that the proposed performance reporting framework could be implemented within member states relatively easily, that it would provide the stability and consistency required, and that it could be used to provide meaningful performance indicators that could be used for benchmarking.

A cost-benefit analysis compared the cost to member states of providing information using the proposed performance reporting framework with the current estimated cost and concluded that, after an initial period of investment during which the location referencing model would be set up, the proposed new framework would make the process of data extraction and reporting more efficient.

Finally, a workshop organised by PG Planning and CEDR EB members considered the most appropriate way to implement the performance reporting framework and concluded that work should proceed on the implementation of a regular internal CEDR report on network performance based on the performance reporting framework, and that the use of the framework to assist member states in the provision of road network information to the European Commission and other organisations should be promoted and supported.

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2 Definition of the issue

2.1 The increasing demand for performance information

Requests for CEDR member states to provide information about the performance of their road networks are numerous and continue to increase. These include:

TEN-T Implementation & Revision Reports
Member states are required to provide EC DG TREN with information about the extent and performance of the TEN-T network within their country in the form of the TEN-T Implementation and Revision Reports.

Ad-hoc requests for information
Member states receive an increasing number of ad-hoc requests for road network information from the EC and others.

New initiatives
New initiatives, such as INSPIRE, are introducing additional requirements for member states to provide information about their road networks.

The work involved in providing such information is considerable and often requires specific data extraction and analysis activities to be undertaken in response to each individual request. Furthermore, as the information is generally based on local data definitions and location referencing models, it is inconsistent, making meaningful comparison difficult and therefore of little value.

2.2 CEDR's response

Recognising the need to help members respond to these increasing requests and to improve performance reporting on the TERN, CEDR identified two priority tasks for inclusion in the Strategic Plan 2005-2009; Task M3 (Road Data) and Task M8 (Performance Indicators).

Task M8 (Performance Indicators) aims to '*...bring together road network performance information in a coherent way, in a consistent format, and at a high level of quality..., as well as to improve TERN and road asset statistics*' to which CEDR will add value by developing '*a set of indicators which [allow]...road directors to benchmark their networks against other networks*'.

The successful delivery of Task M8 requires a robust technical framework that includes appropriate referencing systems, mechanisms for data exchange, and effective data management procedures. This will be provided by Task M3 (Road Data) which aims to '*...promote best practice in the management of road data, the definition of referencing systems, and the exchange of data*'.

Tasks M3 and M8 were assigned to PG Planning in TD Management, and funding was allocated by CEDR to facilitate their delivery. The ongoing need for these tasks was confirmed in the 2007 Strategic Plan Revision Report.

PG Planning merged Tasks M3 and M8 into a single set of activities to be managed by a sub-group of its members. The aim of this sub-group was to develop an improved performance reporting framework that would deliver more meaningful reports more efficiently and based on more consistent information. To be effective, such a framework would require the following characteristics:

- a common location referencing model for reporting on TERN links that complements but does not replace national referencing systems and databases;
- consistently defined and available data; and
- centrally produced performance reports based on data provided by individual member states either through an automatic or semi-automatic process.

The proposed performance reporting framework would complement rather than replace existing local systems and processes and would support local performance reporting as well as reporting to the European Commission. It would also enable the production of network performance benchmarking reports.

The benefits of such a performance reporting framework would be:

- more meaningful performance indicators that reflect the actual performance of the network and meet the needs of a wide range of stakeholders, including the European Commission and CEDR itself;
- reports based on consistent, well-defined data enabling accurate comparison between member states and the monitoring of trends;
- better control and management of changes to reporting requirements and data definitions; and
- consistent data definitions that could form the basis of strategic-level benchmarking reports.

3 Possible solution

The Task M3/M8 sub group developed a possible performance reporting framework based on:

- a common location referencing model for TERN links that complements but does not replace national reference systems;
- more meaningful network performance indicators based on commonly agreed data definitions and available base data; and
- data provided directly by member states.

3.1 The TERN location referencing model

Crucial to the successful implementation of a performance reporting framework is a robust location referencing model that meets the needs of all member states and enables networks to change over time, while ensuring consistent performance reporting.

The performance reporting framework makes use of the TERN location referencing model previously developed by PG Planning. The TERN location referencing model is a link- and node-based model with nodes defined at the intersection of TERN links. The model comprises two tiers of referencing:

The functional level describes the functionality of the TERN by linking major centres of population, intersections of TERN routes, and national borders. It has no discontinuities, and has a single linear representation irrespective of national models/concepts for multilane roads, directions, and other individual definitions. Strategic reporting would generally take place at functional level.

The logical level is more detailed and models the physical location of the TERN and the changes to the TERN over time. It allows member states to relate the network to their own national networks. This model does not replace national referencing systems.

The detailed definition of the location referencing model for the TERN is given in the document *TERN Location Referencing Specification Version 2.5* (see Appendix B to this report). The model is illustrated in Figure 1 below.

