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ASSET MANGEMENT:
TECHNICAL INPUTS TO DECISION MAKING

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ABSTRACT

This report is the Danish reply to the PIARC call for National reports on Strategic Theme 4 Asset Management about approaches to Asset Management with focus on technical inputs to decision-making and regarding the political decision-makers' perception of conveyed information.

Denmark is a country in northern Europe, and from January 2007 the road administration will be restructured, and will consist of two instead of 3 administrative levels, the road network being divided between the state and municipalities. The entire road network of Denmark comprises 68,500 kilometres of motorways, highways and trunk roads and local roads. Major part of the goods' transportation is carried by the road network, and this is the challenge envisaged by road administrators in their conveyance of information to the political decision-makers.

The report presents examples from the State Road Network level, but many municipalities operate in similar manner, and even though in some cases it is in a less advanced way, the objective of gaining approval of decision-makers is the same.

Two important instruments in the interaction with decision-makers are described in this paper. First the annual status report about the present condition and deficiencies in the State Road Network, which presents the foreseen needs for maintenance and rehabilitation and for upgrading of the network. The second example is a study giving a total overview of traffic conditions for a major traffic corridor in context with regional and local planning for development in the belt along the corridor. Both studies have been recognised and well received among politicians as a comprehensive basis for decision making.

A solid basis for conveying information is data acquisition and needs analysis, which in Denmark is made in relation to a number of management systems. Management systems are developed both by Danish Road Directorate and by several private consultancy companies (e.g. Carl Bro a/s, Rambøll Denmark, COWI and Dynatest A/S). Management systems are today sub-asset systems, and the principle of pavement, bridge and routine maintenance management systems are described, together with, how each contributes information for the interaction with decision-making.

Asset management in Danish road administrations is today executed based on information from several sources (management systems and more) and compiled into the instruments described.

1. INTRODUCTION

This report is the Danish reply to the PIARC call for National reports on Strategic Theme 4 Asset Management with focus on technical inputs to decision making and on political decision makers' perception of conveyed information.

This report presents a general description about the Road network infrastructure and the administrative structure of Danish road sector, and focuses on the requested issues regarding:

1. the political decision makers' perceptions of the role of asset management systems
2. integration of technical inputs into the decision-making process

A working group headed by Danish Road Directorate has drafted the report. The group represents a vast experience in managing road infrastructure assets at both the State and Municipal level.

Participants in the working group are:

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The content of the report is divided into three main chapters. The first main chapter deals with how the administration of the road network in Denmark is organised and how decision-making is carried out at different road administrative levels, the length and usage of road networks administrated by the different road authorities, and how Danish Road Authorities see their role in the context of road infrastructure stakeholders.

The second main chapter explains and demonstrates the necessary efforts required in modern road authorities to support the interaction with decision makers by compiling asset information and transforming technical demands into information, which can support decision making in a political environment. Some examples of achieved information exchange that have made a difference are presented and the response received as indication of the political perception of the asset management approach is described.

The last chapter gives a state of the art of managing assets in the Danish Road Network. Currently applied management tools are described as well as the technical input monitored by road authorities at different network levels and the measures executed to properly operate and maintain the road infrastructure. Special emphasis is given in describing the modern approach of business organisations to see technical information and measures as enablers in achievement of outcome for stakeholders of the road networks.

2. DANISH ROAD ADMINISTRATION

Denmark is situated in northern part of Europe (see figure 3.1) and covers 43.098 sqr.km. It is surrounded by sea and has a costal climate usually with mild winters and relatively few days with temperatures below 0 ^{0}C during wintertime. The summer is tempered with short hot periods over 30 ^{0}C. The transport infrastructure is well established and functioning with modal diversity of roads, railways and airways. Denmark's location gives it an important role as a gateway or transit country between northern and central parts of Europe. Therefore Denmark has many international links and nodal points especially related to roads, harbours and airways. At the start of 2007 the Danish road sector changes from three to two administrative levels, as the County (regional) level was removed and now only the State and municipality levels remain.