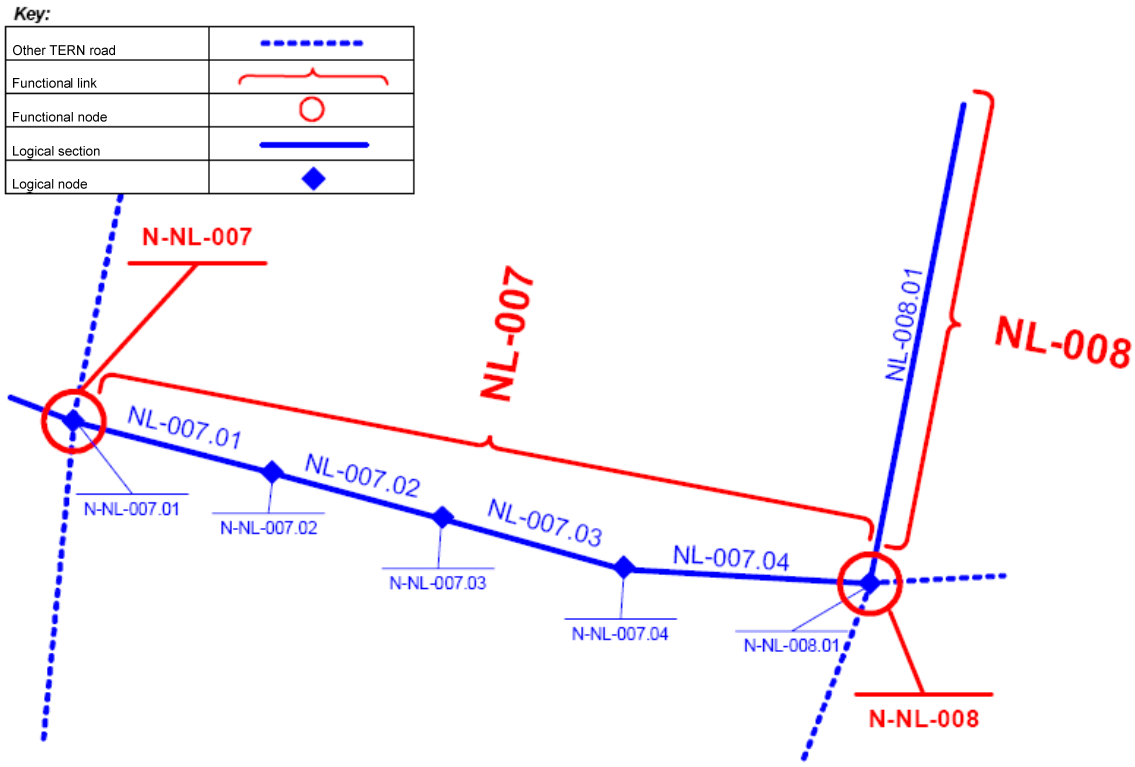


Figure 1: Illustration of the TERN location referencing model

3.2 Performance indicators

Earlier work completed by what used to be WERD's subgroup TERN identified 33 global and network indicators related to four themes based on the proper articles of the EU Guidelines for the TEN-T:

- mobility of persons and goods
- safety of transport
- environmental protection
- economic viability

Based on data that is considered likely to be currently available within member states, an initial set of eight network performance indicators were defined:

1. amount of traffic
2. amount of transport (number of passengers)
3. amount of transport (number of heavy vehicles)
4. speed limit
5. speed of traffic
6. number of injury accidents
7. number of fatalities
8. congestion hours

Indicators that require base data that is not considered to be currently available in the majority of member states were categorised as 'long term'.

Figure 2: The North–South pilot route

Detailed definitions were developed for each of these indicators. These definitions included a description of the indicator, its application, units, base data requirements, and how it is calculated as well as any notes, limitations, and issues. These definitions are provided in a separate document, *Performance Indicators for the Trans-European Road Network: Results and Recommendations from Pilot Study.*

3.3 Pilot study

In order to assess the practicability of the TERN performance reporting framework, a pilot study was carried out involving a 'North–South corridor' comprising TERN links passing through six countries: Norway, Sweden, Denmark, Germany, Switzerland, and Italy. A map of the North–South pilot route is shown in Figure 2.

Each participating country was asked to apply the TERN location referencing model to the links on the route passing through their country and to provide the base data required to produce the initial set of performance indicators to a central body, which produced the indicators and presented them on a map using a GIS tool.

An example from the pilot study is given in Figure 3. Participants were also asked to report on the ease of applying the location referencing model and providing the base data and to identify any issues.

A detailed description of the pilot study is provided in a separate document, *Development of Consistent Road Performance Information: Report on the Performance Indicators and Location Referencing Pilot Studies*. The key conclusions of the pilot study were that:

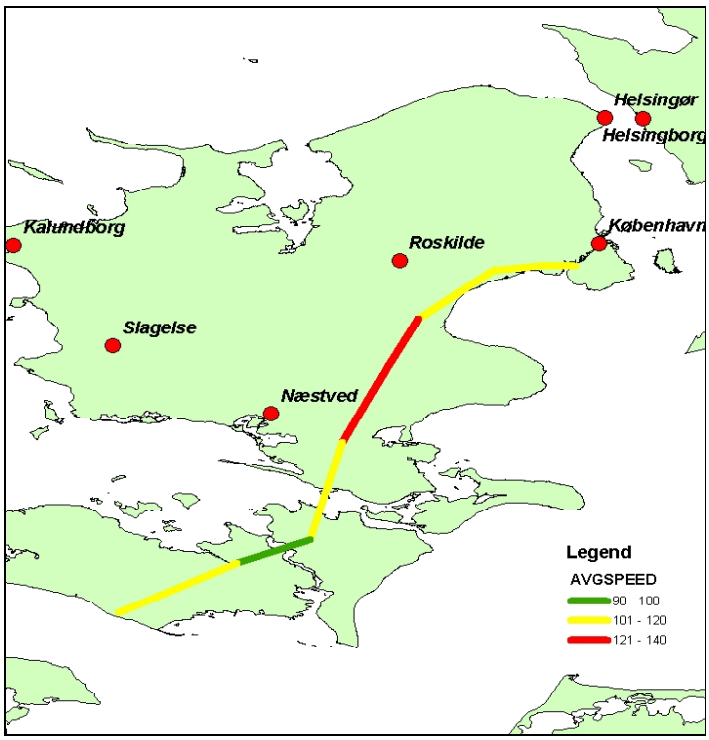


Figure 3: Sample performance indicator (average traffic speed) from the pilot study

- the location referencing model can be used by different countries to reference the TERN network; the model is robust, stable, and can accommodate changes to the physical network such as new links and split links;
- some meaningful performance indicators can be produced from data currently available within member states, but the lack of commonly defined and consistent data means that the number is limited. To produce a wider range of indicators, there may be a need to collect additional data or to process it in a different way;
- data extraction would be easier if regular reporting requirements were agreed so that more permanent data extraction facilities could be set up;
- although the focus of the trial was on the TERN, the proposed framework could be applied to other international, national, and regional networks, therefore facilitating the exchange of data between CEDR members about other roads; and
- the proposed performance reporting framework is a suitable means of delivering data for the TEN-T Implementation and Revision Reports on a consistent basis by all member states and, as such, use is recommended.

3.4 Implementation of the performance reporting framework

A number of options for the implementation of the performance reporting framework were considered. The final choice will depend on how the framework will be used. However, in general, implementation would require the following:

- The establishment of a central body to own and manage the performance reporting framework. It would be responsible for issuing instructions to member states (including data definitions and reporting requirements) and for managing changes to those requirements. The central body would provide support and information to the member states.
- Individual member states would be responsible for maintaining the network referencing model within their countries and for ensuring that it is correct and up to date. They would provide base data to the central body in accordance with the reporting requirements defined by the central body. This data could be provided using an automated or semi-automated process.
- The central body would receive data from the individual member states and would analyse this data with a view to calculating the performance indicators and producing any reports on behalf of CEDR members.

To assist member states in the implementation of the location referencing model, a handbook has been produced to provide practical guidance and examples to assist users in referencing their own networks. The handbook is a separate document *TEN-T (Roads) Location Referencing Model Handbook & Implementation Guidance.*

The location referencing model has been successfully implemented in Denmark. Information about Denmark's experiences is provided in Appendix C to this report.

4 Comparison of ways forward

4.1 Cost-benefit analysis

To assess the impact on member states of implementing an improved performance reporting framework, a cost-benefit analysis was undertaken to provide a comparison with the current method of performance reporting. The costs and benefits of introducing a new benchmark report based on global indicators were also considered, although this could be implemented in addition to the improved performance reporting framework. The three considered options can be characterised as follows:

Doing nothing	Each country continues with the current method of reporting to the European Commission on the implementation of the TERN and responds to other ad-hoc requests for information on an individual basis.
Option 1: improved reporting	Introduction of a more efficient process for reporting to the European Commission on the performance of the TERN in a more consistent way based on the proposed performance reporting framework.

Option 2: benchmark reporting Facilitation of the benchmarking of the performance of CEDR members at an organisational level rather than on network performance.

A survey of CEDR members was undertaken in spring 2007 to assess their current status with respect to data management so that an assessment could be made of their ability to implement an improved TERN performance process.

Among other questions, the survey asked members to identify which of the following five categories of organisation most closely applied to them. Responses were received from 19 CEDR members.

(a) The required data is held by one part of the organisation and in one integrated system, e.g. all the data is in one system, sharing a common location referencing model.

(b) The required data is held by one part of the organisation but in different systems, e.g. different systems are used for different functions or assets.

(c) The required data is held by different parts of the organisation, e.g. different parts of the organisation with different responsibilities have their own systems and data.

(d) The required data is held by regional/local authorities or by private operators of the network, e.g. where these bodies act as an operator of the national network or part of it on behalf of the national authority.

(e) A common system has been developed with other countries for statistical reporting purposes. This could be the case for countries that were part of the TEM Project for example.

A cost model was developed in order to assess the cost of implementing and operating the options listed above for improved performance reporting. In view of the fact that this reporting function is carried out by internal staff in most member states, this 'cost' is expressed in terms of time.

The results of the cost-benefit analysis of the costs of implementing and operating the three options are shown in Figure 4.

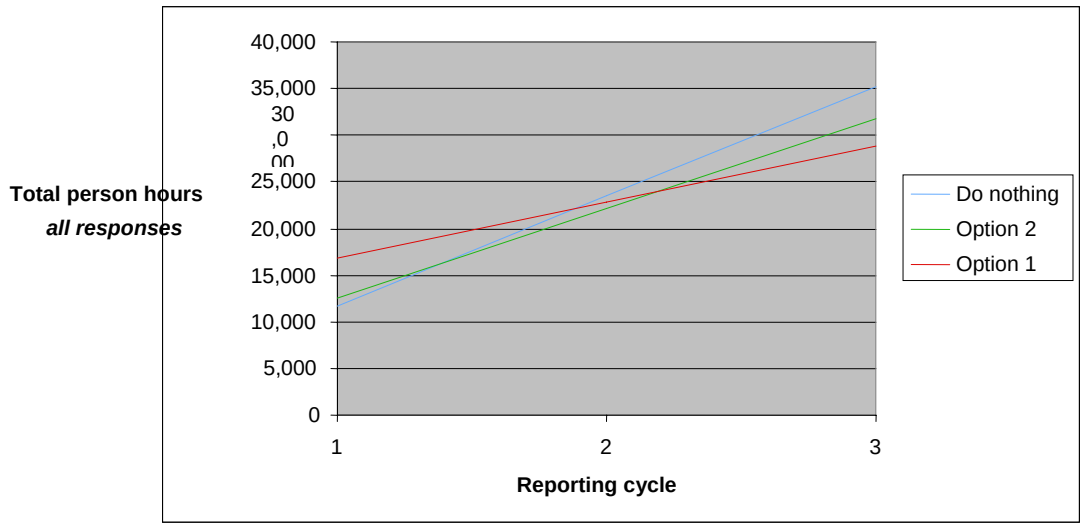


Figure 4: Results of the cost-benefit analysis

Detailed findings of the cost-benefit analysis are given in a separate document, *Proposed TERN Performance Reporting Framework: Results of Cost-Benefit Analysis.* The key findings of the analysis were that:

- Option 1 (Improved Reporting) would require additional work in year one to set up the location referencing model and data compared with the current method, but would lead to efficiency savings that would reduce the amount of work required to produce the report over a period of three reporting cycles. The resulting report would provide better, more consistent information about the performance of the TERN among CEDR members.

- Option 2 (Benchmark Reporting) would not require detailed location referencing but would involve additional costs in year one to identify, extract, and process the diverse range of data required. Subsequently, the amount of work would reduce compared with the current reporting method for some countries, but would increase for the majority of countries where the current reporting process is relatively efficient because all data would then be in one organisation and system. The resulting report might be useful for benchmarking the performance of individual member states but would not provide information about the performance of the TERN itself and would, therefore, probably exist alongside the TERN Implementation Report rather than replacing it.

4.2 Proposed way forward

A workshop was held in London on 18 September 2008 to discuss the way forward for the implementation of the performance reporting framework. The workshop concluded that two strands of work should be undertaken:

1 The establishment of an internal CEDR Performance Report

An internal performance report for TERN/FERN based on the performance reporting framework should be introduced. A dialogue would be opened up within CEDR to agree appropriate content, format, and reporting frequency, etc. Take-up would be optional and CEDR would decide how this report should be used. It is proposed that member states provide base data to a central body that would analyse and produce the performance report. This central body would also manage the overall process including any changes.

2 Reporting to the European Commission and others

The use of the performance reporting framework to help member states meet their reporting obligations (including TEN-T Implementation/Revision Reports) more efficiently should be promoted and supported. Engagement with the EC is recommended in order to promote the wider use of tools as the basis for road data/performance reporting and to open a communication channel that would allow for the discussion of potential improvements to data, performance indicators, etc.