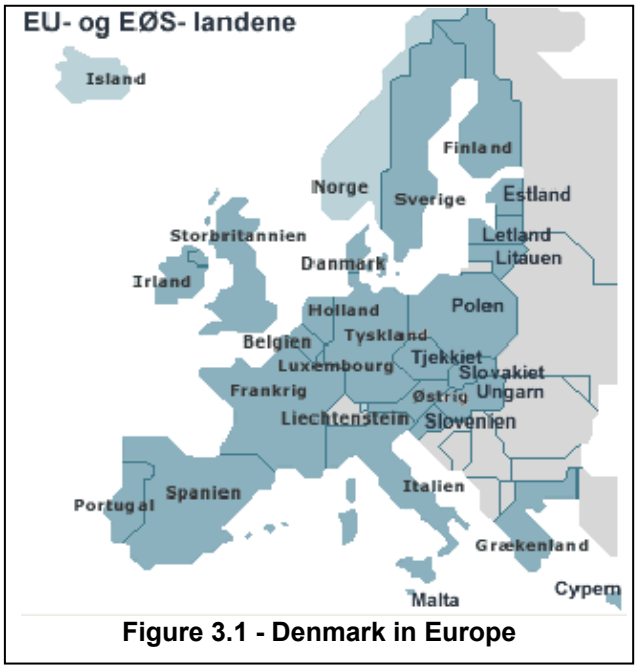

Figure 3.1 - Denmark in Europe

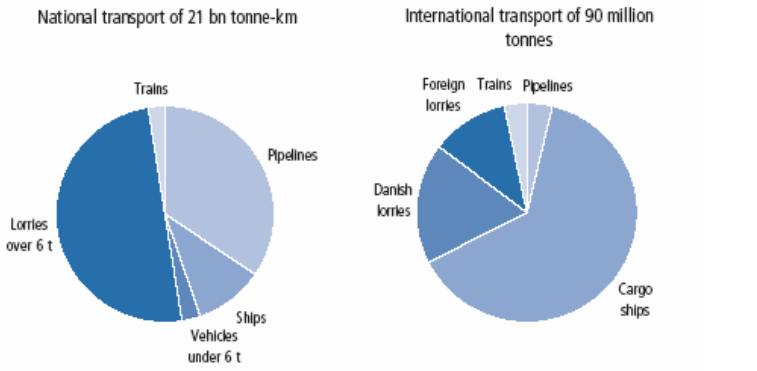

Figure 3.2 - Goods transport per mode, 2004. Source: Statistics Denmark

Like in many other countries transportation of persons and goods is mainly carried out on the road network and even though extensive efforts have been made to induce modal split only a minor part of transportation is carried by rail, ships and aeroplanes as shown in figure 3.2.

The road network in Denmark consists of main roads (motorways and major highways) and local roads, see table 3.1- Network kilometres. The main roads are managed by the State road authorities, Danish Road Directorate and Sund & Belt, see figure 3.3 – Map of Danish State Road Network, and local roads are managed by 98 municipalities and one regional municipality, each having their own independent road authority.

Table 3.1 – Length of road network (kilometres)

Authority	Network	MWY	HWY	Local roads
Road Directorate	3,800 km	1,000 km	2,800 km	0
Sund & Belt	41 km	41 km	0	0
99 Municipalities	68,500 km	0	7,500 km	61,000 km

Figure 3.3 – Map of Danish State Road Network, including Sund & Belt toll roads.

Regarding financing of maintenance and operation of existing roads there are no administrative relations between State and municipality level. There is however an intensive cooperation between authorities so that users don't experience differences in road standards across administrative borders. In addition there are several practical collaboration agreements regarding services across network level interfaces and about knowledge transfer.

Decisions about budgets for maintenance and operation schemes are made independently by each governmental level. Appropriations for maintenance and operation are given by political decision makers on the basis of the scheme and budget proposed by the road authority. The budget levels for maintenance and operation expenses at the State and at the municipal level sector are presented in table 3.2:

Table 3.2 – Budget Levels

State Roads	Municipalities Roads
425 mn EURO	1,190 mn EURO

Typically, road authorities in Denmark are organised with a central unit responsible for general planning, budgeting and tender acquisition, and local districts are responsible for execution of operation and maintenance works on the district road network.

Two fundamental issues are important to Danish road authorities, first satisfying the stakeholders of the road infrastructure and second securing innovation and efficiency of works conducted to operate and maintain the road network.

A specific effort has been made to identify and describe the various stakeholders' interests and perceptions in relation to deliveries from the Danish road authorities to distinguish the outcome and perception of the measures executed in operation and maintenance of the State Road Network. Below is shown the mapping of stakeholders in relation to the road and indicated the value of the road network for each group of stakeholders. This mapping, figure 3.4 – Stakeholder Mapping, is also to be seen in a view of business processes, - how to achieve excellence by regarding activities as enablers in the process, and learn from survey measurements of the effect on outcome and perception as feed-back on the chosen measures.