5 Conclusions

The conclusions of the work undertaken in Task M3 and M8 are as follows:

1. The proposed performance reporting framework based on the TERN location referencing model and a common set of performance indicators could be implemented by CEDR members relatively easily and could provide the stability and consistency required.
2. The performance reporting framework would enable member states to provide consistent data about network performance that could allow for a meaningful comparison of information and benchmarking between member states, possibly in the form of an annual published CEDR performance report. Without such a framework, it will continue to be difficult to make meaningful comparisons between CEDR member states.
3. The adoption of the proposed performance reporting framework would enable member states to provide performance information to the EC and others more efficiently than is presently the case and would enable more effective management of changes to information requirements. Without the use of such a framework, the burden on member states to provide performance data to the EC and others will increase.
4. Work should proceed on the implementation of a regular internal CEDR performance report, based on the proposed performance reporting framework and should be officially supported by CEDR.
5. The use of the performance reporting framework by member states to assist them in the provision of performance information about their road networks should be promoted and supported by CEDR.

6 Recommendations

The work undertaken under Task M3 and M8 has demonstrated that the proposed performance reporting framework based on the TERN location referencing model and a common set of performance indicators would provide more consistent information about the performance of the road network, enabling a more meaningful comparison of and benchmarking between CEDR member states, and that the use of the framework as the basis for reporting performance information to the European Commission and others would result in efficiency savings for CEDR members.

Without such a framework, it will continue to be difficult to make meaningful comparisons of network performance between CEDR members and the burden on members to provide performance data to the European Commission and others will continue to increase.

It is therefore recommended that work should proceed on the implementation of a regular internal CEDR performance report based on the proposed performance reporting framework and on the promotion of the use of the framework to assist CEDR members in meeting their performance reporting requirements.

Appendix A: Reference documents

The following documents, referred to in this report, are available to download from the CEDR website at the page CEDR/1_TD_Management/3_PG_Planning/Reports/.

1 TERN Location Referencing Specification, Version 2.5 [see also Appendix B of this report].

2 Performance Indicators for the Trans-European Road Network: Results and Recommendations from Pilot Study.

3 Development of Consistent Road Performance Information: Report on the Performance Indicators and Location Referencing Pilot Studies.

4 TEN-T (Roads) Location Referencing Model Handbook & Implementation Guidance.

5 Proposed TERN Performance Reporting Framework: Results of Cost-Benefit Analysis.

Appendix B: TERN location referencing specification

The Network Referencing Model

The TERN Location Referencing Method comprises two 'tiers' of referencing:

1 The **functional model** representing the 'function' of the TERN to provide road transport links between major centres of population, including interchanges between intersecting TERN roads. The functional model comprises links and nodes defined at the intersection of TERN links. Functional links and nodes are essentially 'fixed' and do not change, since the 'function' of that link (i.e. to link major centres of population and other TERN roads) does not change, despite the fact that physical aspects of the route and the characteristics of that route may change. These changes are modelled in the logical model (see below). Any change that is fundamental enough to change the function of a TERN link would require that a new link, with new referencing, be created.

Each node and link is given a unique identifier that consists of a two-letter country code followed by a three-digit (or more) number; nodes are differentiated from links by the inclusion of the letter 'N'. For example, a TERN link in Germany might have the identifier DE-014 and an associated start node might have the identifier N-DE-014.

2 The logical **model** models the physical location of the TERN and the changes to the TERN over time. The logical model comprises sections and nodes. Sections can be further divided by the introduction of sub-nodes and sub-links, and these sub-links can, in turn; be further subdivided as many times as necessary.

Logical sections and nodes are 'owned' by associated functional sections and nodes respectively; their referencing reflects this, with the first part of the reference being the associated functional node or section reference.

Figure B1 shows a section of the trial network in the Netherlands showing the functional TERN links and nodes and the logical sections and nodes.

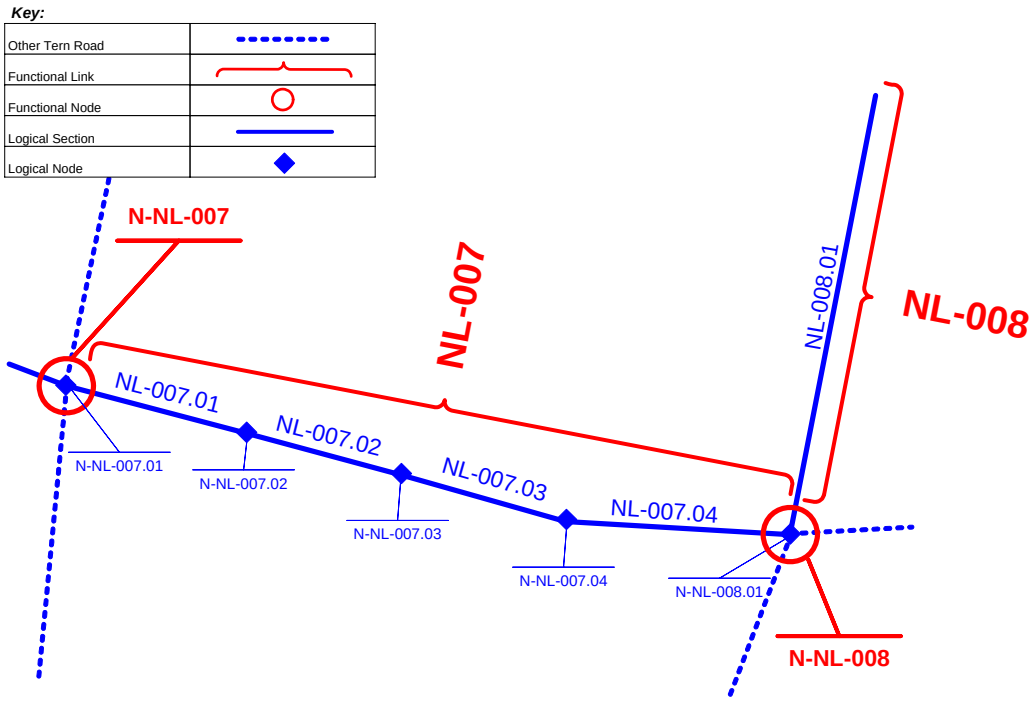


Figure B1: The TERN location referencing method – physical and logical models

Logical nodes should coincide with exit-to-exit node points on the national networks (all road administrations will generally hold data at this level of detail, and this level of detail generally remains stable over time) and this should be the common base-level. This assumption provides a common network-referencing model with an underlying stability. The mapping of national networks, which may be defined at a lower level than this or which may be based on long sections etc., will be the responsibility of national administrations. The following diagram provides an example of this:

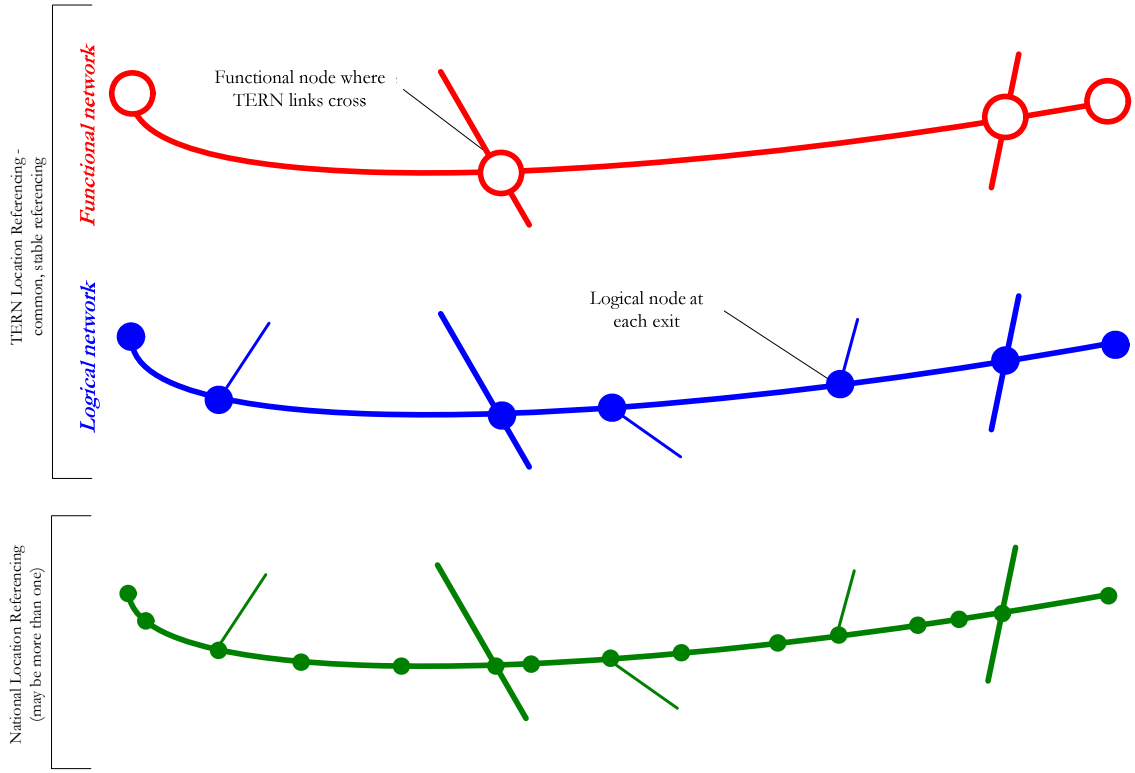


Figure B2: Mapping national to TERN location referencing method

The functional model

1 The TERN functional referencing system is essentially a link/node model.

2 The TERN consists of existing roads, roads under construction, and planned roads

3 A TERN functional link does not, in general, change over time with respect to its identification, start-point, and end-point. However, the geometric properties might change considerably, affecting the length, cross section, and geographic location.

4 The orientation of functional links does not change over time. Orientation is determined by the start and end nodes. Orientation is normally broadly North–South or West–East (over the whole of a route).

5 Functional nodes are used to define start and end points of links. A functional node is **only** placed where two TERN links cross each other, at external coastlines, or where a TERN link crosses a national border. Creating more nodes should be considered carefully and, in any case, be limited.

6 Reporting generally takes place at functional level, for example reporting to the EC for the Implementation Report and Revision Report.

7 The TERN referencing system is (from a data management point of view) one of several application-orientated topological views on a specific national network.

8 A TERN functional link has a single linear representation irrespective of national models/concepts for multilane roads, directions, and other individual definitions regarding the reference system.

9 Changes to the FUNCTION of the link rarely occur; although the means by which that function is achieved (i.e. the physical route taken) may change

10 Changes necessitate re-referencing to reflect change in function.

11 The functional network has no discontinuities.

The logical model

1 The logical model models the physical location of the TERN, and the changes to the TERN over time.

2 The logical model comprises sections and nodes. Sections can be further divided by the introduction of sub-nodes and sub-links, and these sub-links can, in turn, be further subdivided as many times as necessary.

3 Sections will normally be exit to exit, but frequency will depend on the national referencing used, to which data will be cross-referenced. Ultimately it will be a matter of judgement for the national road administration carrying out the referencing, taking into account the need not to introduce so many sections as to limit the value of the model at European level.

4 Sections are mapped on the national network by the individual road administration and the 'anchor points' are defined where convenient in order to obtain an effective data reporting process that supports the overall requirements.

Location of logical nodes

The location of logical nodes (and sections) will, to an extent, be determined by the referencing used on the national road network used in referencing the data to be reported on the TERN.

- A logical node will be located at a junction on the network where the junction causes a major change in traffic flow. For example, a difference of more than +/- 20% would normally be considered a major change.
- In some specific cases, a node might not correspond to a physical junction or identifier, for example where one or more planned but non-existent TERN links cross a planned or existing link, and consequently, the node does not exist physically, or where an intersection has been removed but the sections have not been re-referenced. It is recommended that nodes in general should be physically identifiable.
- A start node can be the start node for more than one section. An end node can be the end node for more than one section.

The nodes play an important role when the road network is anchored to a specific spatial geographic reference system. Assigning a set of spatial coordinates from a common agreed map projection to a node will ease the digital transfer of data between bodies using Geographic Information Systems for analysis and presentation.

Finally, it is important to recognize that guidelines for defining nodes will never be able to cover all possible situations on a road network. Where this is the case, the nodes are defined using common sense and best practice in the field.

Relationship of the functional to the logical network

1. Each functional node owns one or many logical nodes (which may be in different countries, may be in the same position, or in close proximity, and may exist at different points in time). As a general rule, it is desirable to limit the definition of multiple logical nodes at a single functional node, unless absolutely necessary.
2. Functional nodes at national boundaries are shared by all countries at that boundary.
3. Each functional link owns one or many logical sections, which may exist at different points in time.