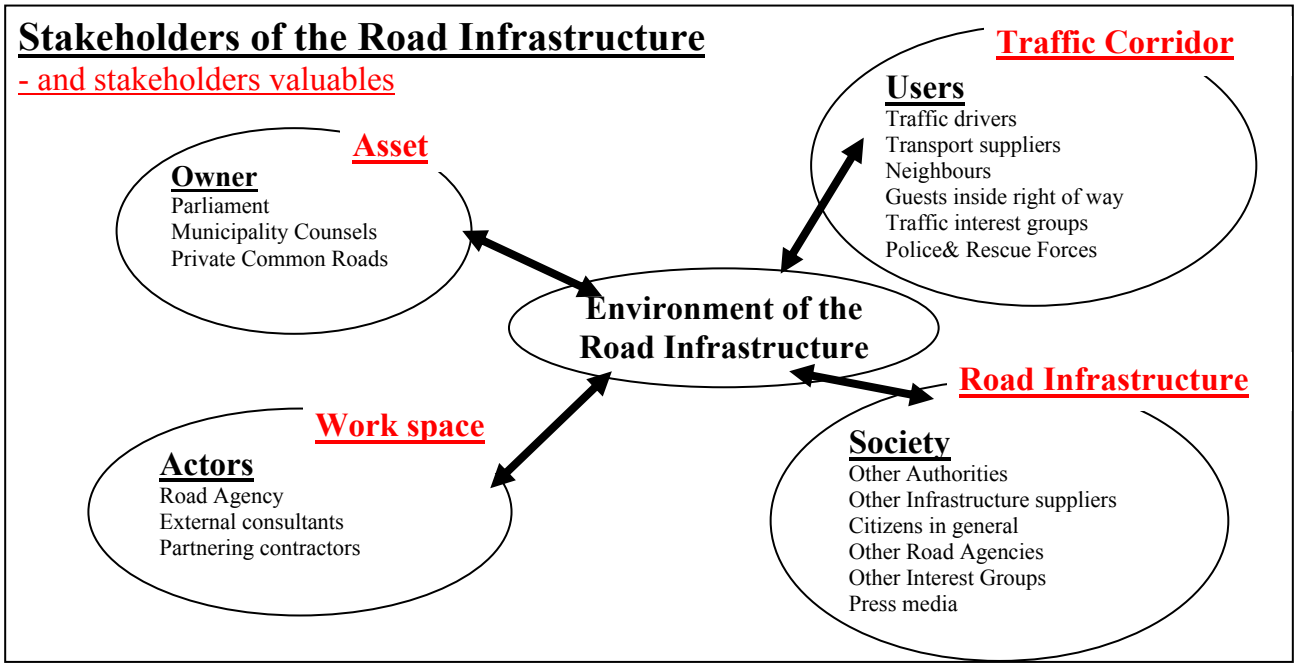

Figure 3.4 – Stakeholder Mapping

Innovation and efficiency are enforced in executing most rehabilitation works, and at Danish Road Directorate also routine maintenance, in partnership contracts with embedded incitements for innovation and better efficiency. The innovation and efficiency will contribute to the key objectives of the Maintenance Unit in providing safety, passability and service to the users, preservation of invested capital in the road network for the owner, and better environment to the society in a professional and responsible manner for the actors. Partnering agreements have been made since 2003 with most contractors about pavement maintenance on State Roads, but also with municipalities as performance based long term contracts.

The Danish experience shows that partnering promotes inclusions of competences and smarter thinking about works and contributes to key values for both parties. Even though some disadvantages have still to be overcome, partnering fortunately also implies mutual openness about the problems which arise and hence the solution to these, is possible to find in dialogue and mutual trust (Simonsen, 2006).

3. DECISION LEVEL INTERACTION

3.1. Financing of Activities on the Danish Road Network

Funds for planning, construction, operation, maintenance and administration etc. of the trunk road network – except the Sound and Belt's toll roads - are mainly provided to the Danish Road Directorate from grants in the State annual budget. A small part of the financing of operations comes from the Danish Road Directorate's contract with service area operators.

Approximately 60% of Danish Road Directorate's budgetary expenses are allocated for construction and approximately 29% for operations and maintenance. The remaining part of the budget is used for administration etc, road sector operations, road user services and traffic management.

The financing of operation, maintenance and construction of roads in municipalities is very similar, besides budgets for local roads are granted by the municipality counsel on the annual budget negotiation act. In municipalities however the major part of the budget is used for operation and maintenance of roads and structures and only a small part for new roads.