Referencing at national borders

Where a national border is shared at a national border, each country will have its own country-specific reference in the logical model. In the functional model, on the other hand, all bordering countries will share a node with a reference that reflects this fact.

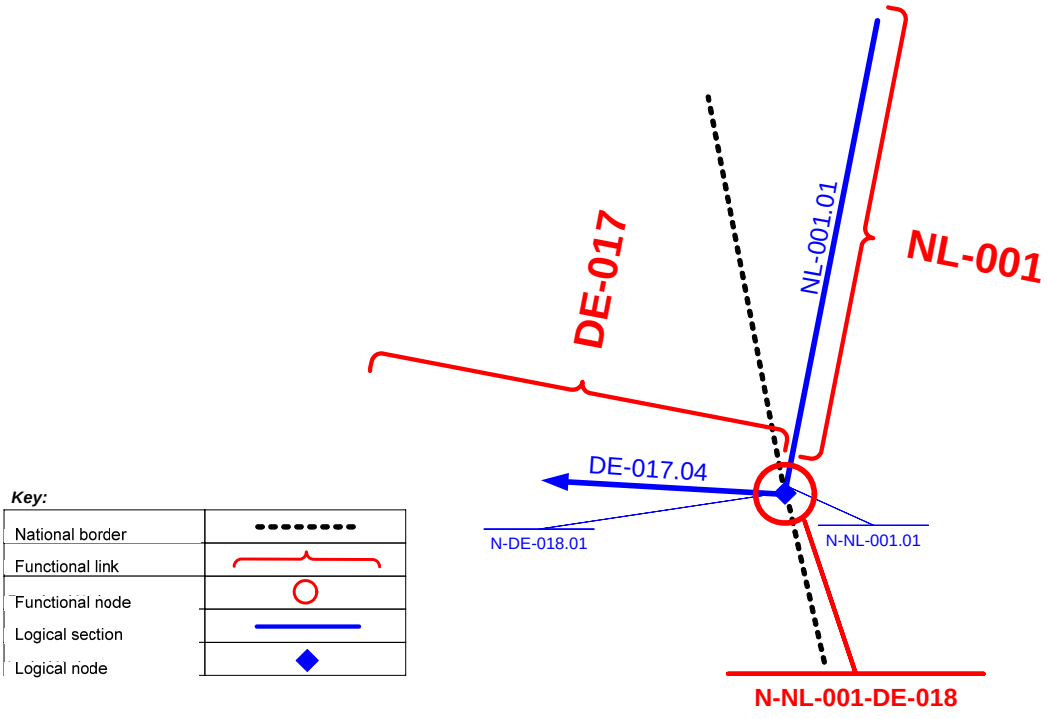


Figure B3: Referencing at national borders

Referencing sections that do not physically exist

Cases where planned TERN links and existing links coincide/cross each other are dealt with according to the situation when the network referencing system was originally defined. If both the planned and the existing link are known at the time of referencing, the existing link is split into two links and all reporting to DG TREN is referenced to the two links regardless of the fact that the node does not yet physically exist.

If the knowledge of the planned link/decision to plan the link arises after the initial definition of the TERN referencing, it is, at the time the decision is made, still necessary to define the required node and split the existing link. However, it is also necessary to keep track of the original link in order to allow for comparisons over time. This can be done using a simple historical mechanism in the reporting by using sub-numbers to the original link.

Referencing nodes and sections

Item	***Template***	***Example***	***Comments***
Functional node	N-CC-nnn	N-NL-001	
Functional node at national border	N-CC-nnn-C2-nnn...Cn-nnn	N-NL-001-DE-018	Intended to cope with borders with more than two countries.
Functional link	CC-nnn	NL-001	
Logical node	N-CC-nnn.nn	N-NL-001.01	The first part of the reference relates the logical node to the associated functional node. Where that functional node is a multi-country node, only the part related to the relevant country is used.
Logical section (first generation)	CC-nnn.nn	NL-001.01	
Logical section – divided (second generation)	CC-nnn.nn.nn	NL-001.01.01	Sections may be further sub-divided until the referencing is too complex to be of value.

Notes:
nnn = Unique (normally sequential) number where 'n' corresponds to the number of characters. Leading zeros are used.
CC = 2-character country code. Country codes used in the trial are:

NO – Norway
SE – Sweden
DK – Denmark
DE – Germany
CH – Switzerland
IT – Italy
GR - Greece

Referencing the network: principles and guidelines

- The reference system must be independent of data and spatial geographic reference systems ('coordinates').
- When using digital maps as the media for presenting road data analysis, it is important to describe carefully how the fixed points (e.g. nodes) are/will be anchored to the geographic reference system used.
- Redundant references are not re-used in other locations.

Tracking changes to the network

The TERN network referencing method is intended to allow changes to the network over time. The date attributes described above are intended to provide for the mapping of changes to the network and of different versions of the network over time. For the user of the network, reporting on performance indicators, for example, the referencing itself allows the current network to be related to previous, historic versions of the network.

Over time, the status of a road will change from 'planned' to 'under construction' to 'existing road'. When the reference system is first established, it is likely that while the road administration will know what roads are planned, in existence, or under construction, it might also be the case that the existence of future TERN roads is not known. The model is able to cope with situations where roads change status and new roads (planned or existing) are introduced.

Changes to the network: rules and principles

In making changes to the network, the following rules and principles are applied:

1 Functional links cannot be changed or divided. Changes to the functional network necessitate re-referencing.

2 Only logical sections that are physically the same can have their references split (see Example 1).

3 Logical sections and functional links do not have to be sequentially numbered (see Example 2).

4 Where logical sections are merged, the new section takes a new reference (see Example 3).

5 Re-routed logical sections have new, non-sequential references (see Example 2).

It should be noted that the decision as to what is part of the TERN and what is not and changes to the network are a question of road policy at DG TREN and in the member states. However, the model is able to support any decisions about the network.

Date attributes

The logical network model includes date attributes that allow changes to the network to be mapped.

In order to allow for the selection of data on a historical basis, the concept of 'date stamping' was introduced to the method with the following additional date attributes applied to the nodes and links within the logical network:

Date attribute	***Description***	***Required?***	***Default if unknown***
Planned date	*Date the section was first planned*	Yes	1/1/2004
Construction date	*Date that construction of the section started if the section is new*	No	1/1/2004
Opened date	*Date the section was opened to traffic (this will be the planned opening date where the date is in the future and the actual date where the date is in the past)*	No	1/1/2004
Closed date	*When the section was removed from the TERN*	No	Not required

Note that the default value applies to the existing network for the initial, one-off referencing trial.