3.2. Information for Decision-making

Decisions regarding the allocation of grants for construction and investments in maintenance in the road networks are based on different types of documentation and reports conveyed to the political decision level, and a few examples of applied instruments from Danish Road Directorate are presented briefly.

Extensive studies are carried out before decisions are made regarding new roads or major expansions of existing roads. In case of improvement schemes (smaller projects) data regarding conditions on the road network (e.g. traffic data, and accident data in case of black spots) are important input for recommending, which activities should be carried out. Every year Danish Road Directorate also produces input used for financial forecast of the investments needs on the State Road Network during the coming four years period. An example of accompanying information instrument for conveying a decision-basis for political negotiations is the Common Key Information on current state of the road network.

Since 1999 the Danish Road Directorate has published an annual publication with key information on the current condition and development needs of the State Road Network. This report is normally published in October and appropriate before beginning of the State annual budget negotiations. The report focuses on giving an extensive description of the present state of the State Road Network covering issues regarding traffic volume, transport quality in pass ability and bottle neck problems, road and bridge maintenance conditions, service facilities, road safety, intelligent transport systems, environmental conditions and road accounts.

The report display information in maps and graphs, which helps to give the reader, a good overview of the condition and development of the State Road Network. This manner of supplying a well structured overview of the detailed information has been well received by stakeholders and especially among politicians as a basis for decision-making.

Members of the Danish parliament have explicitly expressed satisfaction with the information given in the reports. In figure 4.1 and 4.2 are two examples of maps given in the reports.

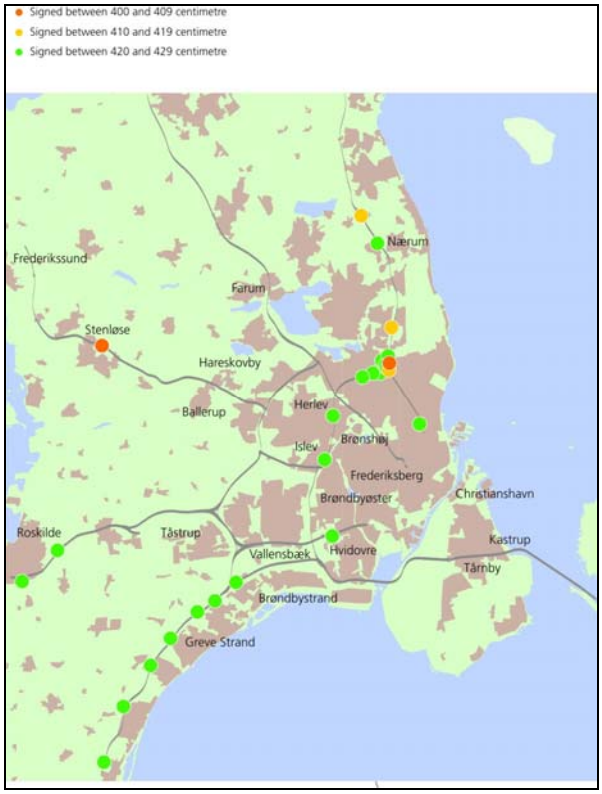

Figure 4.1 - Bridges on the State Road Network with a sign saying that vertical clearance is less than 4.3m.

Figure 4.2 - Average minutes each weekday in 2005, with traffic speed below 40km/h.

For the long term planning another instrument has been developed. This is a report compiling available information about and along specified corridors of the State Road Network. This is made to give decision-makers a more holistic view on transport and development needs in the specific corridor.

In the period 2002-2003 the Road Directorate carried out a pilot corridor study on routes E20 and E45 from Odense to “Trekantområdet” (the triangular area between the three cities in Jutland, - Frederica, Vejle and Middelfart).

The purpose of this study was, to present a total overview of actual traffic conditions on the main road in the corridor, parts of MWY 40, 50 and 60, and to estimate future developments in traffic, and to ensure that the development of the corridor took into account regional and local plans, and with development of other transport infrastructures in the corridor. It was also an objective to create a better basis for planning of more detailed studies of problems and developments in the corridor as well as gaining experience in utilizing the corridor planning concept as a part of the planning and decision-making process.

One of the main purposes of the corridor study was also to make a cross-sectional summary description of identified problems in the corridor. In this context it was necessary to work with different ways of displaying the condition of key indicators in the corridor. New maps, graphs and tables were designed to complement the text in the report. In figure 4.3

an example of cross-sectional summary of identified problems in the investigated corridor E20 is shown.