These dates allow the selection of, for example, open TERN links only or all links, and allow historical reporting to include sections that are no longer part of the TERN (the pilot exercise will further investigate the need for and the use of these date attributes).

Major changes to existing parts of the network

Over time, the amount of traffic and the amount of lanes might change considerably on existing links. It is then up to the individual road administration to decide when to reflect this in the definitions of links and nodes, bearing in mind that the amount of nodes should be minimized.

If, for example, traffic on a part of a link increases to a level that is significantly higher than the average calculated up to that point, it might be convenient to view this part of the link as a new link and introduce the required nodes. Also in these cases it is recommended that the nodes and links be defined in accordance with the principles above (‘keeping historical track’).

Changes to the network: examples

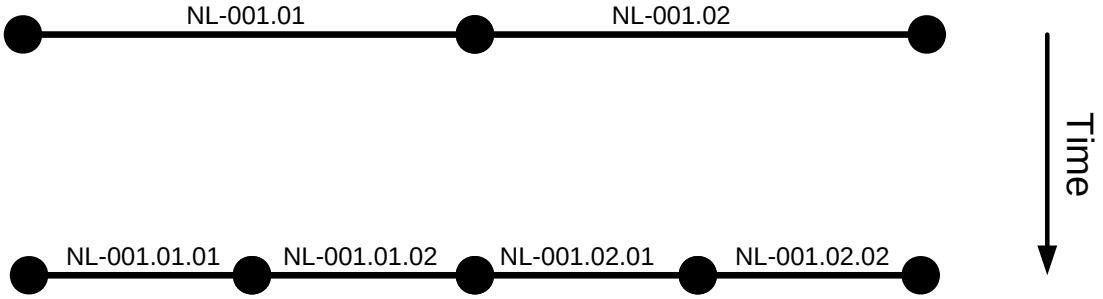
Examples of typical network changes are shown in the following diagrams, including:

1 the splitting of sections by including new sub-nodes and sub-sections with new identifiers that indicate the link of which they are part and the sections of which they were once part;

2 the addition of new nodes and links to the network;

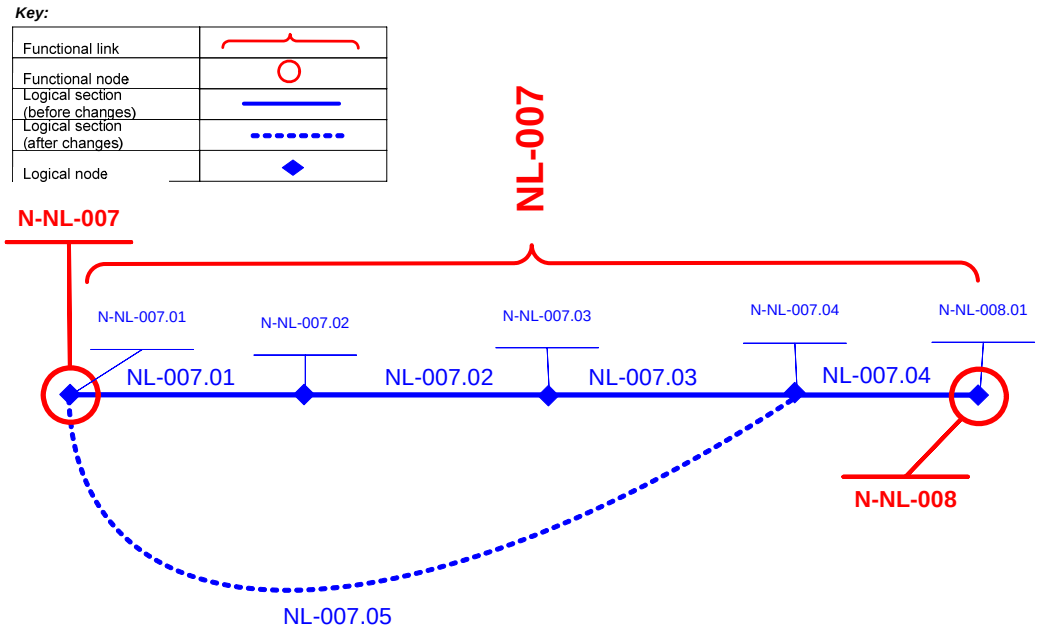
3 the removal of nodes.

Example 1: Splitting of sections / addition of nodes

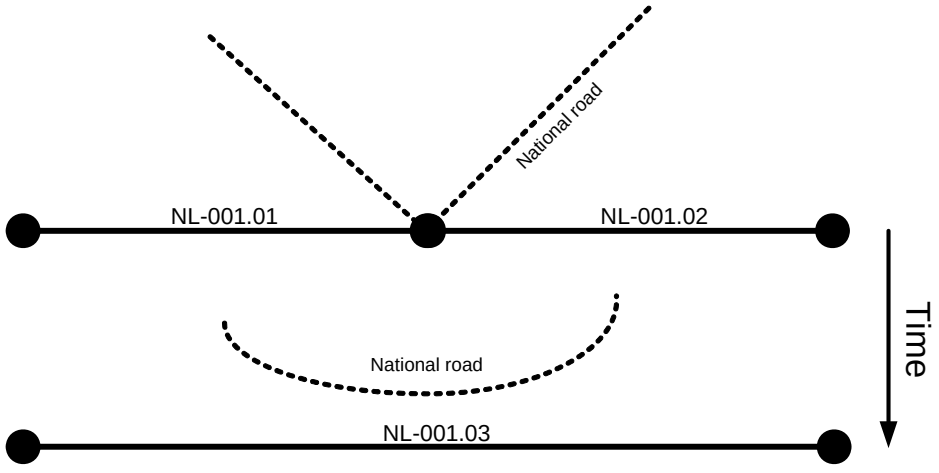


Example 2: Change of route within a functional link, e.g. by a by-pass

Note that this example also shows that after network changes, non-sequential referencing may occur.



Example 3: Removal of nodes



Appendix C: Danish experience in implementing TERN location referencing model

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Dynamic use of road data

CEDR's model for the exchange of information: the Danish experience

The Danish Road Directorate (DRD) has implemented the CEDR Location Referencing Model in connection with the international reporting of data and information on the road network.