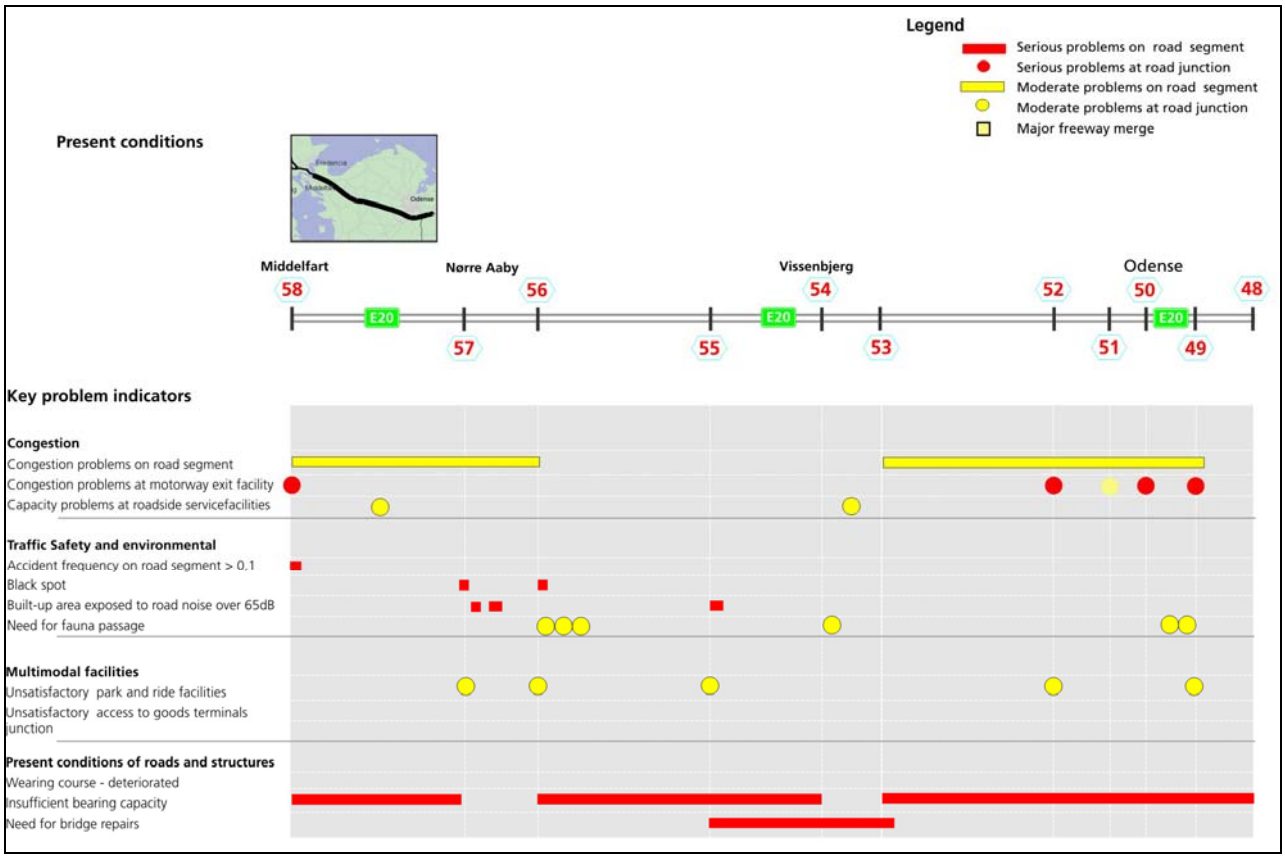

Figure 4.4 - Cross-sectional summary of identified problems in 2001 at corridor E20, between exits 58-Middelfart and 48-Odense East

In September 2002 the Corridor Study report was published. In the following months regional meetings were held with local authorities and politicians. In November 2003 the Danish Parliament decided on a political agreement based on the report information, by which it was decided to expand sections of the MWY 30 in this corridor from 4 to 6 lanes, and presently an EIA (Environmental Impact Assessment) is being carried out about this project, also including public hearings. The preliminary field investigations are expected to be finished in 2007 and followed by a proposal for Construction Act and presented for the Parliaments approval.

However an important precondition for producing appropriate information of political decision-making is acquisition of real data about the road network and objective processing for analysing and forecasting future condition and investment needs.

4. DECISION PREREQUISITES

This chapter deals with the sources of technical data that is used as information to the decision process. Most of the data is not collected with purpose of only supporting political decisions; it is collected or produced on the operational level of the road administration also for supporting the day-to-day management of the asset of existing road infrastructure network.

The information to decision-making is of following issues:

- Technical properties of the existing road network assets provide information on the capacity of the network and its individual components
- Traffic counting, WIM-stations, weather stations, provide information on the physical and environmental impact on the assets
- Prediction of long-term needs provides information of the level of funding that is found to be necessary to fulfil the demands to functioning and safety.
- Feedback from asset management under given, constraint funds, is used for justifying application for funding (When the funds have been granted, detailed decisions on how to invest them are taken at the administrative level, but the technical and economical consequences of limited funds are fed back to the decision-makers at the political level).

4.1. Management Systems

The asset management of the Danish state road network is supported by a number of it systems, all developed by the Danish Road Directorate, the most important in this relation being:

- VIS, the Road Network Information System
- BELMAN, Pavement Management System (Danish Road Directorate, 1999)
- DANBRO, Bridge Management System (Lauridsen et al., 1998), (Bjerrum & Lassen 2004)
- MASTRA, a collection of programs for processing and presentation of traffic counting data.
- MMS-PRIO, Maintenance Management System for economical prioritisation of routine maintenance works on adjacent areas and road furniture.

The municipal roads are managed locally, in some cases at a less advance level, but with the same systematic approach. Some municipalities use systems similar to those mentioned above, which are available from Danish Road Directorate or private consultancy companies in Denmark (e.g. Carl Bro a/s, Rambøll Denmark, COWI and Dynatest A/S). The use of management systems in the municipalities is often complementary to a service contract, under which the Danish Road Directorate or the private consultancy company (Kristiansen J., 2006) performs data collection and more or less of the asset management on behalf of the municipality.

Data Related to Traffic Capacity and Safety
As a basis for decision-making on possible improvements of capacity and safety of a transport corridor, data is collected from a variety of sources, such as:

- Data on the geometry that determine the traffic capacity (Lengths, widths, clearance under bridges, carrying capacities of bridges, number of lanes, etc.) retrieved from VIS.

The data origins from the design and construction phases, supplemented in case of reconstructions or other activities that influence the inventory data.

- Information on the actual traffic, its composition and distribution is found in MASTRA (based on a number of permanent, automatic counting stations supplemented by interim automatic stations and manual counting),
- Supplementary information on the traffic pattern related to commuting is retrieved from "Statistics Denmark", and interviews are also used.
- Information on traffic accidents is found in VIS and in a particular project on Black Spot-identification.
- Information about road's condition is retrieved from BELMAN. Measurements of load bearing capacity, surface evenness, wheel ruts, and friction are carried out every year. The data are transferred to VIS, which also contains other frequently updated data on the road network. These data include information on the reference system, geometry, surfacing type and age.

4.2. Maintenance of Pavement, long-term needs

The determination of long-term needs is an important part of the output from the optimisation process, performed at alternative budget levels, as described in section 0.

The main item is the BELMAN optimisation process that proposes a long-term (normally 10 years) maintenance scheme for maintenance and rehabilitation of road sections.

The optimisation procedure involves a number of forecasting models:

- Models for change in evenness, bearing capacity and traffic volume (i.e. How will these parameters develop over time)
- Models for economic calculations

The BELMAN optimisation algorithm works in four stages, of which the last three are repeated for each of the optimisation years (normally 10):