The basic work with data was done once and does not need to be repeated. The implementation will therefore imply considerable savings for all future reports to the EC. Concerning future reporting, the DRD is now able to focus its efforts on the promotion of information. Examples include the layout of maps and the creation of indicators about the current condition and the development of the road network

Introduction

This summer the Danish part of the TERN Road Network (TERN-DK) was broken down into a number of fixed stretches in the road information system (road database) which enables the easy production of data retrievals and reports about 'TERN-DK'.

This work consisted of four tasks:

1 the definition of TERN stretches by means of a map of the road network;
2 the numbering of the stretches according to CEDR's Location Referencing Handbook;
3 the creation of the defined TERN network in the road database including the definition of the kilometre positions of the endpoints of the TERN stretches;
4 programme data retrievals according to the defined TERN-DK network.

This work necessitated 3 working days for 1 man. The selected set-up and methodology implies that it is simple and inexpensive to maintain data and update the road network.

Future adjustments to the road network might take place because of replacements or other changes to the actual location of the TERN routes. With the proposed setup, any changes or additions of this nature on specific stretches of the road network can be done within a few minutes.

Background

According to CEDR's Strategic Plan, PG Planning (which is part of TD Management) has developed a model that allows comparisons relating to the TERN to be done on a homogeneous and stable basis over time. The model implies that the individual country defines a segmentation of their part of the TERN into general stretches, utilizing maps showing the road network and using information in their road databases. The segmentation of the stretches is carried out according to the principles in CEDR's *Location Referencing Model* and *Location Referencing-Handbook*, which give guidelines on the specific work to be done and explain how to number the individual road stretches.

For all instances where information from the basic road network level is handed over, the task implies two main activities concerning data:

1 Getting and preparing the required data

In order to be able to use data for general planning or to prepare aggregated statistics at network level, it is often very resource-intensive to retrieve the relevant data and make it ready for actual use.

Like most countries, Denmark stores data on the national road network in a road database. Typically, this data is quite detailed because the primary purpose is to support the planning, maintenance, and operation of the road network. The more efficient and automatic the transformation of data for general planning purposes, the more resources can be made available to the subsequent value-creating activity.

2 Transforming detailed data into useful and comprehensible information

This activity includes the presentation of the basic data in an easily comprehensible layout according to the dedicated purpose.

One part of the activity is to aggregate data, to carry out possible calculations of indicators, and to make decisions about the presentation of the results so that it supports the purpose in question.

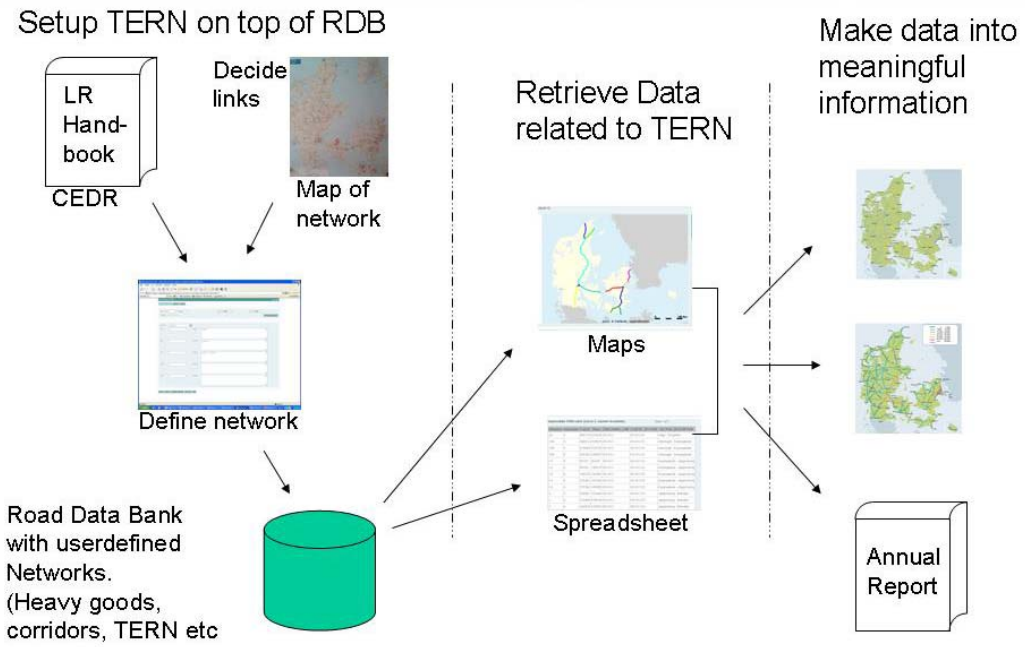
The Road Directorate in Denmark has assessed whether it would benefit from using the model. A minor analysis showed that implementation required only a limited amount of resources. The work was therefore launched.

On top of the Danish road database (known as ‘Vejman.dk’), it is possible to create user-defined ‘virtual’ road networks that are targeted to specific purposes. Examples are road networks for heavy goods, road networks for dangerous goods, and road corridor analysis. Because the TERN—when seen from a data management perspective—is, in reality, a user-defined network targeted to a specific purpose, the same mechanism and methodology could be used.

Every year, the DRD issues a publication entitled *The National Road Network 200x*. This report provides some important key figures regarding the national road network. This publication is a good example of how basic road data can be used for general road reports.

The figure below shows the Danish process for TERN. However, it is the same model as the one used to prepare the report about the national road network.

The steps ‘Set up TERN on top of RDB’ and ‘Retrieve data related to TERN’ correspond to Task 1 mentioned above, while ‘Make data into…’ corresponds to Task 2 with respect to the production of maps and tables.



Most—if not all—CEDR members have at their disposal road databases and maps that make it possible to tailor the systems to the same simple methodology.

The Danish example proves that it is possible to adapt the systems in such a way that the countries can respond more efficiently to requests from the EC and other bodies for information about the road network.

Therefore, the European road sector has a basis on which to establish a methodology that can efficiently supply basic information about the European road network. To achieve this it is necessary to inform the recipients (The European Commission and/or other international bodies) about the possibilities of this reporting system. This would mean that future requests for data from the European Commission would not lead to unnecessary resource-intensive work processes in the individual countries and road administrations.

Ref: CEDR report 2009/06 TDManagement2009 / RoadData & PerformanceIndicators

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