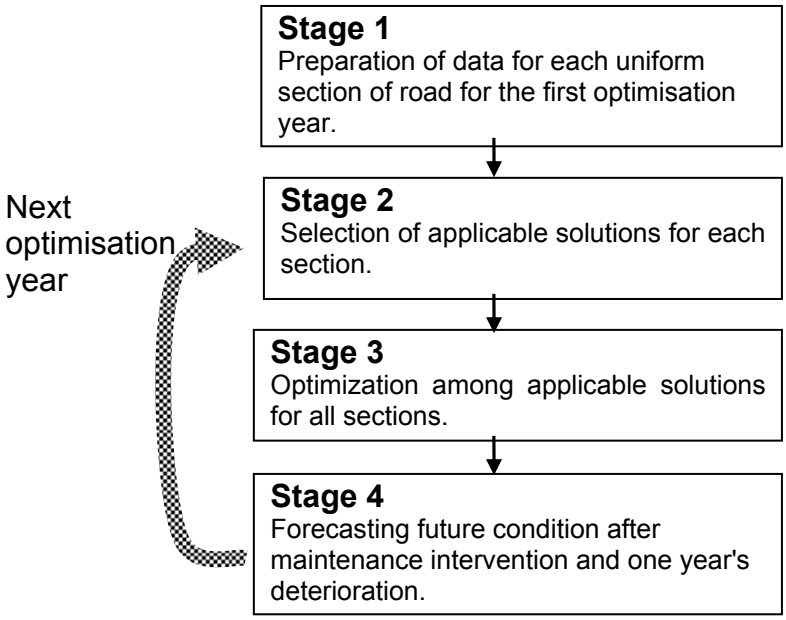

Figure 5.1 – BELMAN optimisation process

Output from the Processing, - Information for decision-making
BELMAN provides various overviews and statistics on the current condition of pavement (the basis of the optimisation), which is valuable information to political discussions on pavement maintenance strategies.

The optimisation result contains information on the chosen resurfacing solutions for each road section, the costs and effects used by BELMAN in the selection phase of the optimization algorithm, the remaining lifetimes of the road sections, the expected evenness after resurfacing, etc.

When BELMAN is used for forecasting, it is primarily the general development that is of interest. A number of optimisations carried out with optional funding levels can be presented and compared. It is thus possible to pre-determine the consequences caused by a budgetary reduction of 20% for e.g. evenness or user costs; or, the other way round, it is possible to pre-determine the budget necessary to keep or achieve a desired quality level, as basis for the information required for the decision level interaction, discussed in chapter 4.

4.3. Maintenance of Bridges, long-term needs

Long-term needs for bridge maintenance are calculated by the long term budgeting module of DANBRO, (Bjerrum & Lassen 2004). It is based on actual construction data of the individual bridges (age, design, quantities of standard components) and experience data on service life, maintenance cost and replacement cost of standard components.

Semi long-term needs (5-10 years) are registered at the Principal Inspection, which is a thorough visual inspection carried out with regular intervals by experienced bridge engineers. At the Principal Inspection a condition rating is assigned to each bridge and each major component together with the needs for repair works and special inspections are evaluated, stating type of work, year of execution, and cost estimate. If the average condition rating gets worse over time, it indicates that the bridge stock and thereby the invested capital is deteriorating, which should an indicator to the decision-makers that funds are insufficient.

At the Principal Inspection the maintenance and cleaning condition is evaluated as well. If there is a significant need for routine maintenance at the time of the inspection it is noted as a “- “, (Minus). If there is no need, it is noted as “+“, (Plus). A large number of minuses indicate insufficient routine maintenance and possibly insufficient funding for routine maintenance.

Maintenance of Bridges, Management under Constrained Funds
Maintenance of bridges fall in two categories, each assigned its own budget:

- Routine maintenance and cleaning
- Repair works

The distinction between the two categories is not very strict; general practice is that works at a cost less than DKK 100,000 are handled within the first category. The major practical difference is that repair works are budgeted individually and subjected to the prioritisation process, while routine maintenance and cleaning is prioritised locally by the operational level and within the maintenance budget available.

Data Input
Needs for routine maintenance and cleaning are determined at an annual routine inspection of all bridges. The needs are expressed as the requisition of a number of routine works with estimated quantities (e.g. 25m sealing of cracks, 5m^2 of superficial concrete repairs) and cost based on a standard price list with experienced unit costs.

Basis for proposals on repair works on bridges is the special inspection report for each of the relevant bridges, as performed by a consulting engineer. The consultant establishes one to three optional rehabilitation strategies and performs an economical evaluation of the options.

The detailed technical input to the optional strategies and thereby to the decision-process is specific to the individual case. Various testing's may be performed to reveal the properties of the structures, depending on the actual damage mechanism involved.

For the calculation of road user costs, important input is the measured traffic volume, its composition of light and heavy vehicles, and its distribution over the day, the week, and the year. These data are collected from MASTRA, the Danish Road Directorate's system fro managing traffic data.

Processing
The quantities of acquired maintenance works from the routine inspections are input to the routine maintenance module of DANBRO. DANBRO calculates the cost estimate for all acquired works options. If the total cost estimated exceeds the available budget, the operational level decides which works to exclude, either individual works, or all routine works of a specific standard.

The economic figures from options specified under the special inspections are input to the prioritisation module of DANBRO. Other inputs are the expected funds available (the budget limits) for the first five years – the budgeting years – and the discount rate to be used for calculating Net Present Value, NPV, of optional strategies.

Then the system chooses a strategy for each bridge, one of the alternative relevant strategies or a postponed variant of one of them is selected.

Among all the combinations possible, when selecting a solution for each bridge, the prioritisation algorithm will find the solution that has the lowest total cost NPV, for which – at the same time –the agency's cost lies within the budget limits for the first five years.

Output from the DANBRO Processing, Information to Decision-making
The output from the maintenance module of DANBRO is a list of specific work acquisitions that have been excluded in the manual ranking process. An implicit result is the back-log of works that could not be performed within the grants.

For each bridge involved in the prioritisation result, DANBRO specifies which strategic solution is selected and in which year the first rehabilitation works are to be performed.

Additionally the incremental cost to society is calculated when the optimum strategies are not selected in the prioritisation. This cost is used as information in the decision level interaction for required funds for bridge maintenance as an indicator for potential society savings.

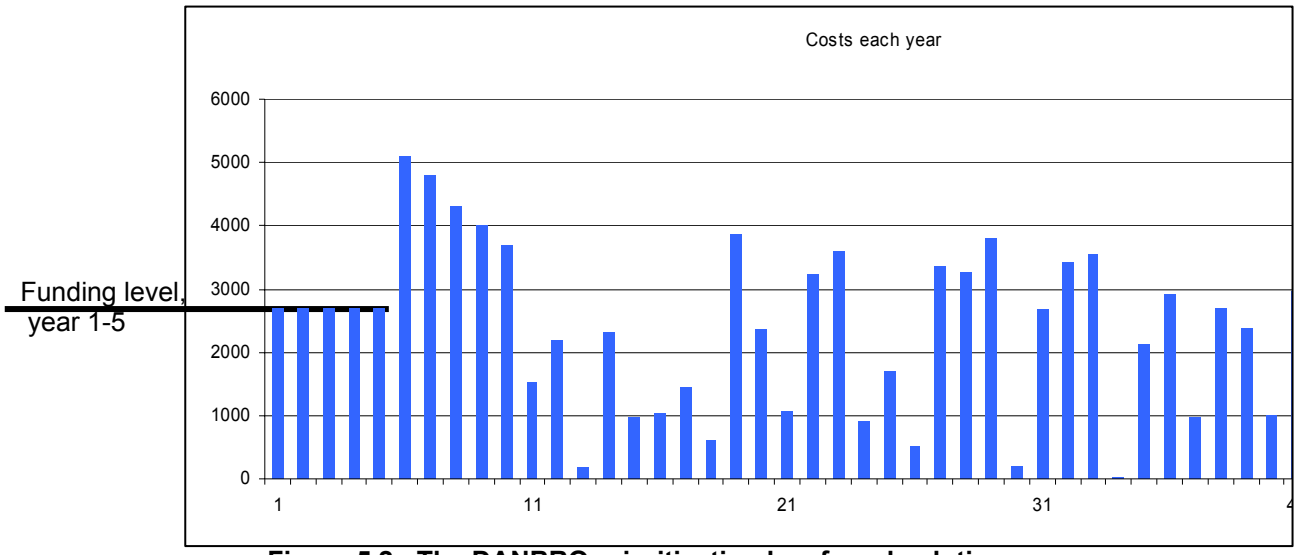

Figure 5.2 - The DANBRO prioritisation has found solutions that meets the available budgets for the first five years.

Further, the chart in Figure 5.2 illustrates the bulk of works that are being deferred beyond the five-year budget period, and which are continuously being pushed ahead as back-log as a function of insufficient funds.

4.4. Economical prioritisation of routine maintenance works on adjacent areas and road furniture

Prioritisation of routine maintenance works on adjacent areas and road furniture is an important task, to ensure that works is executed to pursue the key values for the administration. For State Road Network these are: - safety, pass ability, preservation, service, environment and aesthetics. All routine maintenance works are recurrent needs driven, and therefore prioritisation is important and conveying of information about deviations in provided standard of service have great awareness among politicians and in the society.

In processing of the routine maintenance scheme, MMS-PRIO values each type of activity by impact on key values and the importance of fulfilling the key value. Hence a point of importance is calculated for each type of works and prioritisation is made in order of descending point-value.

The maintenance scheme will contain all works possible with in the available budget, and for some activities a degrading in provided extent or service level may be chosen. These required degrading, to ensure provision of required activities, of course is a strong signal in the interaction with decision-makers to raise awareness about build up back-log or expected user's perception of the road administration outcomes in relation to delivered results.

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